RECORDS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

VOL. VI.

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UNDER THE DIRECTION OF

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SUPERINTENDENT OF THE GEOLOGICAL SURVEY OF INDIA.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1873. [February.

ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA AND OF THE GEOLOGICAL MUSEUM, CALCUTTA, FOR THE YEAR 1872.

During the twelve months of 1872 our working staff was diminished in number by the absence, either on leave, or on special duty elsewhere, of several of the officers of the Survey.

As stated in last year's report, Mr. W. T. Blanford was deputed to accompany the Boundary Commission in Beluchistan and Persia. Two very interesting papers on parts of the Persian Gulf and of the shores of Arabia visited by Mr. Blanford, while waiting for the arrival of his fellow labourers, have been given to the public during the year. Later on, at the close of the boundary labours, he was compelled by ill health to proceed direct to Europe, where he arrived in September. It is to be hoped that he will be able to work up the extensive and valuable materials he has acquired, together with those of his colleagues in the duty. Taken as a whole, it is certain they will form one of the most valuable contributions to the Natural History of a little known portion of the earth's surface, which offers many points of high interest and importance, in so far as it forms a connecting link, as it were, between our Indian empire and the wide areas of Arabia on one side and of the Caspian and Russia on the other. Mr. Blanford also had opportunities not often offered to European naturalists, which, I doubt not, he made ample use of. On this duty he has been absent during the whole twelve months. Mr. Foote was absent for three months from August to November. But this interfered only slightly with the progress of the work. Mr. Fedden, who had been suffering from frequent attacks of fever in the unhealthy district of the Pemgunga and Wurdah valleys, left the country on sick leave in May, and has been absent since. Mr. Hughes, who had been invalided in the same districts during the working season of 1871-72, returned to duty and resumed his work in November 1872, and has since been actively engaged. Dr. Waagen was also compelled to leave for Europe on medical certificate at the close of the year. Mr. J. Willson, who had been absent on sick leave from May, resumed his duties early in December, and at once proceeded to the field. These constant changes, necessitated in a great measure by the heavy work and great exposure to which the assistants of the Geological Survey are subjected, unavoidably retard progress and delay the completion of maps.

At the commencement of the year (January 1872), Mr. Medlicott was actively engaged in the examination of the Satpura coal-fields and adjoining country. Some of the results of this examination are already published. Of these results the most important, practically, were two—the possibility of coal being found to extend under the more recent deposits of the Narbada valley proper outside the hills, and the probability of beds of workable coal being traced more to the south in the Dudhi valley. To test the former, Mr. Medlicott recommended that boring trials should be made near Gadurwarra, and this has been commenced. The actual borings have been placed under the charge of Mr. Collin, a coal engineer who had been engaged at Wurrora in the Chanda district. But badly supplied with tools, and at a distance from any place where mechanical appliances and instructed labour could be obtained, the progress hitherto has been very small and very disappointing. Mr. Medlicott is only responsible for the proper selection of the locality, the actual working being under different control. The false economy of attempting to carry out such an undertaking without proper tools and efficient supervision cannot be too strongly insisted on. Mr. Medlicott meanwhile has been endeavouring to push on the geological examination of the adjoining country, this being the necessary preliminary to any further practical search for coal, his progress in this being, however, most seriously retarded by the necessity of looking after boring operations so inefficiently conducted, without any countervailing advantage.

Mr. W. L. Willson has been steadily engaged in extending the geological lines and boundaries, from the north of Dumoh, where he had been engaged, into Bundelcund and the adjoining territory of Rewah. The district examined is as yet incomplete in itself, and any description must be deferred. Mr. Willson was, during the recess, most usefully employed in the preparation of the maps of Dumoh district on the scale of 1 inch = 1 mile for publication, some of which are now ready.

Mr. Mallet, who had, as reported at the close of last season, proceeded to the coal-fields of Kota, on the southern borders of Mirzapúr district, mapped out its limits. He notices some fourteen outcrops of coal, most of them, however, very thin and worthless; some two or three have a workable thickness of fair coal. All appear to be on about the same horizon, not more than two being seen in any cross section, the richer outcrops thus appearing to be only local. Mr. Mallet has also added many interesting mineralogical observations to those in his previous report upon the rocks occurring in the widely spread gneiss series, especially upon the valuable bed of Corundum which he had noticed in that neighbourhood. These notes having been published in the Memoirs of the Survey need not be alluded to here more particularly. During the later part of the year, Mr. Mallet has taken up the examination of the Hazaribagh district. A considerable part of this district had been gone over some years since, but the topographical maps, which were then available and which were shortly afterwards condemned, were so imperfect, and those resulting from the re-survey so entirely different, that it has not been found practicable to transfer the geological lines, &c., without absolutely going over the ground a second time. Mr. Mallet's labour will be confined chiefly to the crystalline and metamorphic rocks. In a similar way, Mr. James Willson has been, since his return from sick leave, engaged in putting in the geological boundaries and divisions of the coal-fields in the south of the same district on the new maps preparatory to publication.

In the early part of the season, Mr. Ball was engaged in the examination of the coal-bearing rocks in Sirguja. Among these areas, the small coal-field of Bisrampúr is in itself complete, and will shortly be published. Among these rocks Mr. Ball has noticed a case of unconformity between the lower group, or the Barakár rocks, and the upper sandstones, defined by faulting in the lower rocks not affecting the upper. This is a very unusual occurrence, but is of high interest if established by further research.

In the latter part of the year, Mr. Ball has been deputed to accompany Mr. H. Bauerman, who had been sent out by the Right Hon'ble the Secretary of State, in his visit to the more important iron-yielding districts, with a view to giving a definite opinion on the feasibility of establishing iron works in India, and with him has visited

Birbhúm, Raneegunj, Hazaribagh, &c. Mr. Bauerman's report will be submitted to the Secretary of State.

Mr. Hacket has carried his lines and divisions from the adjoining districts of Jabalpúr and Bijiragoogurh into Rewah. A very large part of this area is covered by the Jabalpúr formation. It is seen typically in the north-west of the area, but is extended by Mr. Hacket considerably to the south of Bandogurh. The Bandogurh sandstones are themselves 1,000 feet thick. How far this apparent extension of the formation can be proved to be the fact must be seen from the adjoining country when it comes to be examined. In the present season Mr. Hacket has been sent to work out the details of the more recent deposits of the Narbada valley in connection with the Satpura basin, which Mr. Medlicott is examining at the same time.

Previously to his departure on leave, Mr. Fedden had extended to the south his examination of the rocks of the Nizam's territories adjoining Chanda, tracing out the existence of a group of rocks under the great Deccan trap to west of Sirpúr, containing remains of *Palæozamia*, thus establishing their relations with the upper jurassic rocks of Kutch and the Rajmahal beds of Bengal, and giving another clue towards unravelling the connection of the so-called Jabalpúr beds of the Narbada valley with the others. The full extent of these rocks remains to be worked out.

In the Punjab, at the opening of the year, Mr. Wynne and Dr. Waagen were engaged in the detailed examination of the Salt-range and adjoining country. This has enabled the mapping of the whole of that range to be completed, while a remarkably interesting and extensive series of fossils has been obtained, which have as yet been only partially examined, but which, when fully investigated, promise to open up some very important and intricate results. One of these discoveries I will notice again. At the close of the working season, Dr. Waagen returned to Calcutta and took up the detailed examination of the Cephalopoda from Kutch, our previous collection of which had received very extensive additions from the labours of Dr. F. Stoliczka. This group will form one of the most important contributions to the Cephalopoda fauna of the upper jurassic formations (from the Tithonien to Callovien) ever published. The extent of this group alone, without any of the other classes of Mollusca, may be estimated from the fact that their illustration will require about 60 large quarto plates. The MSS. of the descriptions have been nearly all completed, and great progress has been made in the preparation of the plates. But it was with much regret that we were obliged to suspend the work,—only temporarily, I hope,—in consequence of the serious illness of Dr. Waagen, who had commenced it, and whose wide and accurate acquaintance with the Cephalopoda rendered his descriptions highly valuable. I sincerely trust that a few months and a better climate may restore Dr. Waagen to the enjoyment of full health, and enable nim to resume and complete his history of this most interesting fauna.

Towards the close of the year, Mr. Wynne had resumed his examination of the Punjab rocks, but was necessarily diverted for a time to enable him to aid in procuring and forwarding a complete collection of the salts and rocks of the Salt-range and its salt mines, to be sent to the Vienna Exhibition. Having accomplished this, he resumed the detailed examination of the country north of the Salt-range. A brief but careful description and sections of the well known hill of *Sirban*, close to Abbottabád, has been published during the year—a result of the joint labours of Dr. Waagen and Mr. Wynne. This has been given without delay, both because the hill is close to a well known station, and so accessible to those who desire to examine its structure, but also because this structure had been entirely misrepresented; while it would at the same time form a typical illustration of what might be looked for in other similar areas.

In Madras Mr. W. King had, at the commencement of the year, taken up the examination of the country adjoining the Godávárí, in continuation of the preliminary survey of the same area which had been carried out by Mr. Blanford, whose health did not admit of his returning to that district. As it was important that the more southern portion of the country should be carefully examined prior to proceeding to the less accessible area further north, Mr. King's attention has been chiefly directed to the country extending between Dumagudiem and Kummummett. Some of the principal results arrived at have been already published in the Records of the Geological Survey for 1872, so they need not be detailed here. In one place, a limited area of coal-bearing rocks was traced out, and actual beds of coal found; but the country is so covered with jungle, and so thickly coated with debrís and recent deposits, that nothing very definite can be asserted regarding the extent or value of this coal without borings. Another small area near Ashwarowpetta holds out some promise, but this also must be actually tested before any satisfactory conclusion can be arrived at. Towards the close of the year, when it was too early in the season to enter the jungly country to the north with any safety, Mr. King has made a careful examination of the country between the Godávárí, and Rajahmundry, and the sea, and has there found some fossiliferous beds, the organic remains from which will prove of high interest. He has also brought the well known fossiliferous beds of Kateru, near Rajahmundry, into stratigraphical relationship with those occurring at Pungady on the opposite bank of the Godávárí—here a stream of great width. As the jungles become drier and more accessible, Mr. King will extend his researches northwards.

Mr. Foote has been steadily carrying out the boundary lines between the great area of the Deccan trap rocks and the underlying beds; and between those intermediate beds and the gneiss rocks on which they rest. He has connected his lines with those previously mapped in by Mr. Wilkinson to the west. The entire area examined, excepting a few square miles on the top of the plateaux, is within the drainage basins of the Kistna, Gatpurba, and Malparba rivers. Mr. Foote has also been fortunate enough to add to the valuable series of fossils, bones, &c., of *Rhinoceros*, which he had obtained during the previous year, and to find others of bovine animals, together with deposits of fresh-water shells, which on examination proved to be very similar to those found with the ossiferous clays and gravels of the Narbada valley. There can be no question that these ossiferous beds will prove of the very highest interest when fully worked out, as bearing on the distribution of genera in these pleiocene deposits, which still exist in other areas, but which have entirely ceased to exist within the limits of the districts where their remains are found.

In Burmah, Mr. Theobald has been engaged in extending his examination of the country between the central range and the eastern boundary of the country on the Sittang river. The present season will see the completion of his examination of British Burmah proper; and a map and general report will then be prepared for publication.

Dr. Stoliczka, in the early part of the year, completed his detailed examination of the Province of Kutch (Kach'h), in which he has been enabled, by the application of his palæontological knowledge, to define several well marked sub-divisions or horizons in the jurassic rocks, and to establish their close relationship to the acknowledged groups in European classifications. The full details of these are being prepared for publication, while the magnificent series of fossils also obtained will be worked out as soon as possible.

PUBLICATIONS.—The RECORDS OF THE GEOLOGICAL SURVEY OF INDIA have appeared with regularity at the established three-monthly intervals. In the series for the past year, besides the Annual Report of the Survey, papers, more or less in detail, have been given, treating of very varied subjects and localities. It would have been impracticable for a considerable time to come to publish a detailed account and map of the complicated structure of the hills flanking the great Himalayan range in the Punjab; and it seemed, therefore, desirable to give at once a brief outline and description showing the relations of the rocks and their general physical aspects and structure.

For this purpose, a section close to the most frequented station in those hills, Murree (Mari) was taken. Dr. W. Waagen has pointed out very clearly the distinctions of the beds, as indicated by their fossils. Such a sketch ought to suffice as an index or guide to other observers in the adjoining districts. Descriptions of the mineral contents of the gneiss in the district of South Mirzapúr are given by Mr. F. Mallet, who has pointed out the occurrence there of a very valuable deposit of Corundum, which is also of high interest from its associated minerals being identical with those occurring in America in the same association.

The sandstones of the Godávári are described by Mr. Blanford, while Mr. King, who took up Mr. Blanford's work there, describes in more detail the southern portions of this area near Kummummett, and shows the occurrence of coal there in quantities which will repay the expense of working when the field is rendered more accessible. Mr. Blanford also contributes two valuable sketches of the geological structure of the Beluchistán shores of the Persian Gulf, as well as a notice of Maskat and Massandim on the coast of Arabia. Mr. Medlicott describes in detail a very remarkable case of what appears to be only local jointing in some sandstones at Jabalpúr, and a careful discussion of the physical relations of the 'Lameta' group. Mr. Theobald has given a notice of petroleum localities in Pegu, and further discussion of the relations of the 'axial' group in Western Prome, while, in addition to these more local and limited notices, a general sketch of the geology of Orissa, and another of the geology of the Bombay Presidency, were also published—both drawn up by Mr. Blanford. This brief enumeration of the principal contents of the numbers will show how much has been done to elucidate the geological structure of the parts of India and adjoining countries in which the officers of the Survey have been engaged.

Of the MEMOIRS OF THE GEOLOGICAL SURVEY two volumes have appeared. It was stated in last report that these were well advanced. Both Vol. VIII and Vol. IX have been issued during the year just closed. In the first of these, Vol. VIII, in addition to brief accounts of three small, isolated, and unimportant coal-fields in Bengal, a long and detailed account is given of an immense area, nearly as large as England, to the north of Madras town, including the districts of Kurnool and Kuddapah, with maps and illustrations. Vol. IX includes a notice of the Peninsula of Kutch (Kach'h), a description of the geology of the vicinity of Nagpúr, a notice of the geology of Sirban hill near Abbottabád in Punjab, and a brief notice of the occurrence of Ammonites in beds, in the Salt-range, containing other fossils universally admitted hitherto as of carboniferous age. This last is one of the most striking discoveries which has marked the progress of Palæontology for many years. The occurrence of the Brachiopoda, *Athyris subtilita, A. Roissyi; Producta costata, P. longispina, P. Humboldtii,* in the same beds would at once be admitted as abundant evidence that those beds belonged to the true carboniferous group of Europe, but with them also occur *Strophalosia Morrisiana*, which would rather indicate a Permian age. There is, however, no question whatever that the association of fossils points conclusively to a Palæozoic epoch, whatever doubts there may be as to the exact horizon in the palæozoic series to which the beds may belong. Now, the occurrence of a true Ammonite in any of the palæozoic rocks is a fact altogether new to stratigraphical palæontology, and opens up a whole field of investigation of the highest interest. The examination in detail of the beautiful series of fossils obtained from the Salt-range has unfortunately been interrupted by the serious illness of Dr. Waagen, who has been obliged to proceed to Europe on medical certificate, but when completed, this collection will exhibit other novelties besides those already noticed.

Of the PALÆONTOLOGIA INDICA, during the year terminating on 31st December 1872, the portions descriptive of the cretaceous Brachiopoda and of the Ciliopoda have been issued. In the last reports we pointed out the rapid progress which had been made in this series, and showed that the rate of publication was limited chiefly by the amount of funds it was possible to devote to it. The question commended itself to the favorable consideration of the Government of India, and it is with pleasure I acknowledge the liberality which has doubled the sum granted for this valuable series from the commencement of the next financial year. Meanwhile efforts are being made to instruct the necessary artists, lithographers, &c., so as to be ready to take advantage of this. We had, during 1871, issued, as then stated, the portions of the work which represented the fasciculi due up to October 1872. The two parts since issued have been large ones, while the Echinodermata are printed off and only await the completion of the plates. There remain, therefore, the corals to complete the issue of all the groups of invertebrata represented in the cretaceous rocks of South India. These parts combined will form the fourth large volume of the Cretaceous fauna, and will complete the monograph of this very important group. It will form a monument of skill and labour reflecting the very highest credit on the Palæontologist of the Survey, Dr. Stoliczka, and will prove a very fitting description of one of the richest and most varied faunæ ever obtained from a limited area in a limited formation.

A fasciculus of the Cephalopoda of Kutch is ready for issue. This contains all the *Belemnites* and *Nautilidæ*. It was hoped that we should have been able to continue this series without interruption, the succeeding portion being very well advanced; but the illness of Dr. Waagen already alluded to has disappointed this expectation. The series of the Cephalopoda is very extensive, and will prove a contribution to the fossil history of the upper jurassic rocks of the very highest importance and value.

In addition to the regular issue of the *Palæontologia Indica*, some of the more remarkable forms met with in the Salt-range, as already noticed, have been figured in the Memoirs of the Survey.

MAPS.—Some of the sheets of the district of Dumoh, which had been taken up first for publication on the larger scale of our field maps, or 1 inch equal to 1 mile, are ready, and have been kept back until the whole district be completed, which will be very shortly now.

Of the 'Atlas of India' maps, which are to be used as the final record of our work, six quarter sheets were ready for issue to the public at the close of the year. Of these, the four quarter sheets of sheet 79, containing the larger portion of the Cretaceous area of Madras Presidency, were prepared some time since, but had not been issued, awaiting the completion of the adjoining parts. Two quarter sheets, north-east and south-east, of sheet 78 were printed during the year, and the parts of sheet 77 are now in the hands of the engravers. A small map is annexed showing the present state of the publication and preparation for publication of these final maps. These are now printed in colors with much success at the Surveyor General's Lithographic Office, and the general system having been established after several trials, the rate of issue can now be maintained with some regularity.

LIBRARY.—During the year, seven hundred and ninety-six volumes or parts of volumes have been added to the library of this department. Of this number 489 have been presented and 307 have been purchased. As usual, a list of Societies or Institutions from whom we have received such presentations or exchanges is annexed, while each successive number of the RECORDS has given a list of the additions received during the preceding three months. I rejoice to think that this department has been relieved from the injury resulting to its library from the restrictions imposed on the mode of procuring books, and from the delays consequent thereon. And I doubt not the coming year will again show a return to the larger number of volumes which we have been for years past in the habit of recording. Advantage has been taken of the past year to bring up the binding and securing of our valuable series so far as practicable.

MUSEUM.—The collections in the Museum have been maintained in good order, the additions properly embodied in the general series, and the specimens properly cleaned out and carefully labelled. The collection of minerals, which, as reported last year, had been entirely remodelled and added to so largely, has been in part carefully catalogued by Mr. F. R. Mallet, and it is hoped that this valuable work may be completed during the coming rainy season, when work in the field is impracticable.

The demand for the preparation of a good series illustrative of the mineral wealth of this country to be sent to the great Exhibition in Vienna has entailed on all the officers of the Survey a large amount of trouble and occupation during the last months of the year. The extremely limited and unsuitable accommodation which the present Museum house offered for such extended collections has always prevented our bringing together a collection properly representing the mineral resources of the country. In fact, we had no place to put such a collection if made. While, therefore, our series afforded good specimens in one or two directions, it was necessary to procure fresh and good sized specimens for Vienna. I would here acknowledge the great liberality and very cordial co-operation which I have experienced on the part of the numerous colliery proprietors in the country, who have supplied us with excellent specimens of the coals, ores, tools, &c., from their districts. I am also indebted to the Commissioner of Inland Customs for a very valuable series of specimens illustrative of the salt deposits of India. And in brief, from every one to whom we applied for aid, we have received most ready support. The time at our disposal was far too brief to admit of anything approaching to a complete series being obtained, but that which is to be sent will give a fair representation of the mineral wealth of the country. With the special sanction of the Government, it is proposed also to send some of our unique and valuable collections of fossils, which will excite great interest among the Geologists of Europe, and will afford a much desired opportunity for actual comparison and identification with known European forms.

An Index map is, as usual, appended showing the present state of progress of the field work of the Survey.

The various collections are in as good order and preservation as the limited accommodation at our command will permit.

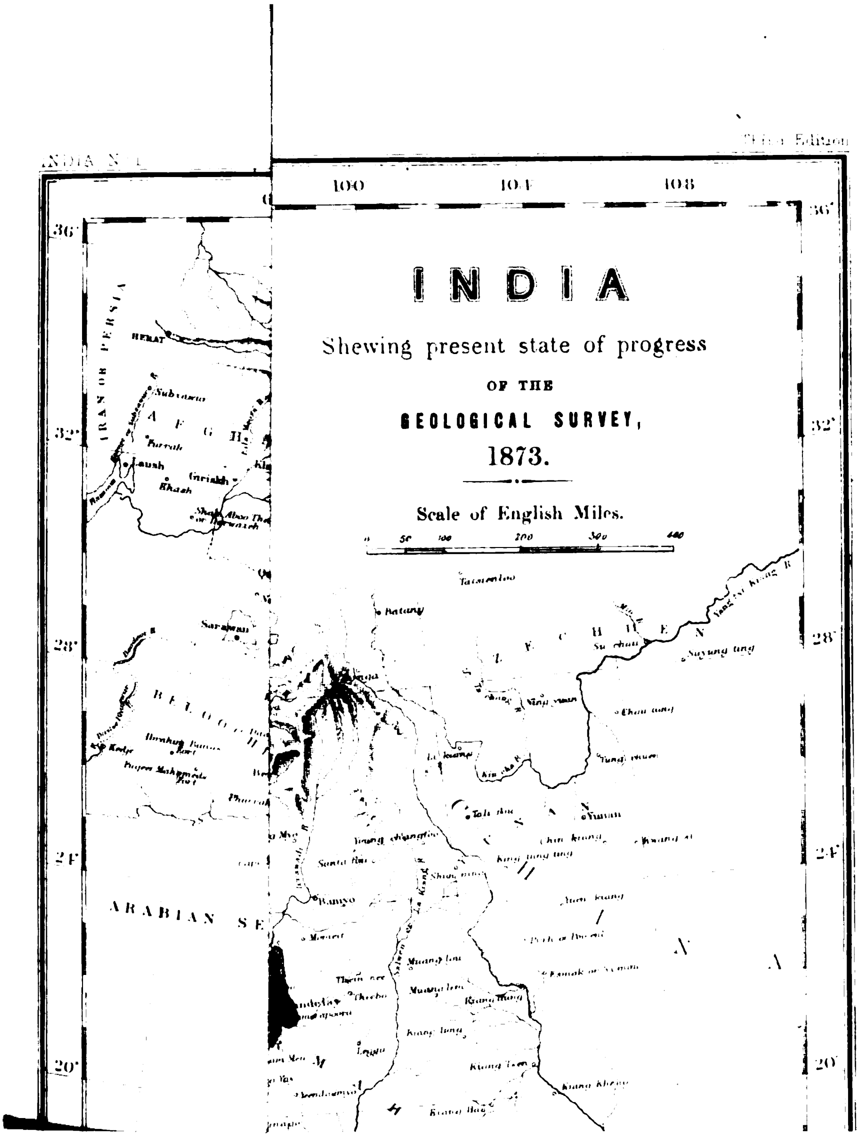
T. OLDHAM,
Supdt. of Geol. Survey, India,
and Director of Geol. Museum, Calcutta.

CALCUTTA,
February 1873.

***List of Societies and other Institutions, &c., from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year* 1872.**

BATAVIA.—Royal Society of Batavia.
BERLIN.—Royal Academy of Science.
DITTO.—Deutsche Geologische Gesellschaft.
BOSTON.—Society of Natural History.
BRESLAU.—Silesian Society.
CALCUTTA.—Asiatic Society of Bengal.
DITTO.—Agri-Horticultural Society.
CAMBRIDGE, MASS.—Museum of Comparative Zoology.
CHRISTIANIA.—Royal University of Christiania.
COLUMBUS.—Geological Survey of Ohio.
COPENHAGEN.—Danish Academy.
DEHRA DOON.—Trigonometrical Survey of India.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
DUBLIN.—Royal Dublin Society.
EDINBURGH.—Curators of the Signet Library.
FLORENCE.—Geological Commission of Italy.
GLASGOW.—Philosophical Society.
GÖTTINGEN.—The Society.
LAUSANNE.—Society of Natural Science.
LONDON.—Geological Survey of Great Britain.
DITTO.—Royal Society.
DITTO.—Royal Asiatic Society of Great Britain and Ireland.
DITTO.—Geological Society.
DITTO.—British Museum.
MONTREAL.—Geological Survey of Canada.
MÜNICH.—The Academy.
NEW HAVEN.—Connecticut Academy of Arts and Sciences.
NEW ZEALAND.—Geological Survey of New Zealand.
PARIS.—L'Administration des Mines.
PHILADELPHIA.—American Philosophical Society.
DITTO.—Franklin Institute.
DITTO.—Academy of Natural Sciences.
PORTLAND.—Society of Natural History.
ROORKEE.—Thomason College.
SALEM.—Essex Institute.
DITTO.—Peabody Academy of Science.
TURIN.—Academy of Turin.
VICTORIA.—Government Geological Survey of Victoria, Department of Mines.
VIENNA.—K. K. Geologische Reichsanstalt.
WASHINGTON.—Smithsonian Institute.
DITTO.—Department of Agriculture of the United States of America.
YORK.—Yorkshire Philosophical Society.

Governments of India, Bengal, North-Western Provinces, Punjab; Chief Commissioners of Mysore, Central Provinces, and British Burmah; Surveyor General, and Superintendent, Great Trigonometrical Survey of India.


INDIA
Shewing present state of progress
OF THE
GEOLOGICAL SURVEY,
1873.
Scale of English Miles.
100
104
108
36°
32°
28°
24°
20°
HERAT
ARABIAN SE

Sketch of the Geology of the North-West Provinces, *by* **H. B. Medlicott, M. A., F. G. S.,** *Deputy Superintendent, Geological Survey of India.*

The geology of the North-West Provinces is conveniently separable into three divisions, corresponding to three distinct geographical regions. Twenty-three of the thirty-five revenue-districts are entirely on the Gangetic plains. Three districts on the north—Dehra-Dún, Garhwál, and Kumáon—belong altogether to the Himalayan region. Out of nine districts on the south, seven are in very large proportion covered by the plains-deposits; three only being in whole or in great part within the rock-area of the Peninsula of Hindustan. It is at once apparent that these geographical divisions are also strictly geological; and it may be here stated that no identification has as yet been made out between the rocks within these provinces on the north and on the south of the plains. The formations of these several regions may be noticed in the following order:—

I.—*The Plains.*—Terms applicable to these deposits. Bhángar and Khádar lands. Whether the great rivers are raising or lowering their Khádars. Bhábar and Tarai land. Age of the Bhángar land. Kalar lands.

II.—*The Himalayan region.*—Physical and geological divisions. The Sub-Himalayan series: Sabáthu group; Náhan group; Sivâlik group. The limestone and slate series: The Krol, Infra-Krol, Blini, and Infra-Blini groups. The metamorphic series.

III.—*The Peninsular region.*—The coal-bearing series: Barakár and Talchír groups. The Vindhyan series: its characters: its distribution. The slate series. The schist and gneiss series.

I.—The Plains.

Terms applicable to these deposits.—The middle region naturally claims first attention. It is often spoken of as 'the alluvial plains of the Ganges,' or by such like expressions. In a general sense these terms are admissible: there is no doubt that the materials forming the plains were contributed by the Ganges and by its tributaries. But in this range of meaning the Sivâlik deposits might claim to be included; for it has been shown that their materials, too, were conveyed through the existing Himalayan drainage system. On the other hand, by confining the word 'alluvium' to its strict geological meaning—to ground subject to flooding from the very channels that now exist—the alluvial ground of the North-West Provinces becomes comparatively small. It is necessary to specify still further to bring out the distinction to be made in the area under notice: the word 'alluvium' is scarcely understood unless as applied to fine deposits from tranquil inundation; and it applies to such indiscriminately; whereas from the proper geological point of view, the distinction to be indicated is what ground is undergoing increase from whatever form of deposition, and, on what ground abrasion (denudation) is in permanent action; or, in other words, where river action is formative and where it is destructive.

Bhángar and Khádar lands.—A large proportion of the plains-area in these provinces is permanently undergoing denudation. The main rivers run through it in confined and fixed valleys, the flood-level of the waters being well below the general level of the country. Several considerable streams, as the Hindan, take their rise within this area; and though subject to local overflow, with deposition of alluvium, they must, on the whole, carry away annually a large quantity of earth. The fixed valleys of the great rivers are of very variable width, generally bounded by steep high banks; they are called *Khádar*, the adjoining high land being known as *Bhángar*. The deep, low-water, channel of the river oscillates within the *Khádar*, or river-plain; the whole of this being liable to inundation from the floods, and to constant erosion and re-formation by the action of the current. *Khádar-mati* is very nearly the native equivalent for 'alluvial land.' But though there is always a large total area of true alluvial land in the *Khádars* of the great rivers, it is possible that, on the whole, these *Khádars* are undergoing denudation, that the river-bed is deepening, and that the new alluvial land formed by its changes of position may be progressively lower than the older patches removed by the same process. It has not yet been defined how much, or if any portion, of the eastern districts come within the sub-deltaic conditions that prevail in the Lower Provinces, where the river-action is broadly formative. The whole of the province of Oude would come under one or other of these descriptive terms—*Bhángar* or *Khádar* land.

Whether the great rivers are raising or lowering their Khádars.—The question whether the great rivers have at present a tendency to deepen or to raise their channels is one of much importance in relation to engineering works, and of great interest to the geologist. Within deltaic regions, where the rivers are essentially formative, the process is sufficiently understood: the bed and banks of the main channel are raised, till the contrast of level determines a gradual set of the water to lower ground through some minor distributary; the new channel is at first scoured out to the capacity of the main channel, when the raising action recommences. Within the narrow river-plain of the *Khádar*, there might be no general feature to betray which process is in force. The river would oscillate pretty much alike in either case, removing and replacing the patches of alluvial land. Still it seems likely that careful enquiry among the natives cultivating the *Khádars* would elicit some grounds for judgment: as, if any very old patches of alluvium were no longer inundated by the highest flood, one might infer that the river had lowered its channel. The *á priori* conditions may be stated briefly thus: Whether a river is cutting or depositing depends, of course, upon its velocity and upon the charge of solid matter, wholly or partially suspended in it. As regards the first condition, it can be broadly stated that the slope (and hence the velocity) within the *Khádars* is everywhere much above that at which silt-carrying rivers become on a large scale depositing rivers: at Kánhpúr the fall is nineteen inches per mile, at Alláhábád thirteen; while in the sub-deltaic region at Pátna and Rájmáhál it is only six inches; and in the Delta proper it lowers to three inches.* It is moreover certain that for eight or nine months of the year, the great rivers rush from their gorges in the mountains as torrents of clear water, or only, in the hot months, discoloured by fine glacial mud; immediately upon entering the *Khádar*, however, the water becomes more or less charged with silt and continues so throughout its course. For these months then the river must be denuding its channel. During the flood season, on the contrary, the water issuing from the mountains is highly charged with detritus; which is, to some extent at least, gradually deposited as the slope of the channel becomes lowered in the *Khádar*. It would be difficult to conjecture to what distances within the plains coarse shingle and gravel might be rolled along by the scour of the current in extreme floods during successive seasons. Large stones not being found in the bed of the river in the dry season may not be a safe indication of the case; as it is conceivable that they should always be buried under lighter deposits as the flood subsided. Whether or not the rivers are able, even with the assistance of the clear water for eight months of the year, to carry out of the *Khádar* all that they carry into it in the flood season, cannot be determined without careful observation; but from all the considerations mentioned, it would seem likely that throughout the greater part of the *Khádar* the balance is in favor of erosion. Any tendency of the Ganges and Jamna to lower or to raise their bed at the mouth of their gorges ought to be discoverable from the effect on the canal-heads at Hardwár and Fyzábád.

* These figures are quoted from Mr. Fergusson's paper in the Quart. Jour. Geol. Soc., Lond., Vol. XIX, 1863.

Continued observations on the silt in the water, uniformly conducted at distant places, as at Fatehgarh, Kanhpúr, and Alláhábád, might indicate whether erosion or deposition is taking place within the Khádar region. But the most satisfactory test would be, continued registration of the rise and fall of the water on permanently fixed gauges, to be checked by an annual exact measurement of the low-water river-section at each gauge.

Bhábar and Tarai land.—Independently of such tracts on the eastern borders of the province as come within the sub-deltaic region of the great rivers, there is a considerable stretch of country where the drainage is formative. The minor streams from the outer skirts of the mountains do not run on into the plains in deep channels cut through deposits of earlier times; they flow, at least for many miles, in broad shallow and ever-shifting beds formed of materials brought down by themselves. The load of shingle, gravel, sand, and earth washed into these torrents by the heavy rainfall from the precipitous slopes of the Siválik hills, formed of soft conglomerates, sandstones, and clays, is far more than the current can carry into the main rivers. It is possible, too, as has just been discussed, that something of the same kind takes place in the upper reaches of these rivers themselves. There is thus, along the northern margin of the plains, a broad belt of ground the formation of which is strictly 'recent.' The portion of it next the hills, having a steeper slope than the rest, is chiefly composed of shingle and gravel with a filling in of sand and earth. This is the forest-bearing zone known as the *bhábar*. Except in the rainy season, it is devoid of water; streams of considerable volume soon sinking into the porous ground, to reappear (at least in part) along the lower fringe of the coarse deposits. This second zone, though having, on the whole, a considerable slope, greater than the general slope of the plains, is thus made watery and swampy; it is well known as the *tarai*. West of the Ganges this formative process is specially active owing to the greater development here of the soft Upper Siválik rocks, which are the most abundant source of detritus. Some years ago, excavations in connection with the Eastern Jamna Canal brought to light the ruins of an ancient town. The tarai in the Jamna-Ganges *Doab* is scarcely a noticeable feature, owing probably to the good natural drainage; the watershed being here 400 feet above the Ganges at Hardwár. Eastwards from the Ganges the *tarai* becomes more and more distinct. In the same direction remnants of an ancient *bhábar* deposit become frequent and of increasing elevation, till in the far east, at the base of the Sikim Himalaya, they stand at 1,000 feet over the actual torrents. To the south of the plains some analogous cases of recent deposits may be found, but they are altogether insignificant; the larger rivers there also running in channels which they do not overflow to any extent.

The phenomena under notice have been only incidentally examined, so that the sketch here given is very incomplete and open to correction.

Age of the bhángar land.—It having been shown that the great mass of the plains-deposits belongs to a bygone period of formation, it devolves upon the geologist to ascertain the age and nature of the process. Very little progress has as yet been made to that end; the systematic study of the question not having been taken up. Some have maintained that the deposits are marine or estuarine; others, as seems most likely, that they are, at least to any observed depth, purely fluviatile, by a process like what is now going on in the Bengal Provinces. No trace of marine organisms has been found in them. But some bones of terrestrial mammalia were got in a hard bed of calcareous gravel in the bed of the Jamna near Etáwá; and which seem to belong to species or varieties now extinct; so that those deposits will probably take rank among the later Tertiaries. From observations made in sinking wells along the line of railway, one of the engineers has stated the general section of the Ganges-Jamna Doab south of Aligarh to be—loam 35 feet, blue silt 30 feet, strong lay 20 feet, resting on a water-bed of reddish sand, from which the water rises some 30 feet.

The bed of clay slopes from north to south at about two feet in the mile, the surface sloping about eighteen inches in the mile. The water obtained from the blue silt is always more or less saline. The only deep section of the plains-deposits is from the boring for an artesian well at Ambála. This position, a little to the west of the Ganges-Indus watershed, is on the zone of recent deposits; the river channels are all superficial, and become lost in the desert country to the south. There is nothing in the section of the boring to mark a change from these surface deposits to others of an older period. None could, indeed, have been expected, as it is only on an extended horizontal section that a plain of denudation, such as that of the present Ganges-Jamna Doab, could be detected between any older beds and perfectly similar materials recently overlaid upon them. There is moreover no presumption that any such break exists in the plains-deposits west of the main watershed, or at least at that watershed. A single boring, too, can tell little or nothing of the arrangement of the strata. The depth reached was 455 feet, or 450 feet above the sea-level. Frequent alternations of clay and sand were passed through. At 286 to 296, and 400 to 417 feet, coarse gravel and large stones were found; strong beds of clay occurring again beneath.

Kalar-lands.—The presence of alkaline salts to a very deleterious extent in the subsurface water, and their appearance as an efflorescence in many parts of the country, has been an object of anxious enquiry in Upper India for many years back; especially as it seems on the increase, and most so in connection with irrigation. The efflorescence consists principally of sulphate, carbonate and chloride of sodium; more rarely nitrate; and occasionally with potassium as base. The crude salt with its earthy admixture is called *Kalar* (Kullur). The cultivators also speak of it as *úsar* and *reh*. But the former word is said properly to mean negatively sterile soil; and *reh* is said to be properly applied to the carbonate of sodium (or natron). Several conjectures have been made as to the origin of the *Kalar*: 1, that it is an aboriginal ingredient of the soil; 2, that it is continually being elaborated from the soil by the action of water; 3, that it is brought up by water from saline deposits at some depth from the surface; 4, that it is very largely and to an indefinite degree due to accumulation by evaporation from lodgement of inundation waters. It is not likely that any of these is the exclusive cause; and it is most important to determine in what degree each of them may operate, with a view to determining the remedy to be applied in each case. The third supposition, which would be the most unfavorable of all, may be set aside. There are some spots on the plains of Upper India, as at Bhartpúr, where deep brine-wells are worked; but the ground near them is not *Kalar*-land; and, on the other hand, throughout the tracts of Kalar-land the water of the deep wells is sweet, holding as little as, or even less saline matter than, the water of the great rivers. It is of course known that the *Kalar* salts are in the main the product of the decomposition of silicious minerals by atmospheric and other surface conditions. But the ingredients of alluvial deposits are entirely made up of mineral detritus that has already undergone the principal phase of this soil-producing action; and its further decomposition would be very slow indeed. Whatever opinion may be maintained regarding very ancient *Kalar*-land, all the evidence upon the recent formation of these salts goes to prove that it is due to accumulation by evaporation in water-logged land; and it is a necessary corollary from this that water-logging from river or canal inundation must immensely increase the rapidity of its growth. Flooding from rain would be limited to the salt-resources of the ground affected, or of such local drainage as it received; whereas river or canal inundation would be an inexhaustible source of importation of these salts. Various remedies have been suggested for this most serious evil: the cultivation of plants, such as the barilla plant, which assimilates a large amount of some of these salts; the application of suitable mineral manures, so as to facilitate the utilization of these salts by ordinary crops; the application of efficient drainage. If one had only a definite amount of Kalar to deal with, as would be the case supposing it to be of purely local origin, the application of the first two methods might be sufficient. But with an inexhaustible and ever renewed source of the salt, such as is supplied by river and canal water (both being drainage water), it seems evident that efficient drainage is the only sufficient remedy.

II.—The Himalayan region.

Physical and Geological divisions.—In Kumáon and Garhwál the boundary of the Province extends up to the great snowy range, the frontier of Tibet. West of the Ganges, the District of Dehra-Dún (including Jaonsár) comprises only a small portion of the Lower Himalaya. The mountain-area presents three well-marked physical zones. There is a narrow fringe of low hills, which, from their analogy to similar ridges in other countries named after the range to which they are subordinate, have been called the Sub-Himalayan range. North of these the mountains rise abruptly to an elevation of 6,000 to 7,000 feet; and from here there is a broad belt, some fifty miles wide, of ridges having this elevation, or but very little over it, up to the base of the great snowy range. This middle zone has been designated the Lower Himalayan region. The geology of the hills has as yet been only cursorily examined. The rocks that appear within the limits of this province may be noticed under three heads: 1st, the Sub-Himalayan series, corresponding in distribution, at least in its upper groups, with the lower hills designated by that name; 2nd, a limestone and slate series, occurring very constantly in a belt of varying width along the margin of the Lower Himalayas, as at Naini Tál; and 3rd, a metamorphic series with granitic protrusions, forming the rest of the Lower Himalayan region, and also the line of snowy peaks; close upon the northern flanks of which, beyond the frontier, there rest the Palæozoic and Secondary rocks of Tibet.

The Sub-Himalayan Series.—The youngest of these divisions, the Sub-Himalayan series, includes a wide range of the Tertiary period; from the nummulitics up to the Miocene Sivaliks; and these are closely connected with the Pliocene deposits of the plains. In this series three well marked physical stages have been described. In point of elevation the order of sequence of these has been reversed—the oldest being highest and the youngest lowest, in their respective zones. This has not taken place by inversion; nor yet (it has been argued) by upheaval in steps, through faulting. Appearances are best explained by the supposition, that during successive periods of elevation an irregular scarped line of erosion was weathered out along the newly raised strata (like the present cliffed face of the Sivalik hills); and that against this, as boundary, the newer groups of deposits were accumulated, just as we see the *bhábur* slopes of the present day. As would result from such a process, the oldest group has been most elevated and longest exposed, and so has suffered most from denudation. Only remnants of it are left along the margin and on the flanks of the higher hills.

The Subáthu group.—The typical area in which all the sub-divisions of the lowest group are seen lies out of the North-West Provinces, to west of the Jamna. The hill stations of Kusaoli, Dagshai, and Subáthu are on these rocks, which take their name from the last of these places. The base of the group consists of brown clays with limestones and fine sandstones, passing up into thick red clays and strong sandstones. The age of the lower portion is well characterized by abundant *nummulitic* fossils. Only a very small remnant of these beds has yet been observed in these provinces. It occurs on a gap of the ridge bounding the Eastern Dún, close above Rikikés, and just north of the village of Bone. The hills of Kumáon and Garhwál have been only cursorily examined, and other outliers of this group may yet be found.

The Náhan group.—The middle group of the series is largely developed in the hills immediately at the base of the mountain range, as spurs of which they might be hastily described; but their distinctness as a range is well marked by a line of low gaps and open longitudinal valleys along the geological boundary, the drainage passing through the range by narrow transverse gorges. These features may be well seen along the Western Dún under Masúri. In the Eastern Dún, from Rajpúr to the Ganges, this flanking range has been removed; but east of the Ganges it appears again in great force, continuing so up to the Nepal frontier. The strata are well exposed along both roads up to Naini Tál. They consist principally of massive gray sandstone (very like the molasse of Switzerland), with subordinate bands of clay. The small nests of lignite found at many places in the sandstone have more than once given rise to exaggerated hopes, and even to confident statements, as to the existence of coal. The fine hæmatite iron-ore of Dechouri near Kálidúngi is only a local concentration of the iron oxide which occurs so freely disseminated as an ingredient of the clays. This middle member of the series has been called the Náhan group, from the chief town of Sirmúr.

The Sivalik group.—The youngest member of the Sub-Himalayan series is the Sivalik group, so called from the name given to the outermost range of hills by Colonel Sir Proby Cautley, who found in those rocks the splendid collection of vertebrate fossils, partially described by Dr. H. Falconer in the Fauna Sivalensis. These hills are much lower than those of the middle group, from which they are generally separated by the broad longitudinal valleys known as the *dúns;* which are structural features, not mere valleys of denudation. The form of disturbance of the strata is very regular: broad 'normal' anticlinal flexures, the axis-plane sloping towards the mountains. The Sivalik hills have been weathered out along the axis of the flexures; and the *dúns* lie on the flat northern slope. The original 'Sivalik Hills' are that well-defined portion of the range between the Ganges and the Jamna separating the Dehra-Dún from the plains. From a short distance east of the Ganges the range is broken and scarcely recognisable, having probably been denuded off and covered up, if indeed it had ever been so prominent as to the west. The *bhábar* deposits here often reach up to the base of the inner range of the middle group of rocks. The Pátli Dún is an irregular valley of denudation in these hills of the Náhan group. The lower part of the Sivalik group is very like the Náhan group in composition, save that the sandstone is softer and fresher. At top there is a great thickness of conglomerate, both earthy and sandy. The physical separation between the Sivalik and the Náhan group has recently been clearly made out; but the distinction was unfortunately not observed in the collection or the description of the great series of fossils formerly procured from this region. The vast majority, if not all, of the large mammalian remains were obtained from the younger group; some vertebrate fossils were found in the Náhan rocks, but they were in great part lost or were mixed with those from the Sivaliks: a very interesting point—the comparison of the two faunas—was thus missed.

The limestone and slate series.—The second rock-system to be noticed consists of an unknown thickness of slates, limestones, and sandstones, forming the first range of the mountains from end to end. The stations of Chakráta, Masúri, and Naini Tál are on those rocks. The strata are greatly contorted, although preserving a strike approximately parallel to the mountain range; and the relations of the several bands of rock can now be only vaguely suggested. From the more regular sections in the hills west of the Jamna the series has been roughly divided, in descending order, into—The Krol limestone; the Infra-Krol slaty shale (often carbonaceous); the Blini limestone and conglomerate; the Infra-Blini slates. It is the Krol limestone that determines the picturesque outline of the outer ranges, as at Naini Tál, compared with that of the great mass of the Lower Himalayan region. The Blini limestone has also been traced eastward, along the outer flanks of the mountains, to as far as under Naini Tál. The Krol group has been asserted to be of triassic age; but the only fossils certainly known to have been procured from these rocks within these provinces were some indeterminate casts of bivalves from a band of limestone in the gorge of the Tál river, at the east end of the Dehra-Dún. The lead-mines of Sirmúr and those near Subáthu are in this series of rocks. Trappean intrusions occur at many places in them.

The metamorphic series.—At many places, as on the Simla section, there is a complete transition from the slate series into the crystalline schist series, through a graduated metamorphism. Elsewhere the passage is abrupt, as in the valley north of Naini Tál, where the junction is complicated by profuse trappean intrusion. The great mass of the lower Himalayan region, and also of the snowy range, is composed of crystalline schists, gneiss, and granite. There is a large mass of intrusive granite near Almora. Copper ores occur at many places, and are worked by the natives. They have not been favorably reported on by European mineral-viewers. There are also many fine bands of rich iron ore; but the inaccessibility of the ground prevents their being extensively used. Impure graphite is found in several places.

III.—The Peninsular region.

Although the rock-area south of the plains and within the North-Western Provinces is very small, it forms an extended line; and thus it includes representatives of the principal rock-series of Hindustan, excepting only the Deccan trap formation and the cretaceous rocks below it. There are thus to be noticed—

The coal-bearing series.
The Vindhyan series.
The slate series.
The schist and gneiss series.

The coal-bearing series.—The great plant-bearing series of rocks, so widely scattered over India, has been divided in different basins into a number of well-marked groups. But the characters of many of those sub-divisions, or their equivalence in time, do not exactly correspond from one basin to another, so that it is impossible as yet to adopt a scale of groups applicable throughout. The two bottom groups of the series are the most widely distributed and the most constant in character. The Talchírs, the lowest group, is of special interest as exhibiting undoubted glacial action in very ancient rocks (probably Palæozoic), and in what is now an intertropical latitude. The most characteristic bed of this group is a fine greenish-gray silt, in which there frequently occur huge boulders of rock, sometimes rounded, and sometimes, in the same spot, quite angular, occasionally polished and deeply grooved by friction; just as is at present only known to occur in glacial deposits. It is not possible at present to conjecture to what conditions—whether to great elevation, or to change of climate from cosmical causes—these phenomena were due. In most of the fields throughout India the coal-measures are confined to the Barakár group, which is largely made up of coarse felspathic sandstones.

In British Singrowli, the southern extremity of the Mirzapúr District, there are about forty square miles of the Talchír group exposed; and about twenty more overlaid by the Barakárs. From the Kota mine in Singrowli all the coal was procured, which used in old times to be carried on pack-bullocks for forty miles, across the Vindhyan plateau, to Mirzapúr, for the steamers on the Ganges. The sandstone forming the small plateau over the coal-measures at Kota probably belongs to one of the upper groups of the series. This is the only patch of this series of rocks within the North-Western Provinces. It is the eastern extremity of the great central basin of South Ríwah.

The Vindhyan series: its characters.—The base of the plant-bearing series is separated all over India by total unconformity, involving a great break in time, from the next preceding formation, which is known as the Vindhyan series. The precise range of this series has not yet been fixed. The rocks to which the name was first given, or rather adopted from the old geographical name, are the strong fine sandstones forming a very long range of cliffs along the north side of the Narbadá valley from Hosungabad to Jabalpúr, and continuous thence along the north of the Sôn valley to Sasseram in Behar. As the sandstones recede from this line of cliffs, they become steadily split up by thick bands of shales, with limestones, and so necessitating a division into three principal groups, as Bhanrer, Ríwah, and Kaimur, forming the original Vindhyan series. In the Sôn valley the sandstone cliff is weathered back to the north of its line in the Narbadá country; thus exposing older beds, underlying the Kaimur sandstone. These consist of limestones, fine flaggy sandstones and shales, with strong bands of very peculiar porcellanic and trappoid beds; the whole forming a series of local groups. Beds of exactly the same description as those of the Són Valley appear again along the north edge of the Vindhyan basin; and here also they stop out against the gneissic rocks of lower Bandélkand, and so are entirely overlapped by the Kaimur sandstone. They were here first described as the Semri series, but are now properly merged in the Sôn series. As these strata present throughout steady parallelism with the Vindhyan beds above them, both occupying the same basin, being alike affected by local disturbance, and alike free from any symptoms of metamorphism (except the conversion of the sandstone into quartzite in certain positions of disturbance), the name Vindhyan has been extended to the whole series, with only the distinction of Upper for all the original Vindhyans and of Lower for the Sôn series. On the north side of the gneissic area of lower Bandelkand, about Gwalior, there is a group of rocks resting, just as the upper Vindhyans themselves do, upon an old surface of the gneiss; they have scarcely undergone any more disturbance or metamorphism than the Vindhyans; but the Kaimur conglomerate rests unconformably upon an ancient surface of erosion of these rocks, and is largely made up of their débris. There is, however, at least one marked character common to the Gwaliors and the lower Vindhyans—the peculiar porcellanic and porphyritoid beds occur in both; and it would be by no means improbable to suppose that the two are in part cotemporaneous deposits. There are also marked differences between them; the Gwaliors are highly ferruginous and include some strong sheets of cotemporaneous basic trap. These new characters, on the other hand, suggest another link in the descending series of formations: recrossing the same gneiss, to the south, we find in the Bijáwar country a new group of rocks, still again resting flatly upon an eroded surface of the gneiss, only partially disturbed and showing only incipient metamorphism, but upon which the original lower Vindhyans rest unconformably. Cotemporaneous trap and highly ferruginous deposits are marked features of this Bijawar group; and it would not be extravagant to assume that it is, in part, cotemporaneous with the Gwalior group. Again, in the Són Valley, the lower Vindhyans rest with extreme unconformity upon beds that have been thought to represent those of Bijáwar, and which have become highly metamorphic and associated with gneissic rocks. We thus finally arrive at the suggestion of a younger and an older gneissic series; without finding, below the Vindhyans proper, a clearly marked physical break applicable generally over even so small a geological field as the Indian Peninsula.

The stratigraphical difficulties observed in the preceding paragraph might be removed by the aid of fossils; but to the great disappointment of geologists in India, the Vindhyans have as yet yielded no organic remains, although the undisturbed and unaltered strata composing them, often covered with fine ripple marking, continually tempt one with the hope of successful search. Some forms supposed to be corals were found by Mr. Hacket in a limestone of the Gwalior series.

Besides producing in abundance building stone of first rate quality and limestone, the Vindhyans are only remarkable as containing diamonds. The mines near Pannáh are now more worked than any others in India. The gem is, of course, found in the diluvial deposits; but the diggings most prized are in the Riwah group of the Vindhyan series. Although, however, this group has a very wide range, diamonds are not known to occur in it beyond a very limited tract in the State of Pannah. This fact and other observations have suggested that the diamond was not originally formed in the Riwah group; but rather in some peculiar contact-rocks at the base of the lower Vindhyan, or Sôn, series, and well exposed in the sections close to the north of Pannah.

Its distribution.—The Karamnásá, forming the eastern boundary of the North-Western Provinces, flows from the eastern extremity of the Vindhyan plateau. From here to Futehpúr Sikri (which stands upon a ridge of Bhanrer sandstone), south of Agra, the north scarp of the Vindhyans corresponds approximately with the south boundary of the provinces; the native states of lower Bandelkund being intricately interwoven with the districts of Banda, Lalatpúr, and Jhansi. Only, on the east, the Mirzapúr district stretches southward across the Vindhyan plateau, here formed of the Kaimur group, and across the Sôn valley, where there is a full section of the lower Vindhyan, or Sôn, series. The northern outcrop of this same series is exposed in the Banda district, about Kirwi. The Gwalior series just touches the border of the province in the Etáwah district.

The slate series.—In discussing the range of the Vindhyan series, the Bijáwar formation was mentioned as showing incipient metamorphic action. It is made up of hornstone-breccias, quartzite-sandstone, cherty limestones, ferruginous sub-schistose slaty shales, and thick sheets of basic trap-rock. The districts of Banda and Lalatpúr just touch upon the original area of these rocks in Bijáwar. In the Mirzapúr district, in the hills south of the Sôn, similar rocks occur, in a state of high contortion, and connected on the south with a broad band of clay-slates, which are in turn intimately associated with crystalline schists and gneiss.

The schist and gneiss series.—The wide bay formed by the Vindhyan scarp between Gwalior on the north-west and Kirwi on the south-east is occupied by highly metamorphic rocks,—coarse porphyritoid gneiss and crystalline schists. In the districts of Jhansi and Lalatpúr these rocks appear freely; but to the north-east, in the districts of Jaloun, Hamirpúr, and Banda, outcrops become more and more scarce as the rock disappears under the plains deposits. The strike of the foliation and of the bedding, where observable, is generally east and west. Greenstone dykes are very abundant, with a prevailing north-west-south-east direction. None of these dykes pass into any of the overlying sedimentary rocks, and are therefore presumably of older date. The most striking feature of this area is the prevalence of great quartz-reefs, standing up in great wall-like ridges, sometimes more than three hundred feet high, many yards wide, and running quite straight for several miles continuously, or with intervals appearing again on the same strike. They have a prevailing north-easterly run, but exceptions are frequent. These also are certainly older than the Bijáwar formation, and also apparently older than the trap dykes. It has been thought that gold should be found in or about these great quartz-reefs; but there is no trace or tradition of its occurrence. According to some theories, this would be accounted for by the extreme antiquity of these reefs and of the enclosing gneiss.

The gneiss at the southern point of the Mirzapúr district in Singrowli belongs to the great metamorphic area of Behar and Bengal. Here also massive porphyritic and granitoid gneiss is the predominant rock, with subordinate bands of hornblende schist. There is a strong band of fine Corundum in it near the village of Pipra. Bands of crystalline dolomite and limestone are also frequent in this gneiss; whereas none whatever has been observed in the gneiss of Bandelkund.

H. B. MEDLICOTT.

September 1872.

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January 10th, 1872.


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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] **1873.** **[May.**

The Bisrámpúr Coal-field, *by* V. Ball, M. A., *Geological Survey of India.*

Name. *Position and boundaries.*

The above name being that of the capital town has been given to an area of coal-measure rocks which is situated in the eastern portion of the comparatively low-lying ground of Central Sirgújá. On the north and east the limits of the original basin of deposit are defined by, in the former case, a ridge of low hills composed of metamorphic rocks, and in the latter by the flanks of a plateau formed of the same rocks. This plateau rises from 1,000 to 1,800 feet above the generally elevated country of Western Chota Nágpúr; thus forming a step or barrier between Lohardugga and Central Sirgújá.

In some cases the ancient valleys and indentations in these bounding walls of the basin are occupied by prolongations from the rocks of the Tálchír formation, which, as they crop out on all sides, probably underlie the coal measures throughout. Instances occur, notably one, where spurs from the metamorphics penetrate into the area now occupied by the coal measures. With these exceptions the latter lie within well defined boundaries, which, to a comparatively small extent only, have been affected by faults. On the south and west the case is very different. The original boundaries of the coal measures are far removed from the present limits; and broken and semi-detached extensions of the sedimentary rocks, especially the Tálchírs, connect the Bisrámpúr field with other coal-fields, which, however, for all practical purposes are, and for purposes of description may be, most conveniently regarded as distinct.

Area.

The coal measures whose limits have been thus defined occupy an area of about 400 square miles, throughout which, except in the river beds or their immediate neighbourhood and on a few small hills, no rocks are exposed: a considerable covering of alluvium concealing all. To such an extent is this the case that a traveller might pass over the Bisrámpúr and Partábpúr road for twenty-two miles without seeing a single outcrop of Barákars, save at two or three of the river crossings.

Drainage.

The level of this area falls gradually from south to north, Bisrámpúr at the south-east corner being 1,943 and Kíunrá on the northern boundary 1,747 feet above the sea level.

The drainage of the eastern three-fourths of the field is effected by the Máhán river and its tributaries. The waters of the remainder are carried directly into the Rehr by the Pasáng and other smaller tributaries. The Máhán itself joins the Rehr at a point a few miles to the north-west of the field, in its course traversing a channel deeply cut in the above mentioned barrier of metamorphic rocks which bounds the field on the north. This fact, if others were wanting, affords evidence of the immense denudation which has taken place. But in the isolated Pilká hill, formed of the upper sandstones which rest on the southern boundary of the field, there is a remnant

Denudation.

of the rocks, which, with a covering of trap, filled up the basins and valleys existing in the ancient metamorphic area. Thus, we can see what were the conditions which gave the river a fall from above, sufficient to enable it in the long lapse of time to cut down through what, under other circumstances, would have been an insurmountable obstacle to the formation of a drainage outlet for this area on the north.

Under somewhat similar conditions, two other considerable rivers, the Kunhur and Rehr, have cut gorges for themselves, through which they are gradually removing away all traces of those rocks whose former presence enabled them to force their way to the Sone.

Thus the valleys and basins are being sculptured and cleared out anew, the sedimentary rocks broken up into detached areas, and the basal metamorphics gradually re-exposed to the direct action of denudation.

Previous observers.

Previous to the first visit of the Geological Survey, the information regarding the existence of coal measures in Sirgújá was of a somewhat hazy character, being chiefly confined to brief notices by the district officers, who in their tours had seen or heard of the existence of coal seams.

Colonel Ouseley, J. A. S. B., XVII, 1848, p. 65.

In a paper on the antiquities of Sirgújá, Colonel Ouseley mentions the occurrence of coal, iron, gold, ochre, marble and lime in that district.

Greenough, Brit. Ass. Report for 1854, and map.

In Mr. Greenough's map the Damúda valley coal measures are connected with those of Sirgújá and the Hutso valley. The incorrectness of this was pointed out in the Report of the Committee on Mr. Greenough's map, appointed by the Asiatic Society in 1866. *Vide* J. A. S. B., XXV, p. 425.

Colonel Haughton, J. A. S. B., 1854, p. 105.

Colonel Haughton states "the Gangpúr coal formation is probably connected with that of Sirgújá and Palamow; but on this point I have no reliable data."

Colonel Dalton, J. A. S. B., XXXIV, pt. II, No. 1, 1865.

Colonel Dalton alludes to the occurrence of coal in parts of Sirgújá.

Topographical Survey Maps, 1867-68.

Localities for coal are given on the 1-inch maps constructed under the superintendence of Major Depree and Captain Sale. Reference will be made to these localities in the following pages.

I.—General Geology.

The sedimentary rocks of this area are referable to three formations, *viz.* :—

Tálchír series.

Damúdá series (Barákar group).

Upper sandstones (= Máhádevás?)

Tálchírs.

As to the maximum thickness of the Tálchírs, there are no sections sufficiently definite to enable us to determine its amount with certainty; but in no part of the field where the rocks of this formation are exposed do they reach 200 feet. In the clearest section in the area—in the Goinghatta—the same beds roll over and over and it is impossible to measure them. Outside what we have adopted as the limits of the present description, there may be a much greater thickness, and in one section underneath the Máin pât, they certainly do exceed 200 feet.

Barákars.

Similarly with the Barákars, though occupying a considerable area, there is no tilting or disturbance of the beds for any continuous distance, the consequence being that no measurements can be made which are of the least value for determining the thickness. The prevalence of sandstones to the almost total exclusion of the other rocks which go to make up the Barákar group in the eastern coal-fields renders it impossible to identify individual beds in sections at any distance from one another. And the coal seams are far too irregular and variable in thickness to be of much use for this purpose.

From the general horizontality of the beds, from the character of the basin in which they lie, and the outcropping of the Tálchírs on all sides, it is evident that, as compared with the eastern fields, the thickness must be inconsiderable, and I find it difficult to bring myself to believe that it anywhere amounts to even as much as 500 feet.

Upper sandstones.

With the upper sandstones it is less difficult to assign a definite thickness, though it be a minimum one. The horizontal beds which form the Pilká hill are about 1,000 feet thick.

II.—Tálchírs.

Extent of Tálchírs.

The natural geological boundaries of the Bisrámpúr coal measures include an area sufficiently limited and compact for convenient description; but such is not the case with respect to the underlying Tálchírs. Were the usual practice—one very well suited to the Tálchírs underlying the coal measures of the eastern basins—of following out the rocks to their extremest limits adopted in Western Chotá Nágpúr, we should find ourselves obliged to follow the extension in one direction towards Riwá and Mirzápúr, and in the opposite some 100 miles or so towards Sambalpúr.

As it has been found with the metamorphic rocks elsewhere, so the Tálchírs, which spread over such an enormous area in Sirgújá, can be most satisfactorily discussed in a general account of the district, apart from their relations to any particular basin occupied by coal measures.

In describing the distinct areas of coal measures which occur in Western Chotá Nágpúr, I propose in future to adopt artificial boundaries, which will include a limited margin of the surrounding rocks.

Limits of Tálchírs here described.

In the present instance the Rehr river serves as a very convenient boundary, except for a short distance near Pahárbullá, where the coal measures themselves cross it.

Tálchírs west of Kíunrá.

On the north of the field, outside the fault which bounds the coal measures, there are two patches of Tálchírs. The principal of these situated west of the village of Kíunrá, is of an irregular triangular shape, and is traversed by the Máhán river. The rocks in the lower portion of this area adjoining the fault are pebble and boulder beds, with some hard sandstone: the latter I did not at first recognise as belonging to the Tálchír formation, but further on it is seen to pass into true Tálchírs, which extend up the Súkáiá river for about a mile. A short distance north-east of Sugri these rocks are cut off by a ridge of slaty quartzites. In the upper reaches of the stream just mentioned, outside our limits, there is a strip of Tálchírs the boundaries of which have not yet been mapped.

Tálchírs south of Maháispúr.

The second patch of Tálchírs lies south of the village of Maháispúr; it is of quadrangular shape, and is in area about 1¼ square miles. Its northern boundary is very irregular, a stream which runs with it alternately exposes Tálchírs and metamorphics.

From the position of the faulted boundary, which is well seen in the Bánkí river close by, there can be little doubt that these patches lie outside the run of the fault, but I did not succeed in finding any point where the section showed direct opposition of the edges of the Barákars and Tálchírs.

Tálchírs in Máhán valley.

From the eastern corner of the field, a long irregular strip of Tálchírs runs with the valley of the Máhán towards Uphiá, near which place it probably disappears under the sandstones exposed on the southern face of the Máilán pât. So far as it could be traced between Uphiá and Bárbáspúr, it appears to be unbroken for about fourteen miles. When it does not occupy the present bed of the river, it is often much obscured by alluvium and jungle. The boundaries of this strip are frequently indented by noses of metamorphics and submetamorphics, and there are also several inliers of the same rocks.

The bottom rocks of the Tálchírs in the sections exposed in the Máhán are the boulder bed with very irregular bedding and a hard grit sandstone. Overlying these is a considerable bed of yellowish-green sandstone, which, near Bárbáspúr, has been thrown by a cross-fault against the edges of the Barákars. In the Máhán itself shale beds are of comparatively rare occurrence, but they are exposed in some of the sections in the streams which join it on the south.

Origin of boulders.

One point in reference to the boulder bed, which plasters over quartzites and slates in the river south of the Ránchí and Partábpúr road-crossing, is deserving of especial notice, as it has an important bearing on the origin of that rock. The principal proportion of the boulders are derived not from the underlying rocks, but from the granitic gneisses which occur three miles to the north. One rock, a pink porphyritic granite, which is seen *in situ* north of Tárki, seems to have been a prolific source of these boulders.*

Tálchírs on eastern boundary.

A branch from the strip of Tálchírs above described borders the Barákars southward as far as Karnji. This branch is traversed by the Gebúr river, in which there is a section of sandstones and boulder bed, which continues up to the mouth of the Doldoá stream, where slates and quartzites strike into the river and continue in its bed for several miles.

In the Gágur river west of Karnji there is a very intricate section in which Barákars, Tálchírs, Slates, Tálchírs, Slates, and Barákars are successively exposed.

The jungle on the banks is very dense, and the map is, probably from that reason, deficient in detail, so that it is difficult to trace out the geological boundaries. The accompanying map may, however, be taken as affording a fair approximation to the true state of things. The second appearance of the slates is due to the same cross-fault as that above mentioned at Bárbáspúr. They occur as a very small inlier in the base-beds of the Tálchírs, whose ends are against the Barákar sandstones.

Fault.

As to the continuation of this fault further south, I could see no satisfactory evidence. Possibly it bounds the Tálchírs south-east of Udúkatrá, but with the streams, in which the Tálchírs are exposed, inclining, according to the map, to the westwards, it is impossible so to represent it.

Between Kárnji and Chárgar there is a very small patch of Tálchírs exposed in the low ground.

Tálchírs north-east of Sidmá.

North-east of Sidmá there appears to be a narrow strip of Tálchírs cropping out from underneath the Barákars, but the evidence of its existence is afforded rather by débris in the stream, than from rocks *in situ*.

* In some of the boulder beds which occur in the country west of the Rehr, a considerable proportion of the boulders consist of a reddish quartzite sandstone, probably of Vindyan age, which, if that supposition be correct, must have been transported to their present position from the neighbourhood of the Sone. This could only have been effected through the agency of ice.

Near the village of Bhopoli there is seen the commencement of another bordering strip, which is traceable in the bed and neighbourhood of the Bánki river; thence to Bisrámpúr it is covered and obscured by alluvium; but sufficient is seen to enable two branches of Tálchírs to be traced with approximate accuracy, one extending southwards to the Máin pât, where it is covered by the upper sandstones which underlie the trap, and the other westwards to the Pilká hills, under the sandstones forming which it also disappears.

Tálchírs between Bhopoli and Bisrámpúr.

The first of these branches is between seventeen and eighteen miles long, with an average of about three miles in width. On the east the boundary is throughout natural, but the western boundary is in part faulted, with an inconsiderable throw, against the metamorphics.

Eastern branch.

The best section of the rocks in this strip is exposed in the bed of the Goingháttá, between the villages of Pári and Librá, where sandstones, pebble and boulder beds, and needle shales, all of typical appearance and lithological character, are seen.

Section.

In several of the reaches a peculiar effect is produced by the gneiss boulders, which have been washed out of the boulder bed, and are scattered about on the surface, as though they had been only just dropped from floating ice. One boulder, still *in situ* in the bed, gave the following dimensions 7′ 4″ × 6′ 8″ × 2′=97 cubic feet, and I observed several others which could not be measured, which were still larger. Further south in the valley of the Barnái, where the strip is bounded by two ridges of gneiss hills, the boulder bed, shales and sandstones, all occur, but no clear, consecutive section is exposed.

The Tálchírs which stretch westwards from Bisrámpúr to the Pilká hills, are faulted against the metamorphic rocks along the southern boundary. The line of junction between them and the Barákars on the north, is completely hidden by alluvium, but the probabilities are in favor of its also being faulted, as west of the hill its continuation certainly is so.

Western branch.

The Tálchírs disappearing under the grits and sandstones of the Pilká hill, re-appear on the western side much increased in their lateral dimensions; this is due partly to the original divergence of the boundaries, and partly to the effects of a cross-fault, the position of which is marked by a ridge of fault-rock at the south-west corner of the hills, and by the effects produced by it in the Rámpúr coal-measure area, of which more hereafter.

Between the hills and the Rehr an irregularly shaped area of quartzites cuts the Tálchírs in two parts, running up to both boundaries and being faulted against the Barákars. Resting on these quartzites, are three small patches of Tálchírs, remnants of the rocks which at one time spread all over them. An isolated outcrop of these quartzites is exposed in the Goinghâttá section, in which, as well as in the Rehr and its tributaries, Tálchírs are seen in many broken and detached sections.

Quartzites.

The further extension of the southern fault, westwards from the point where it crosses the Rehr, is not at present known. The Tálchírs continue to border the coal measures to within a mile and a half of Pahárbullá, where the latter terminate. At Pahárbullá the extension of the Tálchírs in a southerly direction is limited by a considerable group of quartzite and slate hills, which will probably prove to be bounded on the south by the above-mentioned fault, whose western extension has not been yet traced out.

Pahárbullá.

As stated above, the Tálchírs extend far to the west of the Rehr, underlying one or more distinct areas of coal measures. The present account is limited to that portion of them bordering the coal-field and east of the Rehr.

Tálchírs west of Rehr.

Section in the Rehr.

The boundary between the Barákars and Tálchírs is pretty well seen in the Rehr north of the village of Púndih; but in the surrounding country the rocks are completely obscured by alluvium, and I have been compelled to draw the boundary straight from point to point. It is probably somewhat less regular than is represented.

Proceeding northwards from this junction down the bed of the Rehr, there are greenish and yellow sandstones with some shales and flaggy beds, which are chiefly exposed at the salient points in the bed of the river.

Sandstones what?

East of Sármá there are some rather coarse sandstones, not altogether like Tálchírs, but apparently geologically inseparable from other more typical rocks of that series. A short distance beyond, a nose of submetamorphic-looking quartzites and hornblendics strikes into the river. From the mouth of the Jumarpárá stream northwards for about three miles no Tálchírs are seen in the Rehr, the rocks exposed being for the first mile hornblendics and slaty quartzites, with a west-north-west, east-south-east strike, changing to east and west. Nearly due west of Khopá V. S., coarse granites come in and continue up to and beyond Khopá.

The Tálchír boundary leaving the Rehr close to the mouth of the Jumarpárá stream strikes north-eastwards, passing round the village of Nouápárá.

In the streams north and south of Káronji the rocks are much covered; but where exposed, except at one spot below the village, they are clearly Tálchírs. At that point there are some coarse sandstones, which I could not, as in the previous case, satisfactorily separate.

Gobri sections.

In the Gobri river and its various tributaries which traverse the country between Chungári and Datmá the boundaries between the Tálchírs and Barákars are very obscure. This is owing partly to the imperfections of the sections, partly to the presence of rocks of indefinite character, colored like Tálchírs, but lithologically resembling Barákars.

There is an inlier of Barákars south of Dhorá whose boundaries can only be approximately represented. A reference to the map will explain the position better than any description.

North and north-west from Nouápárá the Tálchír and metamorphic boundary runs with the Gobri, where it is very irregular and intricate. The river exposes granitic gneiss and Tálchír rocks alternately. West-north-west of Kurkáli, a belt of Tálchírs, half a mile wide, occupies the low ground below Káskelá, and is seen in contact with the edges of the gneiss under the east bank of the Rehr.

Boundary at Sálká.

Boulder beds.

Leaving the Gobri the boundary bends round Aginá and Sálká. At the latter place there is a remarkably fine boulder bed. The large masses of gneiss which have been washed out of it, when seen from a short distance, look like rock in situ. A mile north of Kotiá the Tálchírs are cut off by the fault which bounds the field.

Outlying patches.

A few small outlying patches of Tálchírs occur in the metamorphic area which intervenes between the north-west corner of the Bisrámpúr field and the eastern extremity of the Jhilmilli coal-measure area.

III.—Dámúdá Series.

Barákar Group.

Rocks in high ground.

Before proceeding to the description of the rocks exposed in the river sections, it will be well to say a few words on the localities where the rocks appear in the high ground uncovered by alluvium. For the most part the rocks so exposed consist of coarse grits, and pebble beds which form bossy mounds or small hills.

A few very striking instances occur, where the hidden boundary of the Barákars is sharply defined either by the character of the jungle growing above, or by the undulating or sloping character of the surface, as compared with that of the ground, where the underlying rocks are Tálchírs or metamorphics.

Boundary of Barákars marked by vegetation.

At the north-east corner of the field close to Mukánpúr there are some small mounds of a coarse grit, which are separated from the gneiss by a run of fault-rock. In the country to south-west bending to south as far as Chánchi, there is high ground, some of the hills, as the Bál H. S., rising 100 feet above the plain. The rocks are coarse sandstones and grits, with bands of pebbles, which are sometimes of considerable size and little water-worn.

Grits at Mukánpúr, &c.

In the neighbourhood of Koilári there are coarse grits near the surface, most of them excessively ferruginous.

At Bárdhá there are mounds of whitish grit sandstones.

Close to Púndih (or Púnri) there are several small hills, the highest of which is 200 feet above the plain. The principal rock forming them is an open-textured grit with pebbles, which I was at first disposed to regard as belonging to the upper group, as it presented the very strongest resemblance to the rocks of the Pilká hill. However, with the general resemblance which exists between the Barákars and rocks of the upper group, it is, in the absence of any well marked geological features, almost impossible to attempt the separation of such isolated patches. South of the hill there is a run of fault-rock, which marks the continuation of the bounding fault of the north-west corner of the field. So far as I could see, its throw must be inconsiderable. I am the more inclined to regard the Púnri rocks as Barákars, in consequence of the range near Bhatgáon, which is at the same level, being formed of rocks exactly similar to the grits and pebble-beds on the east of the field, north of Chánchi. Towards the south and south-west of the field, as at Sidmá, Bisrámpúr, Karwá, and Jáinnagar the coal-measure rocks are completely concealed by alluvium.

Púnri hills of pebbly grit.

Fault.

In describing the river sections, I shall begin with the Máhán, and then take up the tributaries successively from east to west.

Máhán River Section.—The first Barákars exposed in the Máhán section* are seen near the village of Bárbáspúr, where, as already stated on a previous page, they are faulted against Tálchírs. South of the river Barákars occur outside the fault; possibly some of the sandstones seen in the river too, should be so grouped, but at the fault there is a greenish sandstone which is certainly Tálchír.

On the west of the fault there is a small seam of carbonaceous shales with irregular coaly layers.

Seam.

From this down to the mouth of the Dekiá stream the section exposes sandstones with some carbonaceous shales; but even of the latter, at the point west of Bedrá where *coal* is marked on the published map, there is not a trace of shales, much less any sign of coal. Here as well as at several other points to be noticed in due course, the Topographical Survey must have marked *coal* from seeing drifted pieces lying at those points and not seams in situ.

Opposite the mouth of the Dekiá stream there is a seam, of which 4 feet, consisting of coal and carbonaceous shale, is exposed. The coal is of inferior quality, but burnable. The base of the seam is quite concealed by sand and water; possibly there may be a better quality of coal below.

Seam.

* Disregarding for the present the probable occurrence of Barákars in higher reaches of the river outside the limits of the Bisrámpúr coal-field.

Seam.

Higher in the section there is a considerable seam, which is exposed along the northern bank. The clearest view of it is to be obtained in the next reach.

The actual base is concealed, and the top much weathered and covered by surface débris. Section ascending. Dip variable (rolling).

1.	Shales ...	...	...
2.	Coal ...	...	5½″
3.	Concretionary shale ...	...	8″
4.	Flaky coal ...	2′	
5.	Concretionary shale ...	...	10″
6.	Same as No. 4; portions more coaly; contains much iron, about ...	2′	8″
7.	Concretionary shales ...	2′	3″
8.	Hard band of strong coal ...	5′	
9.	Same as No. 6 ...	2′	
10.	Hidden, about ...	4′	
11.	Concretionary shales ...	...	8″
12.	Flaky coaly shale ...	1′	
13.	Concretionary shale ...	3′	2″
14.	Similar to No. 8, perhaps a little better ...	2′	3″
15.	Coaly shale ...	} 3′	
16.	Concretionary shale ...		
17.	Coal, fair ...	4′	8″
18.	Concretionary shale ...	1′	6″
19.	Coal ...	...	2″
20.	Indistinct concretionary shales alternating with flaky coaly layers ...	12′	

Though this seam, as at present exposed, does not give promise of any considerable supply of first rate coal, it undoubtedly contains much of 3rd or 4th rate quality, which might be easily worked.

Owing to the horizontality of a portion of this seam, and the various rolling dips of other portions, it is impossible to represent its strike and outcrop in one. The line on the map is intended to indicate that the coal is seen throughout the distance marked on the bank of the river, rather than to convey any definite idea of strike.

From this to the mouth of the Patpúriá (Dhariá) stream I did not find any coal-seams, the *coal* marked on the Topographical Survey map south of the site of the deserted village of Pánsidánd having no existence. The principal rocks which are seen are horizontal sandstones, some of the individual beds of which are traceable for several miles.

Seam.

Just beyond the Pátpuriá stream there is a small seam of inferior but burnable coal; the section is—

	Descending.	
Sandstone, about ...	20′	
Coal ...	1′	7″
Bluish sandy shales ...	3′	

After this for about five miles the only rocks seen were sandstones and grits. There is no coal *in situ* at the mouths of either the Ghogor or Bánk, as has been indicated on the Topographical Survey map.

Seam.

At the Koteá and Bhojá road-crossing there is a seam containing about 2′ 11″ of poor coaly shale. It is seen again in the adjoining stream on the east. Where seen in the Máhán it has been let in between sandstones by two small faults. The tops of two other seams are exposed in the two next reaches, at the localities indicated on the map. What the thickness and quality of the coal may be which they contain can only be determined by excavation.

Two seams.

There is no coal at either of the localities marked near the mouth of the Gálphúlá.

In the long south-to-north reach which follows, the lower portion of a seam is exposed, paving the bed of the river for about two miles. A clear section of the top of this seam is exposed near Bhagárá.

Seam.

Seam—Descending.

	Sandstone, about ...	12′	
1.	Blue shale	?	
2.	Coal, portions shaly, but for the most part fair	4′	
3	Blue shale		4½″
4.	Coal, fair, upper 3″ stony	1′	1″
5.	Shale ...	1′	4″
6.	Coal like No 4		3″
7.	Shale ...		8″
8.	Coal like No. 4 ...		3″
9.	Blue shale, about ...	1′	8″
10.	Carbonaceous shale		3″
11.	Coal like No. 4		?
12.	Shale,—covered.		

Some experiments with No. 4 showed that it does not coke, but retains its shaly shape. On roasting, it evolved gas freely in quantity, see p. 39.

The east-to-west reach beyond this has a deep channel, which retains a considerable body of water. This and a dense grass and tree jungle which clothes the sides render it almost impossible to keep the river in sight.

At the bend to the next reach there is a seam which is possibly only another outcrop of the one just described at Bhagárá. However, it contains less coal, and the constituent layers of coal and shale do not correspond.

Seam.

Section—Descending.

	Felspathic grit sandstone.		
	Interval.		
1.	Blue shale	1′	
2.	Coaly „	1′	3″
3.	Blue „	1′	4″
4.	Coaly „		4″
5.	*Coal*, fair	2′	2″
6.	Blue shale	3′	
7.	Coaly shale	1′	2″
8.	Coarse grey and blue shales	2′	4″
9.	Coaly carbonaceous shale	1′	
10.	Shale.		
	Base covered.		

From this northwards to its junction with the Bánki (Pertabpúr) river, the Máhán exposes sandstones at intervals; east of Durti a fine trap dyke causes a fall in the river. The strike of this dyke in the bed of the river is 15° north of east to 15° south of west. A possible continuation of it is seen in the Johoá, six miles to the west; but in the intervening country and also to the east of the river I could see no trace of it.

Trap.

Beyond the junction with the Bánki, under the eastern bank, there is a small seam which contains some hard coaly shale, but apparently no coal. After this for nearly a mile there are Barákar sandstones; and then no rocks are seen for nearly a mile, the deep channel of the river being filled with water. The first rocks exposed are some Tálchír boulder beds, which crop out from underneath the western bank. The faulted junction is therefore hidden here, but is very plain in sections both on the east and west. North of this the Máhán does not again traverse Barákar rocks.

Seam.

Taking up the tributaries of the Máhán, in regular succession from east to west, the first to be noticed is the Dekiá.

Seam.

Dekiá River Section.—South-west of Markátánd a nearly horizontal seam of from 1′6″ to 2′ of coaly shale and coal crops out at several places. Above it are ferruginous pebble beds and concretionary iron bands, the former resembling rocks occurring in the upper group, *e. g.*, in the hills near Kussumbi on the Ranchi road.

Seam. Seam.

Gagur River Section.—Although Barákars occur east of the cross-fault above described, the river section of these rocks commences at it. They consist of massive sandstones, which are horizontal or only slightly rolling, and are deeply cut by the river. North-west of Udukátrá, a seam of coal is partially exposed on the southern bank underlying these sandstones. Apparently the same seam is again seen at the loop bend east-north-east of Burká-Dhuriá; it there underlies some much honey-combed sandstone. The thickness of coal is about 2′ 4″. At the next reach there is another badly seen seam. Throughout the remainder of the section up to the Máhán the rocks are all coarse sandstones.

The small streams flowing into the Gágur on the south were not examined in detail, but where crossed, they showed no signs of containing coal. They for the most part are at a higher level than the Gágur channel, and have not yet cut down to the coal exposed in it. The watershed where they take their rise is the spur of quartzite which penetrates the Barákar area, and which has been already referred to.

Seam.

Patpúriá River Section.—The Patpúriá stream rises in the high ground of the quartzite spur below Dhuriá, where it passes on to the Barákars. The rocks exposed are of very peculiar appearance; they consist of pebble-beds and coarse conglomerates, which latter contain masses of blue quartz, jasper, and jasper breccia, derived from the sub-metamorphics in the vicinity. Not far off a large fragment of coal was seen, but no seam from whence it could have been derived was discovered. Half a mile from the mouth of this river there is a seam of coal which measures 2′ 11″; it underlies massive sandstones, and is not improbably a thickened continuation of the seam described in the Máhán section on page 32.

Seam.

The stream east of Khargáoná, which joins the Patpúriá near its mouth, passes underground for some distance east-north-east of the village. At the base of the tunnel a seam of about 1′ 6″ of poor coal, possibly the same as the one in the Máhán and Patpúriá, is exposed. My attention was drawn to this peculiar tunnel by a flock of blue pigeons suddenly rising out of a hole near the road. This hole proved to be an entrance to the cavern, the existence of which I might otherwise not have suspected.

Turrá River Section.—The Turrá river, as well as its tributary, takes its rise in the ridge of metamorphic rocks outside the northern boundary of the field, and joins the Máhán rather more than one mile west-south-west of Kertá.

Seam.

A short distance from the mouth there is a seam under a thick bed of sandstones which contains about 11″ of inferior coal. About half a mile further up the stream, there is a flat seam containing coaly and carbonaceous shales, the thickness of which is uncertain. The map not being plotted, I am unable to say to what exact spot the next locality for *coal* marked on the topographical map may refer. Somewhere in that neighbourhood there are traces of carbonaceous shale, but no coal. Like so many others in Sirgújá, this river proved very difficult to follow up: throughout long reaches the accumulation of the water in the deeply cut sandstone channel rendered it impossible to wade, and the thickness of the jungle on the ravine-intersected banks made it almost equally impossible to keep along the bank in sight of the rocks.

The next coal seam exposed is situated slightly south of west of Chourá. It is flat, and paves the bed of the river; portions are coaly, but the thickness is not disclosed.

Seam.

In the western branch of the Turrá called the Gohogor, I saw no traces of coal at the junction. But the river has not been examined.

Bánk River Section.—The Bánk river rises in the metamorphic hills to the east of Bisrámpúr, and joins the Máhán north of Bhojá. It first enters the sedimentary rocks (Tálchírs) near the village of Tákiá. Thence it proceeds northwards along the eastern boundary of the field, bending at one locality into the Barákars, and at another into the metamorphics, and for the remainder of its course up to Ghangri, traversing Tálchírs.

In the Bhiti river, which joins it close by, there is a seam of carbonaceous shale which is seen at the road-crossing below Bakná. In a stream which joins the Bhiti south-east of Bakná, there is another seam containing about 1′ 6″ inches of coaly shale; this is covered by coarse sandstones, the exact position of the boundary between which and the slates is hidden. Returning to the Bánk, the Tálchírs, which occur in the bed of the river north of Ghangri, are gradually covered by pebbly Barákar grits. About a mile from the junction, there is a seam containing about 5″ of good coal; after this, half a mile further, there is a rolling seam which contains 2′ 10″ of shaly coal; it is several times repeated higher up. West-south-west of Abkorá, there is a seam which is exposed by the deep-cut channel included between massive beds of grit. It has a slight inclination to north and a variable thickness, the average being about 2′; it is, like many other of the seams in Sirgújá, in all probability only a lenticular mass with limited lateral extension.

Seam.

Seam.

Seam.

For about two miles beyond this only sandstones and grits are exposed. But east of Chátásárái there is a seam of shaly coal of which 2′ 1″ is exposed, the base being hidden. The streams which join the Bánk in this neighbourhood from the east did not, at their mouths and for some distance in, give any promise of coal. At the point where the Partábpúr and Bisrámpúr road crosses the Bánk there is a seam, with a slight dip to the south-east, which contains about 8′ of poor flaky coal and carbonaceous shale exposed, the base being hidden. In a stream which joins the Bánk north of Ráimá, there is a seam containing somewhat similar shales. Nearly north-west of the deserted village of Chora, there is another seam with the same constituents; of this 2′ 6″ only is exposed.

Seam.

Seam.

Seam.

For about two and a half miles more the river runs along through a gorge cut in q. p. horizontal beds of massive sandstones and pebbly grits. Nearly due east of Bhojá there is a seam of coal dipping 5° to north, in which there is about 1′ 8″ of coal exposed.

Seam.

The remaining two miles or so of the Bánk, up to its junction with the Máhán, I was prevented from examining by an attack of fever.

Koteá River Section.—In the stream which joins the Máhán south of Koteá, the rocks are much covered, especially near Gourá. East of Koteá, there are sandstones; and close to the mouth there is a section of the seam which is seen in the Máhán, vide p. 32.

Galphúlá River Section.—In the loop-bend of the Galphúlá near Biláro there is a seam containing some coal, about 8″ of which is seen. In an adjoining stream the whole seam, measuring about 7′, is exposed, in which there are seen to be coaly layers mixed up with carbonaceous shales. I do not

Seam.

think there is any promise of good coal being found in workable quantity. This seam has a more decided dip to the north-east than is common, the rocks being for the most part horizontal. Coal was met with south of the deserted village of Jhaprá. The seam consists of carbonaceous shales, with thin layers of coal, one near the base measuring 6″; the dip is 10° to south-east.

Seam.

The same seam is better seen in the Báherádol branch of the river; it is here seen to be of considerable size, and contains about 6½ feet of fair coal. Some of the accompanying shales contain *Glossopteris* and other plant fossils.

Fossils.

There are several other seams containing carbonaceous shale, with portions coaly. One is situated west of Jhaprá and another west of Bhojá; the character of the latter hardly justifies the insertion of *coal* on the Topographical Survey maps.

Seams.

Jhampi River Section.—In the Jhampi from Doin to its junction with the Máhán I only met with one seam of carbonaceous shale associated with the Barákar sandstones. Some fragments of coal, however, indicated the presence of a seam in the area drained by the numerous small tributaries.

Seam.

Chengodri River Section.—From the character of this river and its banks it was absolutely impossible to follow it up closely. The only seam I met with, was one containing 1′ 1″ of coal which is situated at the junction with the Jhámpi.

Seam.

Másán river Section.—As indicated on the Topographical Survey map there is coal in the Másán north-north-east of Járhi; the total thickness of the seam is about 7′, of which 2′ is coal. It dips to north-east. From its more shaly and generally inferior character, I am inclined to think it is distinct from the seam about to be mentioned. This seam runs with the stream for a considerable distance, being last exposed about half a mile from the junction with the Máhán; it contains from 5 to 6 feet of coal, the upper portion of which is very fair. It has an unsteady dip to south-south-west, which never exceeds, and rarely attains 10°. This is the most promising seam in this part of the field.

Seam.

Seam.

Bánki (Partábpúr) River Section.—The boundary of the coal-field crosses the Bánki about two miles north-north-west of Bardhá. The section clearly shows it to be faulted; the edges of the sandstones are presented against the faces of some much tilted and disturbed slates and quartzites, the penetration of which by granite-veins and their relations to the granitic gneissose rocks I shall allude to further on. At the junction on the western bank of the river a thin band of 7″ of coal underlies the topmost sandstone, and is itself underlaid by a greenish yellow sandstone, which I at first thought might be Tálchír, but subsequently concluded to be Barákar.

Seam.

From this to the junction with the Máhán there are more or less horizontal sandstones.

In the Daldali stream, nearly due north of Burdhá, there is a seam of coaly and carbonaceous shale, which with its accompanying sandstones is (locally) upheaved to an angle of 45°; from this to the point where the stream passes into the Tálchírs sandstones only are seen.

Seam.

Nákti River Section.—The Nákti for a portion of its course runs with the faulted boundary of the Barákars, crossing and recrossing it frequently. The only rocks of this group which it exposes are sandstones. In the Márátá branch of the stream there is a small seam of coaly shale of no importance.

Seam.

The Barákar faulted boundary leaving the Nákti north of Narkolá is traceable south of Pakni to Károti, where it is cut off. In several places along it the sandstones are highly indurated.

Rehr River Section.—The Rehr river with its tributaries drains the south-western portion of the coal-field.

The bounding fault of the south-west corner of the Barákars of the Bisrámpúr area crosses the Rehr one mile north-east of Beltikri; the actual junction line is here covered, but Barákars and Tálchírs are exposed at no great distance on either side.

Trap.

In the reach which strikes eastwards from Pachirá there is a trap dyke, which for a mile forms the northern bank of the river; at the other end it is flung by a small cross fault which brings it down to the southern bank. Besides this principal dyke there is a second, irregularly parallel to it, which traverses the sandstones for a short distance.

Seam.

In the next reach there is a coal-seam containing about 18 inches of fair coal. Dip 5° to north-east. Further on there is seam which is, I think, distinct from the last. It is inaccessible, being under a thick bed of sandstone which overhangs a deep pool. It is probably from 15″-18″ thick. Rather less than a mile beyond the junction with the Pasang there is a seam exposed in the bed of the Rehr, of which the measurable thickness is about 3 feet. It has a slight dip, which varies in direction between east and north-east. Most of the coal is fair, and a portion excellent. In the bed of the river beyond this, blocks of coal of considerable size—from what seam derived is uncertain—are abundant and of good quality. They may have been washed out of the seam just mentioned, or carried in from some of the seams in the Pasang. Beyond this seam, up to the boundary, the only rocks seen are coarse Barákar sandstones.

Seam.

Pasang River Section.—East of the Silphili Ghát, the section in the Pasang for about four miles exposes horizontal sandstones only. The same beds persisting throughout.

Seam.

West of the ghát the same sandstones continue for about four miles. In some places the river has cut for itself a deep channel. South of the deserted village of Kasalgiri there is a seam which at first, from the manner of weathering, appears to consist entirely of good coal. On close examination, however, more than half proves to be quite useless, and the remainder inferior earthy coal.

Section—

1.	Carbonaceous shales	8″
2.	Shales with plant fossils	2″
3.	Carbonaceous shale, passing into	1′ 5″
4.	Earthy coal	2′
		4′ 3″

Four seams.

At the mouth of the Chapar river there is a seam, which, so far as it is exposed, consists of slaty carbonaceous shale, with portions coaly. Before the mouth of the next northern tributary there is an inconsiderable seam of coaly shale, which has been locally tilted. Immediately after it the top of another seam is seen under water. Before reaching the mouth of the Ársothá tributary, the top of another seam, containing about 1′ 6″ of coal, is seen at the water's edge, and underlying the massive sandstone through which the channel is cut. This, or a distinct seam, is exposed in the reaches beyond the Ársothá stream; it contains 3′ of coal and coaly shale, possibly more.

Seam.

From this up to the mouth of the Karchá the rocks are covered. But a short distance beyond it a seam is imperfectly seen under the southern bank. Possibly a continuation of the same is exposed at the mouth of a stream which joins the Pasang near the Jáinnuggur and Kúmdá road. It there contains 1′ 6″ of good coal *(vide* p. 39*)*. The top is much weathered, and covered with soil, but the base is well seen. Another seam is badly exposed west of the road, after which up to the junction with the Rehr the only rocks seen are horizontal sandstones. In the Khoá and Gambadiá rivers west of Pilká the Barákar sections contain grits and sandstones only; the latter are sometimes of a somewhat pinkish color, as also are some of those in the Pasang associated with the coal.

Seam.

Gobri River Section, &c.—The character of the sections in the Gobri, with its tributaries the Dámundá, Patpúriá, and Kadáriá, can be best gathered from the map. In so far as the Barákars are concerned, there are no points of sufficient interest to be made the subject of special detail. No traces of coal were met with in any of them.

IV.—UPPER SANDSTONES (LOWER MÁHÁDEVÁS?)

Within the limits of the Bisrámpúr coal-measure area, the only locality in which sandstones referable to any of the groups higher than the Barákars occur, is in the Pilká hills, a remarkable looking cluster which stands out isolated in the centre of the Sirgújá plains.

Pilká hills.

These hills are formed of hard quartzose sandstones, grits and pebble conglomerates, the beds of which are horizontal; and the elevation of the top of the highest hill above its base, or about 1,000, may therefore be taken as giving the total thickness.

Thickness.

The evidence here afforded of great unconformity between the rocks of this and the older formations is singularly conclusive. The basal bed of grit laps from Barákars across Tálchírs on to metamorphics, the relations between which had been first established by faults. A doubtful case—not yet fully examined—of similar faulting having taken place in the Barákars previous to the deposition of the upper sandstones, occurs in the hills to the north-east.

Unconformity.

In the Káranpúrá field too, a fault has been mapped as running under the Upper Pánchets.

In describing these rocks, I follow what appears to be now the accepted belief, *viz.*, that the Upper Pánchets of the Damúdá fields are of Lower Máhádevá age, and the general lithological resemblance between the Pilká grits, &c., and the Upper Pánchets, is so strong that I think their identity may be safely asserted.

The only difference that I could detect between the pebbly beds of Pilká and those of Panchet and Lúgú* was that the former are somewhat less ferruginous, in which respect they resemble the Rájmahál grits, which appear to be also referable to Máhádevá age.

On the level top of the hill there is a little soil, but no trace of either laterite or trap. Judging from the similar hills and the plateaus, both to the north and south, trap in all probability at one time did also exist here.

No laterite or trap.

TRAP DYKES.

In addition to the general horizontality of the beds, and the small throws of the few faults in the Bisrámpúr coal measure area, the scarcity of trap dykes affords evidence that the rocks have been subjected to a very small amount of disturbance, as compared to that which has affected the more eastern fields.

One trap dyke is exposed in the Máhán section, two miles east of Durti. A possible continuation of it is seen in the Tálchírs and metamorphics, in the Jojhoá stream, seven miles to the west, but no other trace of its continuance beyond the bed of the Máhán was discovered.

Máhán dyke.

* Hills situated respectively in the Ránigan j and Bokáro fields.

The only other trap dyke is seen in the Rehr section, where it runs for about a mile along the northern bank of the river, below Pachirá. At the east end of the reach it has been flung to south by a small fault.

Rehr dyke.

Both the above are coarsely crystalline diorites.

V.—ECONOMIC RESOURCES.

With the exception of building stones which are of the usual character found in the Barákar and Tálchír rocks, the economic resources of the Bisrámpúr coal-field are limited to coal.

Building stones.

From the imperfection of the sections, and the difficulty of identifying the partially exposed coal seams at different localities, any attempt at a tabular statement of the number of seams would only tend to exaggerate the importance of a large proportion of them, which, while they will in all probability prove to be worthless, cannot at present, from the limited data which we possess regarding them, be individually asserted to be so.

Many seams worthless.

It may be regarded as an established fact that good coal does exist in fair abundance, and from the horizontality of the seams, in a suitable condition for working. But borings can alone furnish facts sufficiently reliable for estimating the extent and thickness of individual seams, and generally the total amount of coal existing in the field. Such borings at a few well selected sites, would, in consequence of the undisturbed character of the beds, and the comparatively small thickness of the whole formation, give conclusive and exhaustive information as to the amount of coal obtainable.

Good coal.

Borings.

To prove the individual seams which, as at present exposed, are the most promising, I would recommend borings being made on the west bank of the Máhán, a mile and a half north of Chendiá; on both banks of the Máhán at Bhagárá, and on the southern bank of the Pasang, north of Jaldegá; and from these points in whatever directions the original results would render it probable that the seams extended.

Points for boring.

For proving the total amount of coal throughout the area occupied by the coal measures, borings should be made all across it. It is at present hardly necessary, however, to go further into the question, as the probability of this hill-surrounded area being ever the seat of mining enterprise is so slight that the existence of coal there in whatever quantity can hardly be said to have any immediate importance from an economic point of view.

The coal-fields below the plateau in the Mánd valley, ninety miles to the south, are the only localities in Western Chotá Nágpúr which are ever likely to be made use of by any railway connecting Calcutta and the Central Provinces.

The following is the result of the assays of coals from five localities:—

	COAL SEAMS.	CARBON.	VOLATILE.	ASH.
1.	Rehr river near Panri ... ... (water 5·5)	57·7	38·2	4·1
2.	Pasang river, Jáinuggur and Kumdá road	56·2	37	6·8
3.	Máhán „ Bhagárá	50·2	33	16·8
4.	„ „ north of Chendiá	48·5	32·4	19·1
5.	Másán „ ... ... (water 4)	45·5	31·6	22·9

VI.—METAMORPHIC ROCKS.

Two groups.

The metamorphic rocks surrounding the Bisrámpúr coal-field are separable into two groups, chiefly by their respective lithological characters. But their occurrence here, as well as in other parts of Chota Nágpúr, is accompanied by certain geological features, which render it probable that they really belong to two different periods.

Types.

The types of the former group are coarse granitic gneisses with variable amounts of visible foliation. Of the latter the types are slates, quartzites, and hornblendics. Instances occur however where individual beds, lithologically undistinguishable from the latter, are geologically inseparable from beds belonging undoubtedly to the former.

VII.—GRANITIC GNEISS SERIES.

The east and west range of hills south of Partábpúr, which bounds the coal-measure rocks on the north, consists of coarse granitic gneisses and schists which are exposed in section in the Máhán, Bánki, and Rehr rivers; in the Bánki section, however, there are also some quartzites, to which allusion will be made again further on.

Trap-like hornblendics.

On the east face of the field, granitic and porphyritic gneisses are again met with near Ará, where they occupy a zone about three miles wide. South of these a peculiar group of trap-like hornblendic rocks form the high ground near Pársá. At first I was strongly inclined to believe these to be trappean, and only relinquished this opinion on finding traces of foliation in some of the sections exposed in the streams on the top of the hill. These rocks continue to the Bánk south of Sonpúr.

Spurs.

The spurs from the high ground east of Bisrámpúr are formed of granitic gneisses with occasional schistose, hornblendic, and quartzose bands.

South-west of Bisrámpúr and south of the Pilká hills, there is an area occupied by metamorphics, which consist chiefly of granitic gneisses. These extend southwards to the Máin pât through Lukánpúr.

Section in Rehr.

On the west of the field the section of the metamorphic rocks in the Rehr commences with quartzites of rather uncertain affinities; these are followed by granitic rocks, which continue—occasionally including schistose or slaty beds—up to Jhilmilli.

VIII.—QUARTZITE AND SLATE SERIES.

Section in Bánki.

North of the faulted boundary where it crosses the Bánki, there is a thickness of several hundred feet of quartzites and slates, which present a somewhat very unusual appearance. Granite veins or dykes which are ordinarily confined to the gneissose rocks, in this case pass across into the quartzites, and appear to have been the cause of the disrupted and tilted condition of the beds. In some cases fragments seem to have been torn off from the main mass and are enveloped in the granite. Accompanying this disturbance the slates are much hardened, and the faces are lustrous with crystals of actinolite.

Rocks hardened.

On the eastern side of the field, rather more than half the length of the boundary runs between Tálchírs, quartzites, slates and schists. The extreme irregularity of the surface of the latter at the period of the deposition of the Tálchírs is well shown by the broken character of the boundaries. In the Gehur and Máhán sections many of the slates abound in iron pyrites, which is generally decomposed near the surface and covers the rocks with a copious efflorescence of sulphur. I saw no traces of copper, but from the similarity of the rocks to the copper-bearing beds of Singhbhúm, it is by no means improbable that it may exist.

Iron pyrites.

The Gágar river south of Kárnji traverses a deep gorge, and gives an admirable section of the nearly vertical rocks through which it passes. They consist of slates, indurated shales, quartzites and hornblendics, the last mentioned sometimes exhibiting a cannon ball structure.

One slightly calcareous slate contained a few striated moulds, or impressions of apparently organic objects, but what they could have been has not been determined.

Organic impressions?

A steady strike to nearly west-north-west east-south-east prevails in these rocks. Where not vertical, the dip is to south-south-west at a high angle.

Near the village of Kuthwán, interbedded with quartzites, &c., there is a conglomerate formed of rounded fragments of quartzite, jasper, &c., bound together by a very hard quartzose paste.

Conglomerate.

A spur of quartzites, &c., penetrates for six miles west of the main boundary at Chanchi into the basin. It is not now covered by the sedimentary rocks; indeed south of Dariá it forms some small hills which rise above the general level.

In the stream south of Daria, V. S., the conglomerate just mentioned is again seen; it is on exactly the same strike as the portion of it which is near Kuthwan, or nine miles off.

At Ara, as already mentioned, the granites come in, cutting off the slates. On or about the line of junction, there is a run of limestone, which contains crystals of tremolite.

Limestone.

West of the Pilká hill there are quartzites, which must, I think, be referred to this group; and the hills south of Pahárbullá consist of rocks of the same character.

One notable difference I observe between the rocks of this group as seen in Mánbhúm and Singhbhúm and in Sirgújá, and that is, that the varieties of magnesian schist which are common in the former and furnish a considerable proportion of the total thickness, are nearly altogether absent in the latter.

Absence of magnesian schists.

MINERALOGICAL NOTES ON THE GNEISS OF SOUTH MIRZÁPÚR AND ADJOINING COUNTRY, *by* F. R. MALLET, F. G. S., *Geological Survey of India, (No. II.)*

Limestones.

Having last season found the limestone of the Bíchí nadí* to be a normal dolomite, I collected specimens from various localities this year, in order to ascertain how far this character is general in the limestones of the gneissose series. On analysis I obtained the following results:—

I.—Calcite Limestones.

	A.	B.	C.
Carb. of lime	97·92	83·12	85·92
„ „ magnesia	1·47	7·04	8·19
„ „ iron	·38	1·28†	·76
Insoluble	·80	10·16	5·52
	100·57	101·60	100·39

II.—Dolomite Limestones.

	D.	E.	F.
Carb. of lime	67·28	64·68	53·85
„ „ magnesia	30·24	34·14	45·78
„ „ iron	·78	·58	·34
Insoluble	·50	·76	1·00‡
	98·80	100·16	100·97

A is a very coarsely crystalline white limestone, from south of Bilwáda on the road from Singraulí to Mirzápúr; B a dark grey fine-grained crystalline rock, from east of Karámi, (sheet 18, Ríwa Survey); C is a white and greenish-white, rather fine-grained crystalline rock, which occurs in subordinate beds through the dolomite E. It weathers with a smoother surface, and is tougher on account of its more compact texture. D is a rather finely crystalline, or saccharine, white dolomite, from the banks of the Rehr, south-west of Ekpai; its composition corresponds nearly to the formula $2CaO, CO_2 + MgO, CO_2$. E is a white rather coarsely crystalline rock from north of Parárwa, having the composition $3CaO, CO_2 + 2MgO, CO_2$; while F is the white crystalline normal dolomite ($CaO, CO_2 + MgO, CO_2$) of the Bíchí nadí already referred to.

It will thus be seen that the limestones vary from pure carbonate of lime to pure dolomite. In some cases, of which C and E are examples, the two rocks are interstratified. The above dolomitic limestones are all associated with more or less serpentine; and I think it may be assumed that where the latter mineral is present in any quantity, the limestone is magnesian. In the only case I have hitherto observed in which serpentine is actually interbanded with the limestone the latter is true dolomite.

Wollastonite.

In the two patches of gneiss east of Koelkat (sheet 18) occurring as inliers in the Tálchírs, limestone is very abundantly met with, the same beds being probably repeated by folding, with a general strike of about west 30° north. It is a white crystalline rock, varying from a saccharine variety to one with cleavage facets of ½ inch across. The band to east of Ráondí contains a very large amount of wollastonite. In fact the rock is entirely composed of this mineral in places, constituting there a 'wollastonite schist,' which from its greater resistance to atmospheric

* Vol. V, P. 19. † With traces of manganese. ‡ Chiefly minute scales of mica.

influences often stands up above the general surface in a low jagged ridge. The mineral has a greyish-white color and bright pearly lustre, and the approximate parallelism of the principal cleavage faces gives the rock a somewhat fissile structure. Tremolite is very abundant in the limestone of the Bíchí nadí;* but the above is the first instance I have met with of the occurrence of wollastonite.

Corundum.

My work brought me again this year to the corundum quarries between Pípra and Kádopání, which I examined closely. The thickness of the bed cannot be determined with any degree of accuracy from the amount of *débris* lying about; but as a rough guess I thought I was more below than above the mark in estimating it at 30 yards at the quarries where it appears to be thickest, and it may be considerably more. The ground is too obscure for one to say with certainty that the above includes no subordinate layers of other rocks, but I observed no indication of such, and for anything I saw for the contrary, the bed may be a solid mass of corundum. It runs about east-north-east, west-south-west, the bedding being vertical or at a high angle. The section previously given† is only true for the spot where it was made, for some of the associated beds die out rapidly. At the west end of the long low hillock which marks the position of the mineral, porphyritic gneiss and white quartz-schist are seen within 10 yards of each other with corundum in the space between. From this to the Rehr, some 300 yards, is obscured by clay, and no trace of the corundum is to be found in the river. East of the quarries again, the bed can only be followed for a short distance, the entire length visible from west to east being, as laid down on the map, about half a mile.

The corundum, where weathered, much resembles fine-grained hornblende-rock in a similar state, and might be easily overlooked. Its intense hardness is well shown by the way in which hammers which may have stood years of ordinary geological work are in a few minutes split and pounded out of shape on it. It seems strange that it should not form a more prominent physical feature. Pluvial mechanical erosion would apparently act very slowly indeed on it, in comparison with the softer rocks on either side, and the absence of secondary minerals in considerable quantity does not point to important chemical alteration. Probably its weak point is the irregular jointing by which it is intersected.

The quarrymen are, I was told, paid at the rate of one rupee per 31½ kacha mánds raised, but the mineral is only worked now and then when a quantity is ordered by the mahájans who deal in it. Before commencing operations a kid is sacrificed to Deví, to insure good fortune, and protection from accident; fires are lighted against the large masses into which the corundum is divided by jointing, and when they have been rendered somewhat more brittle by this means, they are gradually smashed by heaving other pieces at them. Considering the thickness and length of the bed, it is clear that the supply may be considered inexhaustible.

I have described the minerals which are associated with the corundum in my previous note. The only additional species I have observed this year is kyanite, which occurs in a radiating aggregate of a reddish color. It is a mineral, which as a simple silicate of alumina, is a natural associate for corundum, and has been similarly met with elsewhere. There are also small bladed crystals with a bright pearly lustre, much like diaspore, but their small size and the impossibility of detaching them makes their examination difficult. They may be kyanite.

Magnetite.

Beds of magnetite interlaminated with granular silicious layers are met with not unfrequently, more noticeably in the crystalline inliers near Koelkat, also near Gairár and south of Kádopání. None of these, however, are as rich in iron as the magnetic band at Korché in Mirzápúr.‡ Magnetic sand very

* Vol. V, P. 20. † Vol. V, P. 20. ‡ Vol. V, P. 22.

frequently accompanies other arenaceous materials in the beds of watercourses, n some cases probably in sufficient abundance to repay collection by the native iron-smelters. The difference in specific gravity causes a natural separation of the ferruginous and silicious grains, so that the former could be collected with only a moderate percentage of foreign matter, which could be almost wholly eliminated by washing. As far as I am aware however, no attempt is made to utilize this rich detrital ore, while a few miles to the north, the vastly inferior ferruginous beds of the Barákar sandstones are laid under contribution.

ERRATA IN PREVIOUS NOTE, (VOL. V, PAGE 18).

Page 18,	line	8, from bottom,	*for*	Hæmatite	*read*	Tremolite.
„ 20,	„	3,	„	say	„	vary.
„ „	„	12,	„	chrysolite	„	chrysotile.
„ „	„	5, from bottom,	„	and	„	to finely.
„ 21,	„	21,	„	or in any	„	or any.
„ 22,	„	4,	„	starry	„	strong.
„ „	„	5,	„	falls	„	fuses.
„ „	„	11,	„	white	„	rutile.

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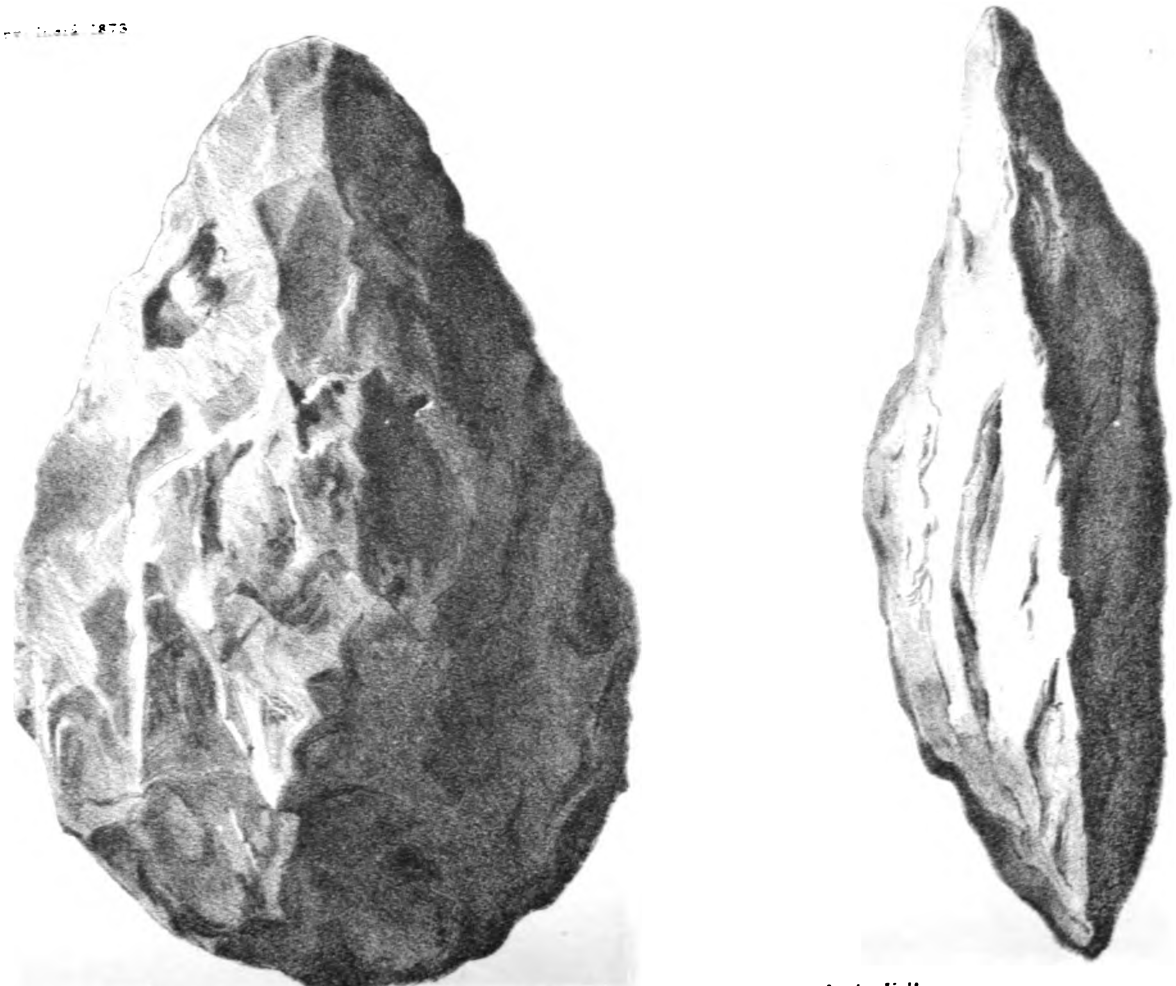
WIEN.—Verhandlungen der k. k. Zoologischen, Botanischen Gesellschaft in Wien, Band XXI, (1871), 8vo., Wien.



Stone implement found in the fossiliferous clays of the Narbada Valley,
near Bhutra, 8 miles north of Gadarwara

RECORDS

OF THE

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Notes on a CELT *found by* MR. HACKET *in the* OSSIFEROUS DEPOSITS *of the* NARBADÁ VALLEY (PLIOCENE *of* FALCONER) : *on the* AGE *of the deposits, by* MR. H. B. MEDLICOTT ; *on the associated* SHELLS, *by* MR. W. THEOBALD.

The celt is formed of Vindhyan quartzite, such as might be procured at any point along the northern edge of the valley; it is of the pointed oval shape, 5″ × 3″⅝, of very symmetrical outline (see figure); and, although rather roughly chipped on the faces, it is unquestionably a manufactured article. Mr. Hacket dug it out himself from where he found it lying flat, and two-thirds buried, in a steep face of the stiff, reddish, mottled, unstratified clay, about six feet above low water level, and about three feet below the upper surface of the clay, upon which there rested about twenty feet of the gravel with bones. From the edge of the cliff of gravel, there is a steep slope passing up through the ravine ground, so common along the border of the main river channels, to the general level of the plains, at 90 to 100 feet above the level of the Narbadá. The locality is on the left bank of the Narbadá, near the village of Bhutra, eight miles due north of Gadarwara.

The age of the ossiferous deposits.—In bringing forward an authentic specimen of human manufacture from the ossiferous deposits of the Narbadá valley, some expression of opinion will be expected from geologists in India regarding the age of those well-known beds; the more so because a name has been already applied to them by a high authority, implying an age very much more remote than that of any human remains as yet found in other countries. In all questions relating to the determination of vertebrate fossils, Dr. Falconer's judgment carries great weight. In India he has not as yet had a competitor in this line of research; and even in Europe he took a leading part in the same studies, connected with the inquiry into the antiquity of man. He determined a number of fossil bones from the Narbadá deposits, and invariably spoke of them as pliocene.

In 1868, the Superintendent of the Geological Survey described in these Records (Vol. I, p. 65,) an agate flake, or knife, found by Mr. Wynne in the ossiferous clays of the Godávarí valley, which he affiliated to like deposits in other parts of India. In this connection Falconer's views were quoted at length by Dr. Oldham in a tone of high approval, without any expression of dissent or of question as to the matter of age; and thus at least a tacit assent and a fresh lease of life was given to the opinion that these deposits belong to the pliocene age of geologists, the name being used by both authors in the confident expectation that these deposits would yield evidence of man's existence. I do not pretend that the question of age can be finally settled now; but it is important to point out that the opinion quoted is not well founded.

For those who are not posted up in such matters, it is well to point out the considerable historical license that is taken in this application of the name pliocene. In the accepted geological nomenclature the tertiary formations end with the newer pliocene. Although the post-tertiary period is as nothing compared with the preceding geological ages, it still represents a great lapse of time, for an estimate of which we are entirely dependent upon geological evidence. After passing the recent, or prehistoric, period, in which all the animals are of existing species, we get into the post-pliocene, or pleistocene, period, in which a variable proportion of the mammalian remains are of extinct species; and according to the distribution of these extinct mammalia, the deposits are arranged into late, middle, and early pleistocene. Nearly all the old river-gravels and cave-deposits with the human remains, about which so much has been published in the last few years, belong to the late pleistocene, or, as it is sometimes called, the quaternary period; this name being sometimes also used as equivalent to the whole pleistocene, and preferably so in my opinion, as distinctly marking its post-tertiary date. Thus it may be said roughly that the oldest human remains in Europe only take us about half-way back in that post-tertiary time. Almost the whole of the glacial period,—during which England was in great part submerged, and the glaciers of the Alps filled the great valley of Switzerland to high up on the flanks of the Jura,—intervenes between those ossiferous valley-gravels and the newer pliocene, or even the early pleistocene. Some supposed evidence of human remains has been brought forward from pliocene strata in England, and even from miocene beds in France, in the form of perforated shells, scratched and split bones, and very rudely-chipped stones; but the correctness of these interpretations has been denied by competent and quite unprejudiced judges.* It may, therefore, be said that from the stand-point of existing information, the genuineness of human remains from pliocene strata, or the true pliocene age of strata containing human remains, would call for particular proof; or, not to disguise the point, supposing (as seems almost probable) man to be an exalted chimpanzee, it is quite an open question whether the change may not have occurred in post-tertiary times—so little positive is still our knowledge of geologic time and of the method of organic evolution.

Even some geologists seem to need to be reminded that the tertiary period and its sub-divisions are based upon the testacea only, upon the proportion of living to extinct species of fossil shells, not of fossil remains in general. The fitness of this limitation was guaranteed in the first instance by the judgment of its distinguished author; and it has been justified by the universal adoption of the classification based upon it. It is with no small astonishment, therefore, that we hear of the grounds given by Falconer for calling the older deposits of the Indian rivers pliocene. After telling us (Pal. Mem., Vol. II, p. 644), on the authority of the Geological Survey, that the shells are all of existing forms, although in somewhat different proportions to those now inhabiting the Narbadá valley, he adds:— "In designating the formation as pliocene, which I have done during many years, I have been guided by the indications of the mammalian fauna, as intermediate between the miocene of the Irrawadi, Perim Island, and the Sivalik hills, and that of the existing period." That is, he takes upon himself to use the word pliocene in a sense quite foreign to that in universal use. The difference noticed here in the relative strength of the molluscan species in the living and the fossil stages is nothing like so great as that in the post-pliocene deposits of Europe. For the living relations of some of the species, even in the late pleistocene deposits of England, one has to go to the Mediterranean or to sub-arctic waters. The whole ground of Falconer's position is placed upon the mammalian fauna. The act is thus either a deliberate attempt to revolutionise the meaning of part of our best established geological nomenclature, or else the word pliocene is applied in a more abstract sense, im-

* Opinion may be reserved at present upon the miocene age of Mr. Calvert's fossil drawings.

plying that these deposits in India belong to the age of the pliocene of Europe. Falconer cannot be acquitted of the grave error involved in the former position; and one scarcely knows whether the error is aggravated, or palliated by the fact that his judgment was here influenced by his temper. It is painfully evident in his later writings that he took a pleasure in ignoring and crossing the authority of Sir Charles Lyell. It was not only to Indian deposits that Falconer applied his independent criterion of classification: upon the evidence of the fossil mammalia he designated the well-known pre-glacial forest-bed of Norfolk as pliocene, in defiance of established usage (loc. cit., Vol. II, pp. 190, 586). One need hardly say that his attempt has been by common consent ignored. In a very recent note upon the classification of the pleistocene deposits, Dr. Boyd Dawkins points out the very marked difference even of the mammalia of the forest-bed from that of the pliocene (Am. Jour., April 1873).

The hint thus given to geologists in India is a very strong one; and the matter would scarcely have been worth notice but for the apparent sanction recently given to Falconer's words. We are in a manner bound to reject Falconer's criterion as such; and it only remains to be seen whether in some non-regulation sense the Narbadá deposits, and with them the old alluvium of the Gangetic plains, can be of pliocene age. It is of course conceivable, albeit in contravention of the harmonies of nature so far as known, that the mammalian fauna might be very strongly in favor of the position taken up by Falconer. Although the fossil shells all belong to species now living in the neighbourhood, the mammalian forms might (at least in argument) be of such antique types as to bear down the standard of the shells. Nothing of the kind, however, is the case. Falconer repeatedly insists, on the one hand, upon the perfect distinctness of the Narbadá fauna from that of the Sivaliks, and on the other hand, upon its strong affinity to living forms. He speaks of the Narbadá fossils as "in time only a little ahead of existing species" (op. cit., Vol. I, p. 21). He nowhere says that the Narbadá fossils are in any specific sense pliocene; but only, without any attempt at precision, that he calls the deposits pliocene because the mammalian fauna is intermediate between the miocene of the Sivaliks and that of the existing period. It is a great testimony to the authority of Falconer's name that an innovating opinion, without even an attempt at defence, should have met with any consideration. I do not, indeed, presume that Falconer's statement of age has ever received much countenance from students in Europe or elsewhere; but since an apparent approval of it has been issued by a high authority in India, it is well, on so fitting an occasion as the present, to examine the merits of the case.

As regards fossil man in India, Falconer's speculations were based a good deal upon biological assumption and geological misconceptions. It is not quite certain that *à priori* the oldest marks of intelligence that can be called human are to be looked for, as Falconer tells us, "in the great alluvial valleys of tropical or sub-tropical rivers." If the analogy of historical times may be taken into account, it would not be under conditions favorable to nakedness and laziness that we should expect contrivance to be born. We may indeed find the most monstrous form of the ape in the deposits of tropical regions; but it may be quite possible we should look for the earliest trace of humanity in the regions now most favourable to its development.

Mixed up with Falconer's mythical, biological and physico-geographical speculation upon the cradle of the human race in India, there is frequent very vague mention of geological conditions; and here we come upon his weak point. It is an excellent example of a confusion very commonly made—showing how a man may be in the first ranks as a palæontologist, and in that sense a geologist, and yet possibly be a very poor geologist in the stricter and primary sense of the word. Although Falconer's clear instinct of observation led him to the broad conclusion that the Sivalik strata were formed of débris conveyed through the existing river-channels (op. cit., Vol. I, p. 8), and deposited along the base of the mountains, it may almost be said that he never made a geological observation in any particular sense of the action. The most amazing instance of this appears in the explanation he gives of the absence of lakes along the base of the Himalaya, as compared with the Alps. He tells us (op. cit., Vol. II, p. 650,) that for ten or twelve years he puzzled over this problem on the ground; yet he accounts for the absence of lakes along the base of the Himalaya by there never having been glaciers to prevent the silting up of the basins. The absence of the basins themselves seems never to have occurred to him, although all the Himalayan rivers are rock-borne torrents in the region of the missing lakes.*

As more directly bearing upon the point before us, it would seem that, in the absence of such conspicuous evidence as the marine boulder-drift of Europe, separating the ossiferous valley-deposits from all the tertiary formations, Falconer failed to observe the very marked stratigraphical features that do occur. He speaks of there being no break visible in the tranquil succession of deposits; that "the present physical order of things, modified only by alterations of level, by upheavement and depression, could be traced back in an unbroken chain to the ossiferous strata of the valley of the Narbadá and of the Sivalik hills" (op. cit., Vol. II, p. 576, and Quar. Jour. Geol. Soc., London, Vol. XXI, 1865, p. 386); he constantly speaks of the Sivalik hills as "an upheaved portion of the plains of India." All this is exceedingly inaccurate and misleading. I have added many proofs to at least one point of Falconer's description, that of the distinct connection of the Sivalik deposits with the present local mountain-features; but the most cursory examination reveals to the geologist great gaps in the series of deposits. At Hardwar, a place well known to Falconer, the old alluvial clay of the plains is found resting upon a deeply denuded surface of vertical topmost Sivalik strata. The relation is stratigraphically similar, and probably nearly historically corresponding, to that of Loess of the Rhine to the Molasse of Switzerland. There is full evidence, too, that the glacial period was sensibly felt in these regions: in the Kangra valley, where a range of considerable elevation (the Dhaoladhar) occurs close to the edge of the low hills, I found unquestionable glacial erratics scattered over a surface of the Sivalik formations, at a present elevation of 3,000 feet above the sea (Mem. Geol. Sur., India, Vol. III, p. 155). I do not doubt that if we could fetch up a meridional slice of the Gangetic plains, we should find deposits representing the whole interval indicated; and it is not improbable that the series may yet be picked out from outcrops in different parts of India. What I want to show is that the two terms of the series we now have hold of—the old Gangetic alluvium and the Sivaliks—are very wide apart; and so, that the Sivaliks being older pliocene or upper miocene, the other may be ever so recent.

If we make any attempt to gauge the age of the old alluvium from the other side, we are led pretty much to the same result. All purely geological computations are estimates of work done; and we have the immense advantage of knowing that the operatives never idle, or never even take rest. The final appeal for the antiquity of the human remains in the valley-gravels and cave-deposits of Europe is not to the little-known laws and conditions regulating the extinction of species, but to the mechanical work done in altering the features of the country, in excavating wide valleys, or in laying out broad plains subsequent to the date of those remains. It is quite true that the result here, too, is only an approximation within wide limits; that the independent variables of the problem,

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* It puzzled me to think upon whose observation Sir Charles Lyell could have adopted such a view as this, as stated in his "Antiquity of Man" (p. 319). The puzzle is now cleared up. If Sir Charles, as Falconer supposed, annexed information without acknowledgment, he did not always gain by the transaction.

while largely affecting the result, can only be indirectly conjectured. For instance, a change of levels would greatly affect the eroding and depositing power of rivers; or a change of climate and of rainfall, with perhaps the addition of severe frost, would have a like disturbing effect upon the work done, without our being able to assign the amount of those by-gone conditions. But taken all in all, reliable indications, and comparative, if not actual, measurement can be made.

The Narbadá valley, meaning that broad area of the river's course from where it leaves its gorge in the trappean plateau of Mandla near Jabalpúr, to where it enters its narrow gorge through the Vindhyan quartzites below Hosungabád, is about as unfavorable a case as one could select to exhibit symptoms of change. It is a rock-basin, a valley excavated chiefly, if not entirely, in crystalline and slaty metamorphic rocks, between two plateaus of little-disturbed sandstone-formations, the Vindhyan on the north and the Máhádévá on the south, and converted into a rock-basin by some oscillation of level. It would seem that the change was not rapid enough to produce a lake, for in all the sections now exposed coarse gravels occur. As soon as this basin had received the charge of deposits due to this change of level, and supposing no further earth-movement to occur, the change of features to what we now find would depend upon the eroding power of the river to lower the rim of the rock-basin, and thus gradually to bring under denudation the deposits it had so lately laid down. If then we could fix the maximum thickness attained by the deposits, and also the rate at which the river can lower its gorge of discharge, we could assign something like actual dates for the successive phases both of denudation and of deposition, on this supposition of normal conditions, without interference of crust movements or other occasional forces. The process is now going on. The river at least cuts faster than pluvial denudation can work in lowering the general surface, for its bed is now some 80 to 100 feet below the level of the adjoining plains. There is nothing to suggest that the depth of the valley-deposits ever much exceeded what we now find. The plains deposits never extended into the valleys of the Sátpúrá, some of the minor streams from which are still accumulating materials upon the deposits of the main valley. There are nowhere any signs of high-level deposits, along the borders of the basin, whether remnants of a former phase of denudation of the actual valley-formation, or (like the ossiferous gravels of Northern Europe) remnants of deposits formed in a more ancient shallower rock-valley. The ossiferous beds of the Narbadá seem to be simply a member of the last and only valley-deposits, which have now for a long period been undergoing denudation. But I know of nothing to suggest that the change from deposition to erosion supervened at a time much prior to the 'recent' of the geological scale.

The only debateable stratigraphical point upon which a stand might be made, is whether unconformity occurs, indicating a general and possibly a great interruption of deposition between the ossiferous beds exposed at or near the present level of the river channels and those above them. I have examined many sections with a view to testing this supposition, but I have failed to confirm it. One often finds local unconformity—coarse gravel upon a weathered surface of stiff clay; but these are no more than must occur in the normal process of formation of river deposits; and most frequently it is impossible to detect any break in the section. The fossils, moreover, occur largely in the gravels above this supposed unconformity, without any sufficient grounds for supposing them to have been washed out of the clays. Thus, then, there is nothing like a corresponding amount of evidence for work done here since the age of these bones, as there is in Europe for work done since the formation of the ossiferous gravels and cave-deposits; although the permanent staff of operatives is much more powerful in the former case. Every season there occurs in the Narbadá a rise of from 40 to 70 feet, with a stream of great force. It is, as I have said, impossible to make an exact comparison, on account of the undetected influences that may have been at work on either side to accelerate or to retard. I only wish to point out that there is no presumption, either palæontological or mechanical, that these Narbadá deposits are older than the late Pleistocene.

If we turn to the great Gangetic valley, the old alluvium of which Falconer ranked with the Narbadá beds, the physical arguments lead us to a like conclusion. Here we have not to deal with a rock-basin; and the conditions are more appreciable. In the upper part of its course the Ganges cuts a broad abrupt valley, 60 to 100 feet below the level of the adjoining plains. In the lower region of the plains the denudation has taken a wider sweep; the old alluvium has for the most part been removed, isolated remnants of it only being found; and those, at least towards the modern delta, are being enveloped in the encroaching deposit of its alluvium. On the whole, the features of denudation in the Ganges valley seem to imply that this action was brought about by the subsidence of a former delta of greater extent than the present one, not by an elevation of the mountain region. Along the upper edge of the plains, the minor mountain-streams are still massing deposits continuously over the old alluvium; and in some of these recent torrential accumulations a fossil Hindú village has been dug out. If we now turn to our comparisons, it is evident that the signs of change and of work done here are nothing like so great as that recorded of the Rhine and the Danube in their valleys within post glacial times. Or absolutely, even stretching to the utmost the legitimate assumption of comparative stability of conditions in India, we can hardly reduce our estimate of the necessary duty of such a river as the Ganges, during the period allowed by a minimum computation for the lapse of time since the glacial period of Europe, to the amount of work I have indicated. So that here again the opinion obtrudes itself, that these old ossiferous alluvial deposits are not more ancient than the late Pleistocene.

From the description given of the implement-bearing lateritic gravels of Southern India by my colleague Mr. R. Bruce Foote (Quar. Jour., Geol. Soc., London, Vol. XXIV, p. 484, 1868, and Mem. Geol. Surv., India, Vol. X, 1872), I should think they may be as old as the Narbadá gravels.

H. B. MEDLICOTT.

July, 1873.

The shells of the ossiferous deposits.—The shells Mr. Hacket has placed in my hands for determination are all of them species, known to occur in the ossiferous gravels of the Narbadá, a list of which is contained in the Memoirs of the Geological Survey of India, Vol. II, page 284. They are all of them in the mineral condition observable in the shells from these ossiferous beds, and some of them are embedded in the ordinary matrix of many of the fossils of the group, a gravel strongly cemented by lime.

The most numerous and characteristic shells are Uniones, of precisely the same species and varieties as those now living on the spot, and it may be incidentally added, that no molluscous species is known to be included in these ossiferous beds which is not now living in the valley, though many species now living, have not as yet been detected in the gravels, which is a fact not without interest when the revolution is considered which has been wrought among the vertebrata since the days of the Hexaprotodon and Tetraprotodon, which, with numerous other pachyderms, proboscidians, and ruminants, then roamed over Central India, and disputed with man for mastery in the primeval world.

Associated with the Uniones, occur also Bulimus pullus, Gray; Melania tuberculata, Müll.; Planorbis convexiusculus, B.; Lymnæa acuminata, Lam. (?); and a Corbicula, probably Corbicula Cor, Sow.

Three species of Unio occur in the collection, U. MARGINALIS, LAM.; U. CÆRULEUS, LEA; and U. CORRUGATUS, MULL., which last embraces four distinct races, usually classed as species by most authors, but which, after some study of the Indian forms of the group, I incline rather to treat as local and permanent races, thereby reducing within manageable and natural limits the crowd of shadowy species, with which the literature of the group is burdened.

U. MARGINALIS, *Lam.*

This species is not uncommon, but is not so finely developed in proportion, in the ossiferous gravels, as the others, neither does it seem to occur quite so well preserved, nor to obtain the same weight of valves as in the other species, in which respect it simply agrees with the same species now living, which never displays any considerable thickening or calcification, under any conditions, however favorable. A perfect example, not fully grown, measures—

Breadth	57	Mills.
* Length	29	
Thickness	19	

Allowing for slightly broken edges in the fossil, these proportions closely accord with the living shell which I give from Manbhoom—

Breadth	61	Mills.
Length	31	
Thickness	18	

A second specimen from these beds, which may be considered fully adult, measures 93 mills by 43.

U. CÆRULEUS, *Lea.*

This species attains to a superb development in the ossiferous gravels, and merits nominal recognition, since it does not quite correspond with any variety hitherto separated. It may stand as var. Namadicus, Theob.

Two perfect examples measure respectively—

	a.	*b.*	
Breadth	56	46	Mills.
Length	31	24	
Thickness	23	17	

A precisely similar form is now living in the Narbadá, and differs less, from the type of the species, than some other races in other parts of India do. It agrees generally in the form of the teeth, in shape, color, and sculpture, save that each character is heightened in the Narbadá form. The lateral teeth often display a carneous tinge, and the sculpture of the valves is not only stronger than in the type, but covers a far greater area, both on the valves and their posterior slope. A very similar form, though departing more from the type as regards shape, inhabits the Kistná valley, where it attains a breadth of 60 mills—(the type measuring only 43).

U. CORRUGATUS, *Müll.*

It is a great pity that the type of that species of Unio, which seems to unite the greatest number of races in India, should be so ill characterised, difficult of identification, and apparently, with a good series under view, so aberrant from the more strongly marked forms, which strict zoological argument requires should be united to it. On this subject I would

* Length is measured at right angles to a line tangential to the ventral margin.

refer to Mr. Blanford's contributions to Indian Malacology in the Journal As. Soc., Bengal, for 1866, page 134, which contain a highly useful and condensed paradigm of our Indian Uniones.

Mr. Blanford is undoubtedly correct in saying that "both Lamarck's and Chemnitz's types (of Corrugatus) are quite distinct from Benson's U. favidens, which has been confounded with them," but with a very large series before me, I consider that this distinction is a *racial* one, not a *specific* one.

If the rules of priority would have permitted it, I should have preferred, as the more natural course, to have taken Benson's U. favidens as the type of that species round which so many races or sub-species cluster; but as this cannot be, U. favidens must stand as a race perfectly separable, but still only a race of the wretched, ill-nourished U. corrugatus, Müll., for the epithet "*tenera*" applied to any of the forms of this robust species, stamps it as an abnormal individual, impoverished by unfavorable local conditions, and subjected to deficient or imperfect alimentation.

That the utmost diversity exists between the races which I unite under U. corrugatus may well be, since without pretending to anything like a complete knowledge of all the forms of this species throughout its entire Indian range, there must still be admitted sixteen separable races, exhibiting very variable degrees of difference from each other; even after excluding *U. lævirostris* of Benson as a synonym of *U. Nagporensis*, Lea, and uniting *Nagporensis*, Lea, with Wynegungensis, Lea, with which it is essentially identical, or too trivially distinct to be separated, judging from a large series of both forms.

U. CORRUGATUS, *Müll.*

1. Var. triembolus, B.

This form occurs very fine, both living and fossil, in the Narbadá.

A fossil specimen measures—

Breadth	66	Mills.
Length	40	
Thickness	26	

and I have no living specimen which quite attains these dimensions.

2. Var. Wynegungensis, Lea.

A stout trigonal and elongate form, which approaches the *U. lævirostris, B.*, seems equally common with the last, and passes into it.

A fossil specimen measures—

Breadth	73	Mills.
Length	39	
Thickness	27	

And in this case also I have no living specimen which equals these dimensions, my largest specimen of this type from the Kistná only reaching 60 mills.

3. Var. Indica, Sow.

This well marked form occurs both living and fossil; one of the last collected by Mr. Hacket measuring—

Breadth	30	Mills.
Length	27	
Thickness	19	

This is not a large race, as a fine recent specimen from the Narbadá only measures 41, 34, 21 mills. It is mainly confined to the Narbadá, though I have it also recorded from Rajpútana.

4. Corrugatus, Müll.

The preceding forms pass into one, which in the young state closely approaches the type, save that it is a stouter shell.

There is, moreover, no fixity as regards the sculpture on the valves, so far as the extent covered by it, still the general facies is that of the type, which, according to Mr. Blanford, would seem more common in Southern India than in the Gangetic* basin. A fossil specimen measured—

Breadth	27	Mills.
Length	20	
Thickness	12	

July, 1873. W. THEOBALD.

NOTE ON THE BARÁKARS (COAL-MEASURES) IN THE BEDDADANOLE FIELD, GODÁVARÍ DISTRICT, *by* WILLIAM KING, B. A., *Deputy Superintendent, Geological Survey of India.*

The question as to the existence of coal in the Godávarí District, and indeed in the Madras Presidency—for the area under consideration is the only known one of coal-bearing rocks in the British territory to the south of the Godávarí river—is still as full of obscurity as it was when I drew attention to the Beddadanole field last year. I have had, during this season, another opportunity of examining the ground most closely, but without success; and this search was so close that it does not seem possible that any outcrop of coal will ever be found by surface searching. Any further exploration must, therefore, be made by boring, and I am not without hope that coal may then be found.

2. The most important point, and in fact the only tangible one to be relied on, is that the rocks of the Beddadanole area are *Barákars;* that is, they belong to the lower member of the DAMÚDÁ SERIES, or the coal-bearing rocks of India. It is true that no seam of coal is visible, but this does not at all necessarily imply the non-existence of coal.

3. To try and show that coal may exist in this field, I shall compare it with other adjacent fields, *viz.*, that to the north-west, on the Godávarí below Badrachellum; and the Singareny coal-field to the westward, in the Nizam's dominions. In the first of these, though it was reported by Colonel Haig to Mr. W. T. Blanford that coal was said to have been found down there, no coal was to be found at the place; indeed, the borings afterwards put down would seem to show that coal could not occur at the surface. At any rate, the rocks were seen to be DAMÚDÁS; and borings revealed seams of coal. These are, however, not of much extent on the British side of the river, though they are probably large enough on the Nizam's side, as I have since found that an outcrop of possibly the same beds shows at some twenty-five miles to the south-west.

4. As regards the Singareny coal-field, I can compare it more closely with that of Beddadanole, having likewise again visited it this season, when it is now being thoroughly examined by Mr. Heenan, the Superintendent in charge of the Nizam's coal-fields. The only difference of outward circumstances, as regards the present enquiry, between this and the Beddadanole field is, that coal did show at the surface in the former, though only in the most fortuitous way. Otherwise, the series of rocks (*Barákars*) in each field are identical

* For the information of Naturalists at home, I may as well add that the Narbadá does not belong to the Gangetic basin.

in every way, in their appearance, constitution, and mode of occurrence. There are plenty of outcrops of rock over this Singareny area where one might expect that seams of coal, if they existed, might appear at the surface; but such is not the case; there is only the one large "pot-hole" hollowed out in the low ridge of sandstones in the bed of the river with the seam of coal showing at the bottom. Nevertheless, since the borings have been put down by Mr. Heenan, not only has the first found seam been traced in other parts of the area, but three more have been struck, one above my seam and the others below. So that here we have a field with at least four seams of coal, the lowest found as yet being a very thick one, and having its strata so laid down that all these seams ought to crop out at the surface, whereas only one is just exposed. Outcrops of all the seams do probably exist; but, as would be likely, owing to the coal being cut into and washed out at these places by the weather and the streams, they are either now covered up by sand and débris gathered between the exposures of the harder beds, or are hidden by the settling down of superincumbent strata.

5. This concealment, or washing out of coal outcrops, may equally exist in the Beddadanole field, as, it is hardly necessary to state, there are numerous spaces in the nullahs between the exposed rock masses which are filled in with sand, though, as a general rule, the sandstones are very well and frequently exposed. Again, the lie or dip of the strata is very low, on the average about 5° to the westward, and they undulate to some extent; while the general surface of the area occupied by the *Barákars* is flat; and thus the sandstones have not been deeply cut into by the streams, so as to show enough of the strata.

6. There is, besides, a physical feature of this area which seems to hold out some hope that there may be hidden coal. The field is traversed by a river of from 50 to 60 feet in width, which flows in the direction of, or with the strike of the strata, or along the outcrop, that is, nearly north and south, a course which, viewed with the rest of its route over the *Kámthi* area, is somewhat exceptional. This course of the river may be due in part to the existence of a band of softer strata occurring between the sandstones which show at rare intervals on either side of the river. Indeed, I think there can be no doubt that there is a band or seam of softer or more easily worn strata covered up by the sandy bed of the river; or we should have had rock cropping up at places in the channel. But boring alone will tell whether coal seams occur in this soft and denuded bed.

7. The exposed area of *Barákars* is, unfortunately, not extensive, being only about 5½ square miles. It is covered up immediately on the western side of the field by the great series (*Kámthis*, of Blanford) of red and brown sandstones, in which there is no coal, constituting the upland country of Asharaopettah (Nizam's dominions) and Jeelagoomilly, &c., (British territory) to the westward. There must, however, be a good spread, equal in area at least to that exposed, of the *Barákars* hading down underneath the *Kámthis*. I am led to expect that this *infra* Kámthi extension is larger than I originally thought, on account of the westerly dip and the great thickness (about 300 feet at least) immediately under the covering edge of the *Kámthis*. Also, as we may judge to some extent by the lie of these last towards Jeelagoomilly, there is a roll up again of the beds towards that village, thus forming a synclinal or depressed curve of the strata, indicative of an ancient valley, over part of which the Beddadanole *Barákars* were deposited. This same valley beneath the *Kámthis* appears to have opened out south-eastwards, leading to the inference that if the *Barákars* do extend any distance underneath, they would lie down this valley, rather than up or across it, and so be still in the British territory.

8. An indication of the possibly large extension of the *Barákars* underneath the *Kámthis* is shown some miles to the north-west; for, as already stated, I have lately found what certainly appear to be *Barákars* cropping out on the western edge of the great

Ellore-to-Badrachellum spread of *Kámthis* at a point some twenty-five miles south-west of the coal-field below Badrachellum, and which may be an extension of that field.

9. To summarise, I think it may be concluded—

1st.—That there is a likelihood of coal from the fact that the sandstones of Beddadanole are of the *Barákar* group.

2nd.—That there is some slight reason for suspecting that the Beddadanole river bed conceals coal outcrops.

3rd.—There is every expectation of the area, exposed and hidden, of the *Barákars* being at least ten square miles in extent, if not a great deal more, and that it lies in the British territory.

So that, should it be decided to try the field by boring, and I would most earnestly recommend this proceeding on account of the above three conclusions, though they be laden with conjecture, the crucial bore holes ought to be put down near the right or western bank of the stream, where they will run to a depth of over 200 feet before the coal-bearing strata are pierced. One bore-hole at about half-way down the course of the river within the field would be almost sure to strike coal if there be any in the field; though, even if this failed, another might be struck down about three-quarters of a mile further west, as the first bore-hole would only have pierced about half the thickness of the exposed field.

Details as to the character of the rocks, their lie, and the size and position of the field have been already given in the Records of the Geological Survey of India, Vol. V, part 4, 1872.

CAMP, GODÁVARÍ DISTRICT, *April* 18*th*, 1873. WILLIAM KING.

NOTES FROM A PROGRESS REPORT ON THE GEOLOGY OF PARTS OF THE UPPER PUNJAB, *by* A. B. WYNNE, F. G. S., *Geological Survey of India.*

The first two seasons during which the operations of the Geological Survey were extended to the Punjab having been devoted to the examination of the Salt-Range, the following one was, by order, chiefly spent in rapidly reconnoitering the country surrounding the upper plains of the Punjab, both on this side and, as far as possible, trans-Indus, in order to obtain a preliminary general knowledge of the complex geological features presented.

At its close lines of observation were carried through the Hazara district, and a closer examination was made of the Sir Ban mountain region, close to Abbottabád, which was found to afford an epitome of much of the geology of the Upper Punjab (see Memoirs Geological Survey, Vol. IX, Art. 3.)

At the commencement of the succeeding season, that of 1872-73, the detailed working of the one-inch maps of the Rawul Pindi district was taken up and carried on with one interruption, during which the Salt-Range was again visited, in order to obtain a special collection of its mineral products for the Vienna Exhibition of 1873.

With the valuable assistance of Dr. Warth, Deputy Collector at the Mayo Mines near Pind Dadun Khan, a series of specimens of several maunds in weight was formed and despatched to Calcutta. This included a block of rock-salt cut purposely from the mine, about two tons in weight; and amongst the others, a complete series of large specimens illustrating the geological structure of the part of the range overlooking Pind Dadun Khan, ; besides several specimens of newly found minerals from the Mayo Mines, such as Glauberite and Kieserite, varieties of pure potash salts, and others in combination with sulphates.

Specimens of the cubical salt of Kalabagh, the alum shale, gypsum containing quartz-crystals, and gold sand from this latter locality, were also added to the collection with the help of Mr. Wright, Collector of the Salt Revenue, and Dr. Warth.

At the same time efforts were made to obtain a block of trans-Indus salt from the mines of Bahadur Khel, which resulted in the addition of a 27-maund block of this salt to the collection forwarded by Captain Plowden, Assistant Commissioner at Kohat.

These two large specimens show the marked difference of colour between the clear white or reddish salt of the Salt-Range and the gray or dark-coloured trans-Indus salt.

It was during the progress of the Vienna collection at the Mayo Mines that the discovery of the potash salts was made, attention being called to their situation in the mines by the hardness of part of a band of 'Kullur' or impure salt through which a drift was being excavated. On examination of this, the band of potash salts was found to be 6 feet thick, partly pure and partly mixed (sulphates, &c.); but its further extension could not be at the time ascertained owing to its situation, while there was little or nothing in the general appearance of the potash mineral to distinguish it from the ordinary salt. Specimens were immediately subjected to a preliminary analysis by Dr. Warth, but the crystallography of the new found salts was a subject unapproachable for want of proper instruments for measurement. It is hoped that some of the perishable crystals put up in glass bottles may have reached Vienna in a state fit for examination.

The deposit will probably prove interesting, as the only one known within British possessions, and may become very valuable should the importation of these high priced salts into England from the Continent be interrupted. Dr. Warth suggests that it may eventually be found advantageous to work this deposit for the alum factories at Kalabagh. For shipment from India the transport of the salts would present no great difficulty by the wire-tramway from the mines to the banks of the Jhelam, and thence by water to Kotlee on the lower Indus or to Kurrachee.

In carrying out the detailed examination of the Rawul Pindi district eastward of that station, the hills were found to exhibit the relations of the "sandstone and clay" portion of the great outer tertiary belt, well known as the southern border formation of the geological system of the Himalayas. Here the lower, red, or Murree (or Subathu), beds pass upwards by alternations of red clays or shales and gray sandstones (locally distinguished by the Punjab survey-party as the "red and gray" series) into softer gray sandstones with clays of a more orange colour, the highest beds being a thick group of incoherent conglomerate rocks, previously known to exist on the Indus and at both ends of the Salt-Range proper, as well as in some other places. In the generality of cases this conglomerate group was found to present a gentle transition from the lower beds upwards; the pebbles, chiefly of crystalline rocks, after their first appearance increasing in number and size till the whole rock becomes a mass of small boulders or large pebbles slightly held together by an inconsiderable calcareous matrix. The rock is seldom found hard enough to show its own outcrop, and presents the greatest difficulty in discovering clear sections, though hills formed of it possess in their undulating pebbly surfaces a characteristic by which the conglomerate can be recognised from long distances.

Associated with this conglomerate group, and indeed throughout the whole of the arenaceous and argillaceous portion of the tertiary rocks of this country, are various beds, usually calcareous sandstone, conglomeratic sandstone, or a peculiar finely concretionary calcareous and earthy or sandy rock of a gravelly pseudo-conglomeratic appearance, often containing more or less numerously fragments of bones. In the upper and more conglomeratic portions of the series, these bones are frequently mammalian; while below, even to the base, and there associated with Nummulitic, or *Rotalina*-bearing, layers, the bones, rarely in a good state of preservation, are believed to be more commonly reptilian, as appears from Major Vicary's writings to be the case in the corresponding beds at Subathu.*

From Murree† southwards the general stratigraphical structure of the hill country is a succession of great waves commencing with an anticlinal curvature close to that station, the synclinals of the curves embracing some of the higher strata, form grand vertical cliffs, when largely composed of massive sandstones bedded nearly horizontally, as around the elevations of Karor and Nurr'h, very similar to the cliffs on the Indus at Dangote above Kalabagh.

Towards Jhelam the curves appear to become softer and more open, and some of the highest beds, the conglomerates previously mentioned, come in.

In the vicinity of Murree, and along deeply excavated valleys lying in a general direction north of east and south of west, overlooked by the northern slopes of the Murree ridge, the lower red tertiary rocks terminate; one side of these valleys being chiefly formed of the red rocks, and the other of contorted limestones and shales, towards which the Murree beds are frequently inclined. These are the main or striking circumstances of the positions of the rocks, which, however, when examined in more detail, are not found to be strictly limited to opposite sides of the valleys, small portions of the red beds being found in the limestone hill slopes, and a pretty constant rib of nummulitic limestone stretching from the Kooldunna hole (lying northwards from Murree) along the foot of the Murree ridge westwards by south.

The rocks on both sides of the junction-valley present the strongest evidence of disturbance; and faults, or lines of displacement, are numerous. Starting from Murree, red and grayish sandstones, with imperfect plant-impressions alternating with deep red clays, form all the slopes in a descending northerly direction, till the rib of limestone is reached. On both sides of this, calcareous nummulitic layers alternate with the red beds. And gypsum occurs more or less on the Murree side of the rib and close to it. Beyond the rib of strong dark limestone, red and gray sandstone and clay beds (forming the major portion of Kooldunna hill) predominate; and on the ascent of the opposite slopes of the Mochpoora chain, gray nummulitic limestone, sometimes crowded with small *Rotalinæ*, alternate with dark shales. But even here detached longitudinal masses of the red Murree beds lying parallel with the principal features appear to be faulted deeply into the limestone group. Further up on the Mochpoora ridge and beyond it, northwards, jurassic and triassic rocks appear, in the manner shown in Dr. Waagen's paper on the neighbourhood of Khairagully and Chumba Peak (the result of a joint examination of the locality with the writer, see Records Geological Survey, Vol. V, page 15).

In studying the junction of the more mechanically formed tertiary beds with those consisting largely of nummulitic limestone along the Murree valleys but little value can be attached to the distorted dips of the beds; some traces of a former regular succession from the limestones of the Mochpoora ridge upwards into the Murree beds being perhaps slightly indicated; and the present positions of the rocks may be, for all that is seen to the contrary, freely and fairly attributed to the united results of folding and faulting; traces of the latter being too prevalent for faulted displacement to be excluded from consideration in the effort to account for the existing state of things.

Beyond the Murree region westward, the junction of the Murree rocks with the limestones to the north presents very much the same general character, the gypseous zone being

* Quar. Jour. Geol. Soc., London, Vol. IX, p. 72, 1853.

† Koh Mari (*i. e.*, Mari mountain) is the name of this locality, the a having the sound of ŭ; hence the adoption here of the common phonetic and more popular spelling.

traceable at intervals in the position first described. The outer limestone rib expands and is flanked by another similar band, the alternation of limestones and Murree bed being apparently produced by faults; at least it has entirely this aspect in the neighbourhood of Shah Durah.

Further west a strongly marked line, also bearing the strongest resemblance to a fault, diverges north of Rawul Pindi from the main line of junction in the direction of the Margulla pass, on the Peshawur road. Along it the Murree beds are brought against the hill limestones, here including both nummulitic and jurassic rocks (with perhaps an intervening cretaceous band). The jurassic beds contain a very marked layer made up of large *Trigoniæ* resembling *Trigonia Ventricosa*, Kraus, with some smaller forms; while beyond Margulla *Ammonites* and *Belemnites* are also to be found. As usual along the contact of the limestones and finely detrital rocks, the red Murree beds are often either vertical or highly inclined towards the limestones. The actual junction surface, from being situated at the foot of the hills, is concealed; and the branch line disappears beyond Margulla, the low ground in that direction being heavily covered with detrital deposits, and the small hills in which the spur from Mochpoora terminates being formed of the nummulitic and jurassic limestones, shales, &c.

The main line of boundary between the limestones and the Murree group continues from the place of divergence north of Rawul Pindi westwards, marked at first by low limestone hills at the foot of the Mochpoora ridge or spur, which gradually increase in height and width, till they form the chain of the Chita Pahar mountains, abutting on the Indus several miles southward of Attock, near Nilab Gâsh. Beyond this the same feature continues westward along the Affreedi hills passing just north of Kohat; on this line also the gypseous zone seen at Murree and more largely developed at Tret, as well as lower down in the plains, may be recognised at intervals. In connexion with this gypseous zone, and sometimes in the gypsum itself, are sulphurous springs, which bring petroleum or mineral oil to the surface; this also frequently occurs slightly impregnating the adjacent limestones.

Along the whole of this line of junction within British territory, from near the Jhelam* to the Indus and beyond it, *the positions* of the two sets of rocks furnish nothing decisive in the way of evidence to prove which is the older: and in many places the inference from dips would be directly contrary to fact. The nummulitic limestones of the hills being, however, found in some spots close to the boundary passing downwards into jurassic rocks (with or without a thin intervening band which may be, but is not here proved cretaceous), all doubt of the true position of the red rocks is removed; and their close association with certain layers containing nummulites on the south side of the junction fixes their age with certainty.

It will then appear that on one side of the general boundary there are red Murree beds containing layers of nummulitic, calcareous, or earthy rock, while on the other there is a mass of limestones and shales of nummulitic, jurassic, and perhaps some of cretaceous age. The junction itself presents all the features of a fault or band of several faults, and the only reason why it should not be unreservedly accepted as such is that, in the Simla Outer-Himalaya examined by Mr. Medlicott, the same tertiary sandstones and clays as occur in this country have been divided by that gentleman into groups, the boundaries of which, having the same general resemblance to lines of fault, are in most cases believed and in some are proved by him to be lines of unconformable contact and not of faulting (see Memoirs, Geological Survey, Vol. III).

* The continuation of this line in the valley of the Jhelam has been recently seen. It makes a sharp bend northwards near Kohala, and runs along the foot of the Mochpoora and Huzar hills on the right bank of that river, crossing the bend of the stream near Mozufferabad in Cashmere. Here it bends to south-east, following the course of the Jhelam still on the right bank, but far up on the flanks of the Kyj Nag range to Ooree, where it crosses the river and takes a course along the outer flank of the Peer Punjal chain. Slates, metamorphic rocks, and occasionally limestones, are seen in junction with the red Murree rocks, the line still resembling one of faulting.

There can be little or no doubt that the red Murree rocks are, or represent, the nummulitic Subathu beds of Mr. Medlicott, which, in the Simla districts, rest unconformably upon limestones and slates of unknown age; while in this part of the Punjab nummulitic rocks occur on both sides of the junction. It would be manifestly improper to ignore this line of junction and carry the nummulitic boundary across it while it presents so marked a feature. Without some palpable local evidence, it would be equally improper to indicate an unconformable break in the nummulitic series; but as this might possibly exist together with the faulting and displacement which seems to have occurred, it is proposed to express the line upon the map as one of fault, at least provisionally or until the whole country has been explored, with the hope that something further may be found to explain the difference between the present aspect of the junctions here and in the Simla regions.

With respect to the other junctions of Mr. Medlicott, showing repeated unconformity in the ascending series between his tertiary sub-groups, the difference in this district has to be noticed. The description of the rocks would point to their close identity; but in the Simla region the succession appears to have been interrupted; while here the most apparently regular sequence and conformity has only been observed southward from the limestone hills, crossing the country in an east and west direction north of Rawul Pindi; the red Murree rocks, either vertical or dipping at high angles, reach down to the latitude of that place, interrupted only by a long ridge of nummulitic limestone of the hill type, which, lying west by south from the station, appears to occupy a space between two converging lines of fault. Southward of this the Murree beds pass up (still retaining their high dip) into the 'red and gray' series in which the first bands of conglomerate appear. In these conglomerates, notwithstanding the parallelism of the beds, are enclosed limestone pebbles, proved by the small *Nummulites* which they contain to have belonged to that formation; but where the break occurs during which the denudation of the older rock took place it is at present impossible to say.

Above the 'red and gray' rocks come others with more of orange colour in the clays; and these pass up, as already stated, into the conglomerate group. The upper portion of the series in the neighbourhood of these comglomerates has been identified from its fossil bones with the Sivalik group by the late Dr. Falconer (paper by Mr. Theobald on the Salt-Range: Proceedings, Asiatic Society, Vol. XXIII, 1854, page 677). So that in this district the Subathu and Sivalik groups of the Simla region may be considered present; while many of the intervening rocks would answer to the description of the Nahun beds of Mr. Medlicott. The peculiarity of the frequently interrupted succession in that region, contrasted with that almost complete sequence here, would indicate considerable difference in the physical causes which affected the deposition of the tertiary rocks in one region as compared with the other.

It is difficult to estimate the thickness of these sandy and earthy tertiary rocks in consequence of the numerous contortions, and the all but positive certainty that in many places, where the beds are apparently steady at high angles or vertical, the arches of numerous folds are concealed. The fact of this contortion impressed Mr. Lyman (Report on the oil regions of the Punjab) with the idea that the thickness of the whole was much less than it would appear. But while it is of course possible, it is at the same time not easy to imagine, all these contortions lying exactly so that the plane (or approximation thereto) of the surface of the country should intersect them without exposing either recognisable repetitions of each group or some of the next underlying strata. The absence of these cases seemed to point to an enormous accumulation of the beds, notwithstanding their convolution; and this is rendered more probable from an observation lately made in the Jhelam valley within Cashmere territory, where part of the red Murree group, dipping regularly at an angle of 45°, was estimated to have a thickness, on the flanks of the Kyj Nag range, of about one and a half miles. The dip in this case also was (obliquely) towards the adjacent older rocks.

Besides the tertiary conglomerates previously described, there is another very extensive group of more recent age, the pebbles in which are largely composed of limestone; it is very well developed about Rawul Pindi, and spreads unconformably over great tracts of the country, alternating with drab or pale pink or red or purple brick-clays, and frequently associated with calcareous tufa or calcareous conglomeratic solid massive beds called by the natives '*Koonjoor*.' The basal part of this group in immediate contact with the tertiary sandstones is often formed of strong beds of calcareous tufa or travertin.

These conglomerate and clay rocks are at present considered lacustrine, or formed by wandering river action; and their boundaries, if shown upon the maps, will be extremely intricate, as they are often cut through by the nullahs exposing the rocks beneath.

The superficial covering of the country is largely derived from the clays of this group; and where clays, shales, and such soft rocks abound, there is no lack of material to form a frequently thick deposit, the result of atmospheric action.

SRINUGGUR, *Cashmere, May 25th,* 1873. — A. B. WYNNE.

COAL IN INDIA, BY THEO. W. H. HUGHES, C. E., F. G. S., *Associate, Royal School of Mines.*

I trust it will not be uninteresting to the readers of the Records of the Geological Survey to have placed before them a few brief remarks which will tend to widen the scope of their knowledge with respect to our Indian coal-fields, and enable them, when the subject of coal is discussed, to uphold the claim which India enjoys to rank amongst the great coal-bearing areas of the world. It will doubtless surprise many to learn that both in the superficial extent of its coal measures and associated rocks, and in the actual amount of its coal, India is surpassed by few countries; and that with respect to the size of some of its seams it stands pre-eminent in the literature of mining.

Even that land of monstrosities and natural wonders, the United States of America, can exhibit nothing to compare with the gigantic seams of the Hengír and Damúdá coal-fields, some of which are one hundred and sixty, one hundred and twenty, and a hundred feet thick. These figures of course do not imply that there is this amount of pure coal; the term seam is used in its technical sense, as embracing the whole sum of coal and partings in a given bed.

Until within the last few years the information regarding our coal-fields was scanty and imperfect; but of late, the action of Government and the labours of the Geological Survey have been more in accord with the requirements of the country; and the result is that, although our data are still far from being complete, yet we can form an approximate estimate (which may be accepted as a nucleus for future computations) of the area of our probable coal supplies, their geographical position, and the quality of fuel which they can yield.

And in the first place with regard to our probable coal supplies, it becomes more and more important, in the face of the steadily increasing price of English coal, to enquire whether India will be able to furnish the fuel so essential to the further development of those industries which the energies of Englishmen have in some instances created and in other cases fostered to a maturer growth. In answer to this question, around which centres the chief interest in this article, I think it will be sufficient if the reader glance at the subjoined table of areas to feel satisfied on this point.

The same method of calculation has been acted upon in regard to India, in the determination of the superficial extent of its coal-bearing areas as that applied to other countries, and the length and breadth of the tracts over which coal rocks *may be presumed* to extend have been multiplied to give the number of square miles.

Taking the coal-fields already partially and in whole examined, and allowing for the unsurveyed portions of Central India, Assam, Burmah, and the Tenasserim province, &c., we may safely assume 35,000 square miles as being within the mark.

In order to show how these figures are arrived at, I append the following table. Besides, however, enumerating the different Indian areas, I have added a list of such countries the areas of which I have been able to compile from various sources of reference; and I have also noted the countries in which coal is known to occur, but concerning which there is no knowledge of the extent of their coal measures. By thus enlargening the table, I hope its usefulness for the purpose of comparison will be increased:—

Table of Areas.

Name of country.	Area in square miles over which coal-rocks may be presumed to extend.	Remarks.
India	35,000	*This mileage is made up as follows:—* Godávarí area (including its affluents) ... ... 11,000 Son ... ... 8,000 Sirgújáh and Gangpúr area ... ... 4,500 Assam ... ... 3,000 Narbadá area (including its affluents) ... ... 3,500 Damúdá... ... ... 2,000 Rájmahál area ... ... 300 Unsurveyed and uncomputed areas ... ... 2,700 Square miles ... 35,000
United States	500,000	The productive area of coal is much less. Professor Hitchcock estimates the area of the true carboniferous system at 230,659 square miles.
China	400,000	This estimate is not thoroughly reliable, but it is certain that there is an enormous coal-bearing area in China.
Australia	240,000	In New South Wales, the coal area is said to be 120,000 square miles. In Queensland the same area is supposed to exist.
Russia	150,000	This area is probably far below the real extent of the Russian coal-formation.
India	35,000	
British America	18,000	
Great Britain	12,000	Mr. Hull gives 5,431 square miles as being stored with coal to a depth of 4,000 feet.
Spain	8,000	This estimate is vague. Some authorities give 4,000 square miles, and others 2,000.
Japan	6,000	
Germany	3,000	By Germany is meant all the German-speaking provinces, except those under Austrian rule.
France	2,400	
Austria	2,000	Some of the Austrian brown coal seams approach the Indian seams in thickness.
Belgium	520	
Trinidad	318	

Borneo	The coal of Labuan is reported to be of good quality, and very fair coal occurs in the Sarawak territory.
Brazil	There are large coal-fields in this splendid country.
Cape Colonies	There is coal in this as in so many other dependencies of the English crown.
Denmark	Only a small quantity of coal is raised in the island of Bornholm.
Falkland Islands	These islands contain coal.
Greece	Lignites have been worked at Koumi.
New Granada	The coal of this country is said to be cretaceous.
New Zealand	The calculated amount of coal in New Zealand is four thousand millions of tons.
Persia	A large area of coal is stated to occur.
Portugal	A small coal-field exists near the mouth of the Douro.
Zambesi	This coal was brought to light by Livingstone.
Zanzibar	Some coal, said to be Zanzibar coal, was analysed by Mr. Tween, of the Geological Survey, and gave— Carbon ... .. 42·4 Volatile matter ... 30·4 (moisture 4 per cent.) Ash ... ... 27·2 100·0

The geographical positions of most of our fields have been already indicated in the "Coal Resources of India" compiled by Dr. Oldham and published in 1867. It was pointed out in that work that a chain of coal-fields extended across India from near Calcutta to the Haidrabád Assigned Districts (the Berars), lying within the 20° and 25° parallels of north latitude; that other fields occurred in the valley of the Godávarí and its affluents, and that throughout Assam, Burmah, and the Tenasserim province there were deposits of coal.

Some of these fields lie in the route of direct railway communication between Bombay and Calcutta, and of course would prove useful sources whence to draw fuel. But the geographical positions of others again are such that they will probably not answer any useful purpose for many years to come.

The quality of Indian coal is usually denoted by the adjective *bad*, but I believe this word has been too freely used. The average of Indian coal is certainly inferior to that of English; but there are many seams in the Ráníganj field, and more notably one or two in the Karharbári field, which yield very good coal indeed. Much of the Assam coal is said to be excellent. And it is justifiable to entertain the idea that if our fields had been more extensively opened out and worked to a greater depth, coals would have been met with of a quality sufficiently good to make us cautious in regard to the indiscriminate use of the word bad. Several attempts have of late been made on one of the short lines of the north of England to burn inferior coals in the locomotive engines; and I have been informed by a gentleman personally interested in the matter that the experiment in which he was concerned proved very successful. The principal modifications of existing arrangements are, I believe, in connection with the grate and draught, but there are minor ones with which I am not acquainted. Nearly the same amount of work, it is stated, was done by the inferior coal as is at present done by the best locomotive coal. How important these practical experiments are in respect to India no one will deny, and I hope the day is not far distant when we shall profit by them.

CHANDAH,
1st January 1873.

ON THE SALT-SPRINGS OF PEGU, *by* WILLIAM THEOBALD, *Geological Survey of India.*

Prior to the occupation of Pegu by the British, a considerable manufacture of salt was carried on inland, from the somewhat feeble brine springs, which are so plentifully distributed throughout a large portion of the valley of the Irrawadi, more particularly along the eastern skirts of the Arakan range in the districts of Myanoung and Henzadah. Of late years, this manufacture has to a great extent ceased, and is now merely practised on a very reduced scale at a few spots, to supply strictly local requirements. The decay of this industry arises from the abundant supply of the article, now procurable, manufactured in the delta* from sea-water; and we may expect this sea-salt entirely to supplant that manufactured from the springs, as the system of traffic and barter, by means of itinerant traders, enlarges more and more, and the facilities for obtaining the cheaper article become greater, and, therefore, more appreciated. Even now, many spots are pointed out, from which salt was formerly obtained, but at which the precise locality of the wells, long since fallen in, has been forgotten, and every year makes it more difficult to gather information on this point, as the action of the seasons and the growth of vegetation combine to efface all traces of former workings. In some places skirting the hills, the plough now passes over ground where salt-wells formerly existed; and hence it is mainly in the localities where massive timbering was employed to support the sides of the wells that we can best judge of the number and importance of the old workings.

The wells vary in shape, being either round or square, usually the latter, from the greater facility of timbering the sides; whilst some are little better than rude excavations or enlargements of an original cavity, sufficient to permit the accumulation of the brine for convenient removal. Others again are sunk 10, 20, or 30 feet, and have their sides roughly, though effectively, supported by stout planks. In some instances (*e. g.*, Hlahndeng and Kadeng-mah-ngo), these planked wells are sunk to a small depth in the bed of a stream, and during the monsoon become filled with sand, gravel, and fresh-water, but on the season for active operations commencing in the cold weather or towards its close, it was customary to clear them out, when the brine would be found, occupying its own place, a short distance below the ordinary level of the bed of the stream.

The strength of the brine is variable, being often only feebly saline. This probably depends on admixture with surface water, as the strongest noted was yielded by the Sadwingyee spring, which was also most copious, and consequently the least obnoxious to admixture with surface water, which may be supposed often to affect the more feeble and sluggish springs. I may here remark that, though usually spoken of as brine *springs*, these springs are, in the great majority of instances, hardly entitled to the designation, having scarcely any flow. In the case of Sadwingyee, there is a copious spring. In the case of Nummayahn and Sahngyee there is a perceptible flow, and no more, accompanied by a somewhat copious evolution of marsh-gas, which keeps the pools turbid and in a state of constant ebullition. The more usual mode of occurrence of the brine, is among crushed or disturbed strata, especially harsh dark shales, in which the brine occupies cracks and pockets, and, on a well being sunk therein, trickles into it from the surrounding strata, but without causing an overflow. Mr. W. T. Blanford, in a memorandum on the salt-wells of the district of Henzadah (May 1st, 1861), points out thirteen different localities, the richest being that at Sadwingyee, which indeed may be regarded as the richest in the province, and of which I here quote his account.

"The appended list specifies thirteen† different localities in the district of Henzadah at which salt is known to have been worked. Of these, only three were at work at the time

* Imported English salt is now competing with the country-made article.

† Nos. 63 to 69, 71 to 74, 79.

of my visit, the principal of which was Sadwingyee, the spring at which place is probably one of the most productive yet known in the region. The flow of water in the well was carefully measured by my fellow assistant, Mr. Fedden, and found to be 57·15 gallons per hour, or about 1,370 in the 24 hours. By a rough experiment the water was found to contain 4,704 grains of salt to the gallon, so that the quantity of salt daily yielded by this spring amounts to 920 lbs. avoirdupois, or 8 cwts. 24 lbs.

"Few springs probably yield so largely as Sadwingyee, but it was not found practicable to ascertain the quantity procurable from any other. The water is so salt that it can be evaporated at once without previous partial evaporation by the sun. It is boiled down in large iron pans, placed in twos or threes, over an earthen fire-place, the method being somewhat similar to that employed in India for evaporating the juice of the sugarcane."

The pans mentioned in the above paragraph are shallow, extremely thin cast-iron pans, of English manufacture, of about 30 inches in diameter, and principally used in the preparation of the common 'jaggery' or unrefined sugar from the juice of the 'date,' 'fan,' or other palms. Earthen pots are also used for concentrating the brine, of an oval shape, with sides nearly an inch in thickness, and capable of holding between 3 and 4 gallons. In the delta, where salt is habitually made from sea-water, a somewhat different arrangement is adopted. A circular oven of brick is constructed, something like a large bee-hive, with holes at intervals to receive the oval earthen pots above described, to the number, perhaps, of as many as sixty in one oven, the ultimate concentration being, I believe, in the ordinary shallow iron pans, though this is probably a recent innovation.

The distribution of these springs is as follows:—Of 79 localities recorded in the accompanying table, 21 are situated within the area occupied by the newer tertiary strata of the province, of miocene age; 9 within the much narrower belt of country formed of unaltered, and comparatively slightly disturbed, nummulitic rocks; whilst most of the remaining 49 localities form a conspicuous band along the outer hills, on the eastern side of the Arakan range, among altered rocks, grouped comprehensively under the term Negrais beds, of, in part possibly, nummulitic age likewise.

No salt springs are known to me on the western side of the Arakan range, or on the eastern side of the Pegu range. The whole are, as far as is at present known, confined to the Irrawadi valley; though future exploration may possibly show that this remark only holds good within the area to which it more immediately relates.

The most easterly springs are those of Kadeng-mah-ngo and Pyeng-mah-choung, fifty miles to the south of the former, distant, respectively, sixty-seven and seventy miles from the Arakan range, and thirteen and eleven from the Pegu range, measured at right angles to their general direction. Seven miles south of the Pyeng-mah-choung springs occurs the spring of Toung-ngo, rising on the same north by west line of strike, and being accompanied by a copious evolution of marsh-gas. The Toung-ngo spring rises on a line of disturbance, as shown by the crushed and indurated character of the sandstones in its vicinity, and the lesser frequency of springs along this most easterly line of their occurrence may be partly attributed to the greater thickness of the newer strata, which they would here require to pierce before reaching the surface; and, partly, to their presence not having been so sedulously sought after by the natives, owing to the lesser demand for salt at such a distance from the river or lakes, yielding the great bulk of the fish from which the national gna-pee or fish-paste is prepared. Hlahndeng spring probably belongs to the same system, though situated a little off the direct line on which the others rise.

The second line of springs is that of which Nummayahn is the most important, and runs in a direction north by west, distant, respectively, thirty-two and forty-six miles from the Arakan and Pegu ranges. The On-nay-da-gyee spring near the frontier lies almost exactly on this line, which, if considered as one line, measuring from On-nay-da-gyee to Waddau-tha, is sixty-three miles in length, with a general coincidence of direction with the hill ranges bounding the valley.

On this line likewise is situated the spot known as Naht-mi or "the spirits fire," thirty miles north by west from Nummayahn, and which is merely a spot in the jungle from which marsh-gas issues through cracks in the soil, and becomes, from time to time, either intentionally ignited or accidentally during the prevalence of jungle fires. Above Nummayahn, in the river bed, there is considerable disturbance, as evinced by vertical strata, and it seems probable that all the springs of this group rise along one and the same line of fracture, probably a highly contorted anticlinal, though this may not be indicated by the appearance of the rocks at the surface, at the actual point of issue of the springs, which may mainly depend on local conditions, surface arrangement, denudation, and the like.

A little west of this line occur other springs (Nos. 8, 21, 9), which may or may not issue primarily along the same subterranean line of disturbance or fracture; but this is neither material nor possible to say.

Associated with this system of springs may be classed the Boolay, Laymyoung, and Tayzahn springs. The Boolay springs were simple wells sunk in sandstone at the mouth of the Boolay stream, but which have been long disused. The Laymyoung spring rises on the top of a low ridge forming mud pools from which a little marsh-gas escapes, much after the fashion of the Nummayahn springs, only much more feebly. Near the mouth of the Boolay stream, above where the road crosses, and close to the village of Kwonboolay, occurs the only hot spring known to me in Pegu, but it rises in the bed of the river, so that its temperature cannot be well ascertained, and sometimes it is entirely concealed beneath the sand.

The third line of springs is by far the most important, embracing probably several closely arranged parallel lines; and if we assume the Sahngi spring on the frontier to belong to this group, this line would seem to follow a curve, generally corresponding with that followed by the Arakan range. The Sahngi and Day-beng springs are situated in a line thirty-four miles long, with a general bearing north-west by north, with the Lengbhan and Shuagyeing springs a little on either side of it, and distant seventeen miles from the Arakan range. From Day-beng to Shah-si-bo the line is forty-two miles, with a bearing north by west, distant fourteen miles from the Arakan range, and marked by a perfect belt of salt springs. From Shah-si-bo southwards, the springs are rather more scattered, and run in a direction almost due south, the most southerly one recorded, No. 79, being one hundred and twenty-four miles in a straight line from the frontier spring of Sahngi.

This rich belt of springs is situated among a group of harsh dark indurated shales and sandstones; the induration being variable in amount, and never approaching metamorphism, properly so called, within the area immediately adjacent to the salt springs in question. Few or no fossils have been found in these rocks, certainly not within the above area, but their relation to the unaltered rocks of the district lends support to the view of their being possibly of nummulitic age.

In view, then, of the occurrence of these springs most numerously along lines corresponding to the general strike of the beds of the district, and of the direction, moreover, of the twin ranges which bound the Irrawadi valley; and having regard to the indications of compression and violent disturbance which the rocks in their vicinity often display; in view, too, of the association with them, on the same lines of strike, of the only hot spring in the province, and of spots whence issue both petroleum and marsh-gas, we may fairly assume that they rise along widely extended lines of disturbance, (anticlinal fissures most probably,) from the lower beds of the nummulitic or some still older group.

It may here be remarked that whereas the only known petroleum localities lie within the area of unaltered nummulitic strata, or of the newer Tertiaries, yet the greater number of salt springs lie below this horizon among the altered and presumedly lower members of the same group; a point which, if definitely established, as it seems to be, as far as regards the area hitherto subjected to examination, will not be without an important practical bearing in searching for petroleum, inasmuch as there is an idea prevalent that the presence of brine springs in this region is *per se* indicative of the existence below of the more valuable mineral. Having regard to the circumstances under which the mineral oils occur in America, there is nothing unreasonable in the supposition of a similar connexion existing between the brine springs and oil in Pegu, as is found in the new world—an idea strengthened, moreover, by the existence in the same districts of both oil and brine; but, as I have already pointed out, there seems no good reason for believing that, in Pegu, the same connexion between brine springs and oil exists as in the American oil-fields. On the contrary, it would seem that the reverse of what occurs in America is to be anticipated here. In America the connexion between the oil and brine is an established fact; the first petroleum obtained by boring having been accidentally obtained in 1819 "in sinking wells for salt in the little Maskingum river in Ohio," (Erni, "Coal-oil and Petroleum.") In Pegu, it would seem as though, if in sinking a bore, a copious brine spring were struck, this would probably indicate that the boring had penetrated to a horizon below that wherein the mineral oil was produced. In Pegu, as in America, the oil may rise to the surface with the brine, as the horizon of the napthagenic beds is higher than the sources of the brine, which is not the case in the American oil-field. But the non-association of the two in Pegu may, I think, be legitimately inferred from the fact of no indications of petroleum being known within the belt of rocks wherein the most numerous brine springs rise, as would hardly fail to be the case were the origin of the brine and petroleum in one and the same group of beds. That the co-existence, too, of brine springs and petroleum in Pegu is rather a fortuitous than a connected phenomenon (as it would seem to be in America,) is to some extent borne out by the fact of petroleum occurring in the Punjab in connexion with rocks of the same geological age as in Pegu, but without the accompaniment of brine springs, as in that province; so that our present experience may be summed up with the assertion, that whilst a copious discharge of brine and marsh-gas may not be without value in determining a site for sinking for petroleum, in ground occupied by rocks of the upper portion of the nummulitic group or any rocks above that horizon, yet the same indications are not to be relied on as of equal promise, within the area occupied by rocks lower in the series, or of greater geological age.

It only remains to add a few words explanatory of my classing these altered or hill rocks as 'Negrais beds,' or possibly nummulitic in part, after having, in my recent paper on the 'Axials in Western Prome,' included them in that group. When writing that paper, the age of these hill-rocks was quite problematical, and beyond the general absence of fossils in the limestones and the mineral character of the beds, so different from that of the recognised Nummulitics, there was little or no evidence to which group they should be assigned; and the balance seemed to tend towards their union with the older or axial group. During the following season, however, (1870-71), I accumulated evidence, of an opposite tendency, not only by a more extended examination of the ground occupied by them, but I had the good fortune likewise to detect Nummulites in one of the outcrops of limestone, alluded to by me in note at page 38 (loc. cit.), which I had not previously had the opportunity of visiting, thereby demonstrating the relation of a portion at least of these hill rocks, of hitherto uncertain age, with the newer nummulitic group, in spite of their often excessively changed character, rather than with the older Axials, with which they had been previously included. I must defer, however, a discussion of this question for another occasion.

CALCUTTA,
6th August 1872.

W. THEOBALD.

I append a list of springs, a great number of which are not included in the published map of the province. I have therefore spelt the whole on a uniform system as given below, adding the mode used in the published map, where it differs from my own. I have endeavoured to convey the sound, so that the word cannot be mis-pronounced through ignorance or ambiguity. The system is that already adopted in the naming of a very extensive collection of Pegu woods presented to the 'Phayre Museum', Rangoon.

Burmese names spelt on the following system:—

a	as	a	in	m*a*t	*ca*t
ah	"	a	"	f*a*ther	*ah*
y	"	i	"	s*i*n	s*y*ncopy
ei	"	i	"	n*i*le	n*ei*ther
o	"	o	"	p*o*t	l*o*t
oa	"	o	"	p*o*pe	s*oa*p
u	"	u	"	t*u*b	m*u*d
oo	"	u	"	l*u*nar	st*oo*p
ay	"	a	"	p*a*tient	st*ay*
e	"	e	"	s*e*t	m*e*t
i	"	e	"	imp*e*de	concert*i*na
ew	"	e	"	f*ew*	n*ew*

There is no *f* in Burmese, *hp* is its nearest representative; *g* is always hard.

Nos.	Report Spelling.	Map Spelling.	Remarks.
1	Hlahn-deng ...	Hlandeng ...	One and half mile west of the village. Several wells in the rocky bed of a stream, and a few more a little to the eastward.
2	Kadeng-mah-ngo ...	... ...	Several wells in a small stream running into the Khyoung-khoung.
3	Pyenmah-choung ...	Pyengmakhoung ...	Two springs or puddles a little way apart.
4	Toung-ngo ...	... ...	A strong spring with much marsh-gas escaping. Water very nauseous.
5	Sahn-gi	Sangyee ..	Several springs with a copious evolution of marsh-gas, but a feeble discharge of brine.
6	Hpoongi	Pwongyee.	
7			
8	Oan-nay dah-gi ...	On nay dagyee.	
9	Ki-deing.		
10	Boolay	Bhwet-lay ...	Several wells sunk in sandstone on the north bank near the mouth of the Boolay-choung.
11	Lay-myoung ...	Let myoung ...	Springs issue feebly on the top of a small hill, with a little marsh-gas.
12	Tayzahn	Tazan.	
13	Leng bahn ...	Leng bhan.	
14	Shuay-gyeng.		
15	Day-beng.		
16	Nyoung-kein.		
17	Yathaya	... ...	Several wells about one mile south by west from the village.
18	Hsengahn.		
19			
20	Oat pho	Ot pho.	
21	Num-may-ahn ...	Na ma yan ...	Several springs, rather feeble, but with a considerable evolution of marsh-gas about half a mile south-east of town on rising ground.
22	Pyouk-hsiaht.		
23	Pay-goan.		Nos. 21 to 26 all rise along the west side of the range of hills running down behind Prome in a south-easterly direction.
24	Ynah-thyt-koan.		
25	Thoan-ua boung.		
26	Wuddau-thah.		
27	Bhooyo.		
28	Hnet wah	... ...	Several wells.
29	Kahngu choung ...	... ...	The brine here rises in a sort of pocket formed by a crushed anticlinal, and we have here probably exemplified the manner in which most of the springs reach the surface, along lines rendered pervious by extreme folding, and the disruption of the lower beds.
30—35	(33) (38).		
36	Zigoan-choung.		
37			
38	Toung-myouk-choung.		
39			

Nos.	Report Spelling.	Map Spelling.	Remarks.
40—46	Hlay-gu	...	... These seven localities embrace many wells ranged in a line one and half miles long. They are now mostly abandoned.
47	Kamyeng-choung.		
48			
49	Shuaybandau.		
50			
51—53	Kweng-hlah.		
54 & 55	Oashyt-Kweng.		
56	Thayetsahn.		
57	Paybeng-goan.		
58	Chin-uah-gi.		
59			
60	Sayay-kweng.		
61	Shah-si-bo.		
62	Kway-mah	...	... There are some six wells here.
63	Khyon khya ...	...	... The brine of Nos. 63, 64, and 65 said to be very salt.
64	Hsi-soan.		
65	Tsahnda-choung, *N.*		
66	Ditto, *S.*		
67			
68	Piah-hoan.		
69	Boodalet.		
70	Mioung.		
71	Sahdwyngi ...	...	... This is the most copious and important spring in Pegu.
72	Adwynzyn.		
73	Kayahndwyn.		
74	Minahgwyn ...	...	... There is a cluster of some thirty wells here within a mile of this.
75	Kway choung kweng.		
76	Thayet-goan.		
77	Wuddaw kweng.		
78			
79	Hlay goan.		

Nos. 63, 64, 65, 66, 67, 70, 71, 72, 73, 74, and 79 had been already examined and fixed by Mr. W. Blanford. The great majority of the remainder have been visited by myself, whilst many of them have been independently examined by Mr. Fedden likewise. It must not, however, be supposed that the above list exhausts all the localities where brine may possibly occur, but only attempts to give as complete an enumeration as possible of the sites where salt has been formerly extracted.

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AUSTIN, JAMES G.—A practical treatise on the preparation, combination, and application of Calcareous and Hydraulic Limes and Cements, (1862), 8vo., London.

BLAKE, WM. P.—Notices of Mining Machinery, (1871), 8vo., New Haven.

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HARCOURT, CAPT. A. F. P.—The Himalayan Districts of Kooloo, Lahoul, and Spiti, (1871), 8vo., London.

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THE AUTHOR.

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The 2nd July 1873.

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Part 4.] 1873. [November.

NOTE ON SOME OF THE IRON DEPOSITS OF CHÁNDÁ, CENTRAL PROVINCES, *by* THEODORE W. H. HUGHES, A. R. S. M., F. G. S., *Geological Survey of India*.

My present contribution to the Records of the Geological Survey refers to a few only of the deposits of iron-ore found in the Chándá district, and gives some details relative to the amount of ore and fuel ordinarily used in native furnaces, showing what results are obtained without the use of foreign slag-forming ingredients.

I am indebted to Major Glasfurd, the Deputy Commissioner, for my quantitative figures; and although it is always more satisfactory to have an accumulation of data, I think the six experimental trials which are recorded yield a fair indication of the work accomplished by the method of smelting adopted in this country.

Iron-ore exists in great quantity; and as it occurs principally in the metamorphic rocks, it is found in those portions of the Chándá district which are to the north and east of the main Wardhá valley coal-field. Anhydrous hæmatite is the most abundant species, and it furnishes all the supplies for the native furnaces. It is usually compact, and is mixed up occasionally with some magnetic oxide and a little brown iron-ore.

The latter variety of hæmatite occurs often as a coating to an interior mass of anhydrous hæmatite. It presents in many instances an exceedingly beautiful appearance, having a clear smooth surface on the outside, and being finely fibrous on the transverse face. There is no difficulty in distinguishing it, for it gives a well defined brown streak on being scratched; and any person interested in possessing an illustrative mineralogical sample of iron-ore, showing the passage of one variety into the other, may obtain in the Chándá district many such specimens as that which I have described.

The most noted localities for abundance and excellence of ore are Déwalgaon, Gúnjwáhí, and Lohárá; but there are several others which run them close for a place in the first rank. The wealth of Chándá in iron-ore is undeniable. In the form either of magnetic oxide, hæmatites, carbonate, or as laterite, one is constantly meeting with it.

The deposit most worthy of notice which I have hitherto seen is undoubtedly that at Lohárá. It deserves, and will some day obtain, a more than local reputation. The ore consisting of compact crystalline hæmatite or specular iron-ore with some magnetic oxide, forms a hill fully three-eighths of a mile in length, two hundred yards in breadth, and a hundred to a hundred and twenty feet in height. The main lode striking north-east by north can be traced clearly for some distance beyond the distinctive hill portion which first catches the eye, and its actual length if followed out (but which I am sorry to say I had not time to do on the occasion of my visit) would probably exceed several miles.

The view presented by such a mass as that at Lohárá, exclusively made up of almost pure specular iron, it does not fall to the lot of many men to see surpassed; and those who possess the opportunity of visiting this place ought to do so, and carry away with them the remembrance of having looked upon one of the marvels of the Indian mineral world.

The ore at Lohárá has been analysed by Mr. David Forbes, and I extract from the Colliery Guardian* the following statement of its composition:—

Iron, metallic	69·208
Oxygen, in combination	29·376
Manganese, sesquioxide	·090
Silica	·823
Alumina	·432
Lime	·054
Magnesia	Trace.
Sulphur	·012
Phosphorus	·005
	100·000

It will be seen that it is extremely rich in iron, and exceptionally free from sulphur and phosphorus, which are usually two of the most annoying ingredients that the iron-master has to contend with. The amount of silica is less than would be presumed to exist, judging by the external appearance, compactness, and hardness of the ore.

It is not, however, to the Lohárá deposit that I wish to draw attention so much, as to some others, which—since the question of establishing large iron-works in India has been again raised—have lately acquired increased importance, due to their propinquity to a small area of *possibly* coal-bearing-rocks, about six miles west of Chimúr, which I discovered and mapped during the past season.

These deposits are three in number, and occur near the villages of Bissí, Pipalgaon, and Ratnápúr.

(1). BISSÍ.—Long. 79°28′ East, and Lat. 20°39′ North. The ore occurs in a lode about a mile directly east of the village, and contains hæmatite and magnetic oxide of iron.

(2). PIPALGAON.—Long. 79°34′ East, Lat. 20°32′ north. An excessively fine mass of red hæmatite, resembling that which occurs at Lohárá, and having probably the same composition, is to be seen about three quarters of a mile east of Pipalgaon. The strike of the lode is west-north-west, east-south-east.

(3). RATNÁPÚR.—Long. 79°37′ East, and Lat. 20°23′ North. A very rich lode of brown iron ore, forms a terrace on the north side of the small range of hills facing Alísúr. The width of the lode in places is 40 and 50 feet.

The coal rocks which I have referred to as giving increased importance to the deposits just described, occupy a somewhat restricted area. I have not been able to prove the actual existence of coal by the discovery of an outcrop; but Damúdá and Kámthí strata occur; and a very few shallow borings, not exceeding 300 feet at the utmost, sunk between Morepáh

* Colliery Guardian, 13th September 1873.

and Bandar* ought to determine the question. I do not entertain the idea that there is any present chance of profitable blast-furnaces being erected in the Chándá district. We have a long pupilage to go through before we can work successfully with such coal as has hitherto been found in the Wardhá valley field. It may, therefore, perhaps be urged that if this be the case, there is no immediate necessity for proving the ground which I have pointed out. But I am writing with the full knowledge that there is a boring establishment at Warora, and that possibly if the present opportunity of profiting by it be neglected, many years may elapse before mechanical means are again available for purposes of exploration. Should the borings which I recommend be carried out, we shall gain positive knowledge in reference to the rocks, and if there be no coal, we shall not be indulging in vain speculations regarding the utilization of the iron ore deposits to which I have drawn attention.

The native furnaces of Chándá are somewhat taller and larger than those commonly in use in Bengal. Several that I measured were nearly 6 feet in height, owing to a prolongation upwards of the front face of the furnace, the use of which is to back up the ore around the feed-hole. The height of the actual working shaft varies from 4′ 6″ to 5 feet.

The section of the furnace is that of a cone, its internal diameter diminishing from 1′6″ at a height of six inches above the hearth to three quarters of a foot at a height of 36 inches above it.

The hearth, as is usual, slopes from behind forwards, and the bloom is taken out through the face.

The twyers are 9 inches long, 1½ inches in diameter at the larger opening, and ¾ths of an inch at the smaller. The bellows for producing the blast are usually worked by hand.

I need not refer to the method of smelting, further than to say that it is similar to the mode in use in other parts of India, and I will now give the results and details of the six experiments which Major Glasfurd undertook to have made.

Three experiments were conducted in the Múhl Tahsíl, at Chikli, Gúláb-bhúj and Metégaon; and three in the Brahmápúrí Tahsíl, at Armorí, Déwalgaon and Injhéwárá:—

VILLAGE.	Iron ore used.	Charcoal used.	Iron yielded.	Cost of iron ore and charcoal used.	Value of iron.	Wages of 2 men.
	Seers.	Seers.	Seers.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Múhl.—						
Chikli	49	82	17½	0 9 0	1 0 0	0 4 0
Gúláb-bhúj	65	88	13¼	0 9 0	0 13 0	0 4 0
Metégaon	72	90	21¾	0 9 0	1 3 0	0 4 0
Brahmápúrí.—						
Armorí	37½	68	12	0 4 6	0 9 7	0 3 2
Déwalgaon	52	114	12	0 4 6	0 8 10	0 3 2
Injhéwárá	44	88	12½	0 5 10	0 10 0	0 3 2

In these returns there is a great discrepancy in the price paid for charcoal and ore in the Mhúl and Brahmápúrí Tahsíls. Compare, for instance, Chikli (49+82 seers for 9 annas)

* Morepah: Long. 79° 21′ East; Lat. 20°33′ North. Bandar: Long. 79°21′ East; Lat. 20° 30′ North.

and Déwalgaon (52+114 seers for 4*a.* 6*p*). The yield of iron also shows great disagreement. At Déwalgaon 52 seers of ore produced only 12 seers of iron, whereas at Chikli 49 seers produced 17½. It may be that a poorer class of ore was used in the one instance than in the other, but I scarcely think this can be the case, for I have always observed that the natives invariably used ore having the same average composition. And an analysis of the Déwalgaon ore shows that it contains 70 per cent. of metallic iron.

If we calculate the proportion of the amount of charcoal used to iron ore, and the proportion of the amount of ore employed to the iron produced, we find:

Village.	Proportion of ore to charcoal.			Proportion of ore to iron.		
	Ore.		Charcoal.	Ore.		Iron.
Múhl.—						
Chikli	1	to	1·7	8	to	1
Gúláb-bhúj	1	"	1·4	5	"	1
Metégaon	1	"	1·2	3·5	"	1
Brahmápurí.—						
Armorí	1	"	1·8	3	"	1
Déwalgaon	1	"	2·2	4·3	"	1
Injhéwárá	1	"	2·0	3·5	"	1

The iron referred to above, which is called *kít* by the Maharattas, is a mere mass of spongy iron, slag and charcoal, and has to undergo two refinings before being sold as malleable iron. In the first operation it is manipulated by the men who reduce it from its ore. They heat it in a refinery, and then hammer it, whereby the slag is more or less completely extruded and the iron consolidated into a compact bloom. It loses considerably in weight during this process, and the mass formerly weighing, say 14 seers, is diminished to 10 seers. The amount of charcoal consumed is stated to be 20 seers, or perhaps a little less. The bloom is then cut partially in half and is called *Chúl*, and is sold to the regular metal-workers (lohars). These men clean it again, by which its weight becomes still further reduced, fully one-third and sometimes one-half of it being lost; and it is by them worked up into various household and agricultural implements.

Applying the foregoing observations (by taking the mean of the Múhl figures) to arrive at the average proportions of iron-ore and charcoal used in producing iron ready for being actually worked up, it appears that—

(*a.*) Seventeen and a half seers of iron are produced from 63 seers of ore and 87 seers of charcoal.

(*b.*) In the first refining operation, 20 seers of charcoal are used, and the iron loses 5 seers in weight, reducing it to 12½ seers.

(*c.*) In the final refining operation about 10 seers of charcoal are consumed, and clean workable iron, weighing 7 to 8 seers, is obtained.

Thus, 63 seers of ore and 117 of charcoal are required by the native method of smelting as carried on in Chándá to produce 8 seers of metal. Or, stating it in current English terms—

8 Tons of ore
and
14½ Tons of charcoal } Are used in the manufacture of 1 Ton of wrought-iron.

There is no occasion in the present number of the Records to treat the subject of cost in its various branches, nor need I enter upon a discussion of the commercial aspect of the iron trade of Chándá. I hope to dwell at some length upon both these topics when giving a detailed description of the Wardhá valley coal-field.

For the present, I wish to draw attention to 1*st*, the richness of Chándá in iron-ore; 2*nd*, the circumstance of the *probable* favorable association of coal and iron-ore; 3*rd*, the proportional consumption of raw materials in the manufacture of native wrought-iron. Of course, should furnaces intended either for the making of pig-iron, or for the production of wrought-iron by the direct process, be ever erected on a European scale, the data afforded by observations on the liliputian works of the natives of the country will be matter for curiosity rather than of practical interest.

CALCUTTA, 1*st July* 1873. T. W. H. HUGHES.

BARREN ISLAND AND NARKONDAM, *by* V. BALL, M. A., *Geological Survey of India.*

In the month of March last, a few hours were spent on the two Islands whose names are given above by a party consisting of Mr. Hume, Dr. Stoliczka and myself. Although the time at our disposal did not admit of extended exploration, still an opportunity was afforded of checking the accuracy of the accounts which have been previously published.

Having consulted every notice of these islands which, so far as I have been able to ascertain, have hitherto been published, I have been astonished to find how inaccurate has been the information upon which the accounts in Geological Manuals and other works have been founded.

In the present paper I have devoted several pages to an abstract of these accounts, and have pointed out the errors and traced, so far as is possible, their origin.

Dr. Liebig's paper on Barren Island which contains the fullest and most accurate account of the island hitherto published, does not appear to have reached the hands of several authors who have since its publication repeated the old statements in their works.

Barren Island and Narkondam are two volcanic islands situated in the Bay of Bengal at a distance of 70 miles from one another on a north-by-east, south-by-west line. They constitute links which connect what is known as the Molucca band with the volcanic region of Arracan and Chittagong, and of which Mrs. Somerville has written as follows:—

"One of the most terribly active groups of volcanoes in the world begins with the Banda groups of islands, and extends through the Sunda groups of Trimor, Sumbawa, Bali, Java, and Sumatra, separated only by narrow channels; and altogether forming a gently curved line 2,000 miles long; but as the volcanic zone is continued through Barren Island and Narkondam in the Bay of Bengal and northward along the Coast of Arracan, the entire length of the volcanic range is a great deal more."

Dr. Hochstetter carries the line of elevations which accompanies the zone of volcanic action still further, in an oblique S. form, through New Guinea to the north of the Australian continent. "It forms in New Ireland, the Solomon Islands, New Hebrides and New Zealand a curve, concave towards the west, the small group of the Macquarie Islands being possibly considered as the extreme southern end of this curve."

So far as is known, there are no volcanoes in either the Nicobar or Andaman Islands. It has been by some supposed that the hill on Bompoka in the Nicobars and some of the high ground in the great Nicobar might be volcanic, but the evidence is rather against than in favor of this view. Plutonic rocks (diorite and gabbro) not unfrequently occur however in both islands. A statement made in an old account of the Cocos, that the little Coco is formed of volcanic rocks, is quite without foundation.

BARREN ISLAND, Lat. 12° 17′, Long. 93° 54′.

History of the island derived from previous notices.—In the table appended I have given a *précis* of all that has been published on the subject of Barren Island; but a few additional remarks tracing out the way in which certain inaccuracies have arisen seem to be desirable.

The first account was by Captain Blair, in his report on the Andaman Islands, dated 1789. I have not seen the original document, but the account was extracted and reprinted by Lieutenant Colebrooke in the Asiatic Researches. It has served for many years as the text upon which the descriptions published in various Geological Manuals have been founded.

Captain Blair gave the height of the central cone at nearly 1,800 feet, and the angle of the slope at 32° 17′. Were it not stated that the cone was equal in height to the outer walls of the surrounding part of the island, we might, in consequence of Blairs' oft proved accuracy as an observer, be disposed to believe that at the time of his observation the cone was nearly double its present height. That there has not been a general subsidence of the island to the extent of 800 feet is proved by the fact that the base of the cone was then, as it is now, but little raised above the sea level. Blair himself states that it may be seen at a distance of twelve leagues in clear weather, which would only require an elevation of about 920 feet. I can only suppose, as an explanation of the difficulty, that Blair took several heights which varied between 800 and 1,000 feet, and that these, by some error, came to be written together as 1,800.

The angle of inclination of the sides of the cone is given by Blair at 32° 17′. This nearly corresponds with the mean of my observations, which ranged between 32° and 35°. These angles also agree with those on a photograph which I possess. Dr. Liebig, Dr. Playfair and others have given it at from 40° to 45°.

The sketch by Lieutenant Wales given in Lieutenant Colebrooke's paper, save that it represents an inclination of about 60° to the sides of the cone, conveys the best idea of the island of any of the numerous figures which have been published. It was reproduced by Von Buch, and copied from him by Sir Charles Lyell, Dr. Daubeny, Dr. Buist, &c. Von Buch, in his "Memoir on the Canary Islands," gives the height of the cone at 1,690 Paris feet. His account, though apparently derived from Lieutenant Colebrooke's paper alone, contains the statement that the sea penetrates into the circle at the base of the cone. This can only have been due to some misapprehension of the meaning of Blair's words, which were as follow: "The base of the cone is the lowest part of the island and very little higher than the level of the sea."

Sir Charles Lyell, in the earlier editions of the 'Principles,' framed his account from Von Buch's. In the changes from English into French, and back again into English, the elevation of the cone became increased by 48 feet, standing in the 7th edition of the 'Principles' (1847) at 1,848 feet. It is also there stated that the circular basin inside is filled with the waters of the sea. In the 9th Edition, 1853 (I have not been able to refer to the 8th), Captain Miller's estimated elevation of 500 feet is adopted instead of the former one; but the statement regarding the sea inside still remains. In the 10th Edition (1868) Captain Miller's estimate of 500 feet, as the height in 1834, is retained; but it is stated that according to Von Liebig in 1857, both the cone and outer crater were about 1,000 feet high, and in reference to the sea we find the following: "In some of the older accounts the sea is described as entering the inner basin, but Von Liebig says it was excluded at the time of his visit." I believe this statement regarding the sea to have arisen solely in the way I have pointed out. It is important that there should be a clear representation of the case, as otherwise it might be concluded that we have evidence of the rising of the island within the historical period.

The next account to that by Blair is by Horsburgh, about which there is nothing particular to remark here, save that he asserts that in 1803 the volcano was very active (see table).

Dr. J. Adam's account is derived from information and specimens received from a friend who had landed on the island in 1832. He speaks of the stones on shore hissing and smoking, and the water bubbling all round them. The statement has apparently been understood by one writer to indicate that the lava had not then cooled down. But the hot spring was probably quite sufficient to account for the phenomena observed. This is the first mention made of the hot spring. The author supposes that the volcano is only active in the south-west monsoon, *i. e.*, requires water to bring it into a state of activity. Apart from other considerations, it is only necessary to say that the only authentic account of it in a really violent state of eruption is by Blair, who saw it on the 21st of March, and therefore not in the south-west monsoon. Captain Miller's account is very inaccurate in several respects. He has given the height at 500, and the angle at which the cone rises at 45° or even more. If the elevation of the cone in his time were only so much, then, since he states that this was also the elevation of the outer walls or amphitheatre, both must have increased *pari passu*. This view is of course untenable, and we are forced to believe that Captain Miller only gave a rough guess. His remarks on the vegetation are quite inconsistent with one another, for he says,—"there is no vegetation of any kind within the amphitheatre, but *a few small trees* are found on other parts of the island, which, however barren it may have been at one time, is *now well wooded*."

Dr. Daubeny, in his description of Barren Island, though quoting from Lieutenant Colebrooke, gives the elevation of the cone at 4,000′, which must have been due to a clerical error. A somewhat modified reproduction of the original sketch is given.

Mr. Scrope, in his work on Volcanos (*2nd Edition, Lond.*, 1862), writes regarding Barren Island: "This permanently active volcano is a cone about 4,000 feet high, rising in the centre of a circular cliff range, which entirely surrounds it except at one point where the sea has broken in." Though the authority is not given, it is evident that this account is derived from Dr. Daubeny's, as the elevation is not given at 4,000′ in any other work.

In 1846 the island appears to have been visited by the Danish corvette *Galathea*, but the only record of the fact which I know of is an inscription on a rock on the island—"*GALATHEA*, 1846."

In the *Bombay Times* for July 1852, on the authority of Dr. Buist, it is stated that the volcano was very active, but I have not been as yet able to refer to the original account.

The chief points in the accounts subsequent to the above will be found incorporated below. Dr. Playfair, Von Liebig, and the Andaman Committee agree in estimating the angle of the cone at 40° to 45°, and the elevation at from 975—980 feet.

Abstract of the published accounts of Barren Island.

Year.	Authority.	State of Activity.	Slope of Cone.	Elevation.	Temperature of Hot Spring.	Condition of Vegetation.	References.
1787 ...	Colebrooke ...	A column of smoke arising from the summit visible 7 leagues off.	......	......	......	... ...	Asiatic Researches, Vol. IV, 1795, p. 397, fig.
1789 ...	Blair ...	In a violent state of eruption, bursting out immense volumes of smoke, and frequently showers of red hot stones, weighing 3 or 4 tons.	32°·17′	1,800	......	Parts remote from the cone covered with withered shrubs and blasted trees.	Report on the Survey of the Andamans, and Asiatic Researches, l. c.
1791 ...	Horsburgh ...	A quantity of very white smoke close to the crater.	......	......	......	... ...	Horsburgh's India Directory, 5th Edn., Vol. II, 1843, p. 55.
1801 ...	Almes ...	... ...	......	......	......	Firewood could be got with difficulty.	
1803 ...	Horsburgh ...	Exploded regularly every 10 minutes, projecting each time a column of black smoke perpendicularly to a great height. In the night a fire of considerable size continued to burn on the east side of the crater.	......	......	......	... ...	
1832 ...	Dr. J. Adam's friend ...	Large volumes of thin white smoke continually issuing.	......	½ a mile=2,640 feet.	Almost boiling.	Small shrubs scattered about on the S. W. side.	J. A. S. B., Vol. I, 1832, p. 128.
1836 ...	*Von Buch* ...	Account same as in Asiatic Researches, with some variation.	......	1,690 French ft.	......	... ...	Description Physique des Iles Canaries, &c., Paris, 1836, p. 431, Atlas Plate VI.
1840 ...	*Sir C. Lyell** ...	Account founded on Von Buch's.	......	1,848	......	... ...	Principles, 6th Edn., 1840, Vol. II, p. 286, also in 7th Edn.
1843 ...	Lieut. Miller ...	A clear full stream of transparent vapour.	45°	Upwards of 500	......	No vegetation within the amphitheatre, but other parts are well wooded.	Account drawn up by Dr. McClelland, Cal. Jour. Nat. Hist., Vol. III, 1843, p. 422.

1846 ...	"Galathea" ...	... ...	......	......	......	... ...	? Is there any word of this visit.
1848 ...	*Dr. Daubeny* ...	Founded on Blair's account	......	4,000 !	......	... ...	Daubeny on Volcanoes, London, 1848, p. 413.
1851 ...	*Mrs. Somerville* ...	No details ...	......	......	......	... ...	Physical Geography.
1852 ...	*Dr. Buist* ...	Quotes previous accounts ...	......	......	......	... ...	
1852 ...	"Bombay Times" ...	Very active ...	......	......	......	... ...	"Bombay Times," July 1852.
1857 ...	Dr. Liebig ...	Clouds of white vapour issued from fissures near the summit.	40°	980	104°F. ? Almost boiling.	Shrubby patches on the slopes towards the sea.	Zeitschrift der Geollog. Gesselschaft, Vol. X, 1858, p. 302; also in Rec. Govt. of India, XXV, 1859, p. 124; J. A. S. B., XXIX, 1860, p. 1; and in Mouat's Adventures and Researches.
1857 ...	Dr. Playfair and Lieut. Heathcote.	Smoke issued occasionally from a little below the summit.	40°	975	140° F.?	Not mentioned ...	Rec. Govt. India, XXV, 1859, pp. 121—123.
1862 ...	*G. Poulett Scrope* ...	Account same as that by Dr. Daubeny.	......	4,000	......	... ...	Volcanoes, by G. P. Scroope, M. P., London, 1862, pp. 199 and 468.
1866 ...	Andaman Committee ...	A whitish vapour was evolved from several deep fissures.	40°	980	158°—163°	No trees of any height, but on the slopes and ridges are abundance of shrubs, some rising to 20 feet.	Report on Barren Island, P. A. S. B., October 1866, p. 212.

* For changes in subsequent editions, see page 82.

Authorities whose descriptions are not derived from personal observations in italics.

From the preceding we may gather the following. The volcano has probably not been in violent eruption since the years which closed the last and commenced the present century. The lava-flow which stretches from the entrance open to the sea to the base of the cone was probably poured out during this period, and raised the level of the encircling valley some 40′ above its elevation in 1789, when Blair saw it. He makes no mention of a lava stream in his time. If it did not exist then it cannot—as has been supposed by some—have been instrumental in the formation of the entrance. That this fissure was probably due to other causes we shall presently see.

From Lieutenant Wales' figure it is apparent that no material change has taken place in the general configuration, and as it has been shown that 1,800 feet cannot have been the true height, and about 920 probably was, no great alteration in the level is likely to have taken place.

General appearance of the Island.—Seen from any side but the north-west, Barren Island appears as a nearly flat-topped hill with numerous spurs running down into the sea. From some aspects, however, the top of a central cone with a column of smoke rising from it is discernible.

As the north-west side opens up to view, it is first realised that the island consists of a circular ridge forming a huge amphitheatre, which is broken down at one side for a distance of perhaps 150 yards to the level of the sea. The view obtainable through this entrance discloses a bare cone which rises from the centre of the valley. Except at a sort of shoulder not far from the top, and at two peaks close to the summit, no rocks are seen on this cone, its smooth sides being covered with grey ash and occasional strings of shingle. Towards the top some whitish patches are seen, due to the presence of gypsum mixed with the ash.

The total diameter of the island is, on the authority of Lieutenant Heathcote, 2,970 yards. The circuit of the island, from the time it took us to row round, I estimated at about six miles.

The high encircling ridge is formed of somewhat irregularly deposited layers of lava, ash and conglomerate, which dip away from the centre. A section of these may be seen on the left hand of the gap or entrance, and others at various points on the sea-face, no two of them corresponding exactly in character.

These beds or layers generally dip at angles of 35°—40°, which inclination appears to be continued steadily under the sea, as bottom, except at one place, has not been found with a line of 150 fathoms at ¼ of a mile from the shore. This steepness has been unfavourable to the formation of a fringing reef of coral of any magnitude, such as we find surrounding some of the Andaman and Nicobar groups.

The elevation of this outer ridge varies somewhat in places, but it probably nowhere is much in excess of 1,000 feet. Its highest points are towards the south and west.

The appearance presented by the inner scarped face of this amphitheatre is very peculiar. In several places cornice lines mark the position of particular beds, but a purplish grey, or in places brownish, ash spreads over the steep slopes, except towards the south-west and west, where there are some trees and shrubby vegetation. To the north, south and east a few tufts of grass—generally arranged in long vertical lines, the first being a sort of protection to those below it—are the only plants which have managed to establish a footing in the loose ash.

The outer slopes facing the sea are for the most part covered with a luxuriant vegetation, in which large forest trees may be discerned. These latter attract considerable numbers of fruit-eating pigeons (*Carpophaga bicolor*).

From its composition and character, it is evident that this ring of cliffs is the remnant of the original cone which gradually rises from below the sea. Its top and a portion of the side were, no doubt, blown off by a violent eruption, and the present cone was subsequently formed inside.

For a long time Barren Island was considered by Von Buch and others of his school as a most favourable example of his elevation theory of craters.

The gap or fissure in the surrounding walls bears about north-west-by-west from the centre of the island. It is the only place where an entrance can be obtained to the central valley.

Hot Spring.—Close to the landing place, there is a hot spring which has been mentioned in several of the accounts of the Island. Dr. Playfair found the temperature to exceed 140°, —the limit of his thermometer. Dr. Liebig's thermometer was only graduated up to 104°, but judging from the feel to the hands, he estimated it to be near the boiling point. The Andaman Committee record it at from 158° to 163°. At the time of our visit the highest temperature of the water where it bubbled out of the rocks, close to high watermark, was 130° F. We failed to boil some eggs in it which we had brought with us for the purpose.

The water is perfectly clean and sweet,* and there was no trace of sulphureous vapours. Strange to say, where, though mingled with the sea, it was still too hot for the hand to be retained in it with comfort, there were a number of brilliantly colored fish swimming about.

Facing the landing place is the termination of a flow of lava which extends backwards from this for about a mile to the base of the cone, round which it laps for perhaps ¾ of the circumference. The height or thickness of this flow of lava is about 10 feet at first, gradually rising to 50 feet where it emerges from the base of the cone. The upper surface is deeply cleft and covered over with blocks of black cellular lava which rest upon one another in confused piles. Sometimes they are poised so insecurely on one another that it is a matter of some risk to attempt scrambling over them. Towards the base of the flow the rock from its slower cooling is more compact and less cellular. In places it contains white crystals of a mineral resembling leucite. In others it is a true basalt with numerous crystals of olivine.

As pointed out by Dr. Leibig, the older lava seen in the section of the ridge differs from this; it consists of a reddish matrix with crystals of felspar (probably sanidine), olivine, and augite. A somewhat similar rock occurs on Narkondam.

On our way to the central cone from the landing place we at first endeavoured to avoid the rough surface of the lava-flow by keeping on the slope of the gap; but after a short distance the bushes and unevenness of the ground compelled us to strike down on the lava, when we found, to our astonishment, a sort of path which must have been made by the committee sent from Port Blair to report upon the grass.

Arrived at the foot of the cone, we commenced the ascent from the west. The loose ashes and shingle rendered it somewhat toilsome work; and those in front found it difficult to avoid loosening fragments of lava which bounded down the hill in a most unpleasant way for those who were following.

Dr. Liebig appears to have ascended from the north side, where it seems to have been equally difficult.

About ¼ of the way from the top there is a shoulder of rock which shows very well in the photograph. This probably marks the position of an old vent. There is a good deal of firm ground about it.

The summit of the cone is truncated, and contains an oval-shaped depression, one-half of which is partly filled with débris, and the other, some 20 yards in diameter and 50 feet

* The Andaman Committee do not appear to have realised this fact, as they spent no little time and trouble in excavating a well without finding a trace of water.

deep, has a circular bottom, which is filled with sand. This appears to have been the last crater formed on the island.

The two principal edges of the depression strike to north-west, south-east; they consist of ash permeated with fibrous gypsum (selenite); numerous cracks and fissures occur in this part of the hill, and the ground is hot. On turning over the surface, the sides of these cracks are found to be encrusted with sulphur, resting upon the rugosities of which small detached crystals of the same mineral were not uncommon. From the highest point on the northern edge a thin column of white vapour and sulphureous fumes is slowly poured forth. Even when standing in its midst, the fumes did not prove so irritating a might have been expected.

On the southern side of the crater there is some solid lava *in situ*, and on the west there is a peculiarly shaped mass which forms a conspicuous object from below. Some of the lava here has a reddish matrix and is somewhat vesicular. I also found some basalt, the outer surface of which was weathered into a white crust.

It seems probable that the nucleus of the cone is solid rock to a considerable extent, the ashes seen at the surface being only superficial.

By following water channels when they were to be found, and glissading over the ashes, the return to the base of the cone was effected speedily and without much difficulty.

By a small watch-aneroid supplied with a Vernier scale for feet, the height of the cone is 950 feet; but as one heavy storm of rain had passed, and clouds portended another, I am willing to believe that owing to the atmospheric disturbance the observation was not trustworthy, and that from 975 to 980 feet given by Lieutenant Heathcote, Dr. Liebig and others is the true elevation. The temperature on the top was 83°.

The diameter of the base of the cone is 2,170 feet according to Lieutenant Heathcote. The slopes of the cone incline, according to my observation, at angles varying between 30° and 35°. Blair gave it at 32° 17′, or about the mean of these two. Other observers say 40° to 45°, but the photograph of the cone shows that the former is correct.

Dr. Liebig has discussed the question of the amount of sulphur obtainable on the island. He seems to think the chances of finding a permanent supply very doubtful, but recommends a preliminary trial.

Considering the great expense which keeping up constant communication with the Andamans and the superintendence of convict labour would involve, I cannot see that there is any prospect of the collection and refining of the sulphur being made to pay.

So far as is known, the substance occurs only at the summit of the cone, though, doubtless, if the right places could be found, it does also occur lower down. But in such places, it could only be as an old deposit which, on being worked out, would not be replaced again.

On the summit the deposit, so far as I could see, proceeds very slowly, certainly not with sufficient rapidity to keep laborers constantly employed.

NARKONDAM, Lat. 13° 24′; Long. 94° 12′.

History and previous notices.—So little has been published regarding this island that a few lines will suffice to dispose of all that has ever been recorded regarding it.

In 1795 it was passed by Colonel Symes* when on his voyage to Rangoon, whence he started on his embassy to Ava. He speaks of it as "a barren rock rising abruptly out of the sea and seemingly destitute of vegetation."

* Embassy to Ava, Vol. I, 1827, p. 167.

Dr. McClelland, writing in 1838,* says: "It is a volcanic cone raised to the height of 7,800 feet. He gives a sketch showing the figure of the cone, the upper part of which is quite naked, presenting lines such as were doubtless formed by lava currents descending from the crater to the base, which last is covered with vegetation." No soundings are to be found at the distance of half a mile from the shore. This account is reproduced by Mrs. Somerville, Dr. Daubeny, Dr. Buist and Mr. Scrope.

Horsburgh† says—Narkondam may be seen about 14 or 15 leagues from the deck, and appears in the form of a cone or pyramid with its summit broken off; it is bold and safe to approach all round.

Mr. S. Kurz, in his report on the vegetation of the Andaman Islands, writes: "Narkondam Island has an extinct volcano remarkable for the great height of its cone, being twice as high as its outer wall. Owing to the great height of the cone (perhaps 2,000 feet) in proportion to the surrounding wall, this island must have sunk very much, or the volcano must have been formed from a considerable depth in the sea." Mr. Kurz gives an outline sketch of the island as it appeared to him from a distance of 20 miles.

In a paper on the geology of the neighbourhood of Port Blair, I made a few remarks on the appearance of Narkondam as seen from a few miles distance. In it I accepted the height of the cone, 2,150, given on the chart, as authentic. This, it will be seen by the sequel, I do not now adopt as correct. In the *Indian Observer* for the 10th of May a short account of the present visit will be found.

Viewed from the north-west at a distance of about 4 or 5 miles the island of Narkondam appears to consist of a tolerably regular cone which rises from an interrupted ring of irregularly piled masses. The apex is somewhat truncated, but has three distinct peaks. On the occasion in 1869 when I first saw the island a dense mass of cloud rested on the top, and I was unable to make out the character of the summit. But when subsequently seen, it was observed that there were three peaks as represented in the sketches published by Mr. Kurz and Dr. McClelland. The upper parts of the cone and the sides for more than half way down are deeply furrowed by ravines, and what appears to be a low scrub jungle spreads uniformly over the island save upon some vertical scarped faces.

With the general consent of those who have seen it, the conical form has been accepted as a proof of the volcanic character of the island. Dr. McClelland, as noted above, speaks of the lined appearance being "doubtless formed by lava currents descending from the crater to the base." These lines are, however, simply the result of erosion, and mark the position of the watercourses.

The elevation of the summit of the cone has been variously estimated at from 700 to 2,150 feet. Since however, according to Horsburgh, the island first becomes visible from the deck of a steamer at a distance of from 14 to 15 leagues; it is probable that about 1,300 feet would be nearer the true altitude, and such indeed, judging by the eye, appears to be a very fair estimate.

On the occasion of our visit we landed in a small bay on the north-west side of the island. At about 100 yards distance from the beach the water became so shoal that we were compelled to land on a raft. We soon found that the jungle which, in the distant view, appeared to consist mainly of low scrub was really composed of large forest trees with a thick undergrowth. So dense was this, just above high water mark, that at first it seemed probable that it would be impossible to penetrate it. Added to the natural density of the jungle, another obstacle was presented by the prostrate condition of many of the trees, which in their fall had carried

* On the difference of level in Indian Coal-fields, J. A. S. B. VII. Also in the Coal Committee's report, and in Corbyn's Indian Review.

† Indian Directory, 5th Ed., Vol. II, 1843, p. 55.

down tangled masses of creepers and the lower vegetation. It soon became apparent that at no very distant period a violent hurricane or cyclone must have swept across the island. An entrance was at last found, and for three hours, cutting our way and making constant detours to avoid fallen trees, we endeavoured to force onwards to the summit, but were at length compelled to give up all hope of succeeding and returned to the beach. Further evidence of the hurricane was there afforded by numerous fragments of a wreck which had been thrown up on the sand. Subsequently this storm was identified with one which took place on the 26th of October 1872, and did much damage in the Cocos Islands and other parts of the Bay.

The only rock seen where we landed was a conglomerate, or boulder bed some 50 feet thick. The boulders consisted of a trachytic porphyry which contained sanidine, augite, and mica in grey or pinkish matrices. We discovered no evidence whatever of recent lava or basalt occurring, though either or both may exist, as our observations were confined to one small bay.

Notwithstanding the luxuriance of the jungle which included species of Ficus, Palms (Caryota), Acasia, Calosanthes, &c., no fresh water was discovered.

Much remains to be done in the exploration of this most interesting volcanic island. It is particularly desirable to ascertain whether there is really a crater at the summit, and whether there are any traces of recent lavas.

Future visitors would do well to provide themselves with some wood-cutters. They should land near the northern spur, and getting then on the steady rise, they will probably find no insuperable obstacle on their way up.

STRAY NOTES ON THE METALLIFEROUS RESOURCES OF BRITISH BURMAH, *by* W. THEOBALD, *Geological Survey of India.*

Though little that can, strictly speaking, be called precise information respecting the mineral wealth of Burmah exists, either as regards the value or extent of its presumed mineral sites, yet it may be not without interest to give a brief sketch of what stands recorded on the subject, leaving for future investigators the task of sifting these statements and determining the importance in an economic point of view of each separate locality.

A general impression is undoubtedly prevalent that considerable metalliferous resources exist in Martaban and Tenasserim, and that it only requires a thorough examination of these districts to establish the fact in a manner sufficiently clear and precise to tempt the European speculator and capitalist into the field, and originate a new and thriving branch of industry which would soon prove of great value to the province. Unfortunately, nothing very tangible is known, though the matter has never been quite lost sight of, and has attracted the attention of district officers, among whom Mr. O'Riley in Martaban, and Major Malcolm Lloyd in Tounghoo, may be prominently mentioned. A serious cause, however, of error, and of a too favourable view being taken of the productiveness of a new mineral locality, lies in the fact that undue importance is too commonly attached to the result of an analysis of a small specimen, which in reality affords no criterion whatever of the value of the discovery in an economic point of view, since the actual richness of the ore is perhaps the least important element to be considered; the two far more important points for consideration being the amount of ore procurable, and its position as regards water carriage, and other facilities for its extraction and reduction. Of course, all other conditions being equal, a rich ore is more valuable than a poor one; but the mere analysis of a small specimen of ore, how rich soever it prove, is no criterion whatever of its economic value, or whether it can be profitably worked. A reduced copy of Mr. O'Riley's map of Martaban, showing mineral sites, is published herewith for general convenience.

The only ores which need be noticed for practical purposes are those of iron, tin, lead, copper, antimony, none of which, save iron, are known to occur West of the Sittoung, but are confined to the belt of country running up from the British boundary on the Pakchan creek in Latitude 10° North to the frontier in Latitude 19° 30′. This tract of country differs essentially from the ground West of the Sittoung, the former being composed of several groups of beds of Palæozoic age, both altered and unaltered, together with metamorphic rocks seemingly azoic, the whole being traversed by granite and elvan dykes and pierced by numerous hot springs, whilst the latter is wholly made up of Secondary and Tertiary rocks, the newer greatly predominating; and wherein intrusive rocks are next to unknown. Physically also, and as regards climate, the country East of the Sittoung differs no less from that West of the river, than it does geologically. Martaban is essentially a mountainous country with lofty chains stretching in a north-north-west direction, some of whose peaks rise to 6,000 or 8,000 feet, and would afford some of the most charming sanitaria in India were they only a little more accessible to those who might be benefited by a resort to them. As a result of the geological constitution of the ground, copious and perennial springs abound and give rise to a charming verdure and coolness even over the lower elevations to which I know of no parallel elsewhere; and though said to be unhealthy (how truly I know not), the pine forests of the Youzalin are among the coolest and pleasantest districts, as far as temperature goes, which India can offer. It is this very district which, according to common report, teems with mineral wealth; but a most unfortunate drawback to its proper investigation is its wildness and want of population, which means also want of roads of any sort, and difficulty in the matter of supplies, not to allude to risk of sickness (a common concomitant, among camp-followers at least, on a greatly reduced temperature), and the attack of plundering bands, which find a sort of happy hunting ground along all this difficult wild country adjoining on the Karen-ni and Zimmay territories; traders and travellers being the special victims of these freebooters. The regular dacoit, moreover, is not the only 'conveyancer' to be dreaded; as it was but little more than a year ago that the entire police guard escorting some treasure, belonging to a trader, appropriated the money and then humourously stepped across the frontier with their arms, accoutrements and all as they stood, heedless of the feelings of disappointment, if not shame, which their doing so must have caused their comrades whom they left behind.

Iron.—Excellent ores of this metal occur both in Pegu, Martaban and Tenasserim, and in former days were smelted by the Burmese, but the manufacture is no longer to my knowledge carried on in British Burmah, though iron is still made in Upper Burmah, near Puppadoung, from ores similar to that formerly used in the Prome district. In Pegu (Eastern Prome) the ore occurs in the form of concretions of an earthy hydrated peroxide disseminated through the newer Tertiary beds which are there so extensively developed, and of which an account is given in the Records of the Geological Survey of India for 1869, page 83. East of the Sittoung the ore usually met with is the magnetic, a mixture of the protoxide and peroxide, often occurring in thick beds or lodes, and a valuable ore for smelting. Specular iron also occurs as an integral constituent mineral in some of the crystalline schists, and has from its brilliancy been mistaken for galena.

Mr. O'Riley remarks that "iron occurs abundantly in the lower ranges of the hills to the east of this station" (Shuay Ghyin), and the same valuable ore, the magnetic oxide, is known also to occur in Tavoy; but these deposits will probably not prove remunerative to work for many years, or till the difficulties which of late have threatened mining industry in England shall have become more weighty and confirmed.

Tin.—This metal is unquestionably the most important commercially of any produced within our Eastern possessions. Though beyond some workings near Malee-wan on the Pakchan river, near Latitude 10° 10′ North, the ore is nowhere systematically worked on a large scale within British territory. South of the Pakchan stream the richness of the tin washings derived from the degradation of a stanniferous granite, in which the tinstone occurs as one of the integral constituents of the rock, is well known, and reference may be made for information connected with this question to a report of Dr. Oldham, published in Selections from the Records of the Government of India, No. 10, page 56.

But the fact of most interest as regards British Burmah is, that this stanniferous granite and its associated deposits of stanniferous gravel, stretches up as far north as the parallel of Tounghoo, east of which station on the eastern slopes of the Pounglong Range, the metal has from time immemorial been worked by the Karen-ni, or Red Karen tribes within whose territory it lies. Tin ore has long been known to occur in the streams discharging into the Henzai basin in Latitude 14° 40′ and also at "Chando near Palouk, about two days journey from the sea, halfway between Mergui and Tavoy" (*vide* Gleanings of Science, vol. I, page 143); but how far to the north of Tounghoo this stanniferous granite continues, is not known, though as likely as not for 500 miles or more. As the tin works above alluded to at Kamapew, are some 2 miles beyond British territory, it is very important that Mr. O'Riley has traced the ore across the range of hills into the drainage basin of the Sittoung; and to Mr. O'Riley belongs the credit of having first drawn attention to the above fact. His words are as follow: "Tin: of the existence of this metal within the area of this district, I was convinced from having traced the stanniferous formations of the "Kaimapyu" which fall into the Salween, across the ranges of hills, whose drainage flows into the Sittang valley, and on forwarding to the Karens specimens and instructions, I was enabled to procure the specimens A. B." Of course Mr. O'Riley may have been misinformed, and the specimens in question may in reality have come from the Eastern, Salween valley, side of the hills and not from the British or Sittoung side; but as Mr. O'Riley was fully aware of the importance of this point, I am prepared to believe his statement in this particular to be correct. Mr. O'Riley goes on to add: "The specimen A exists in the hills north of the Youkthwah river, within the Tounghoo district, and the other, in the head waters of the main stream." I myself received some corroborative testimony to the same effect, when examining some hot springs in the lower part of the Youkthwah river; but nothing is actually known of the precise locality where the ore exists, nor can be till some one is specially deputed to examine the question. Major Malcolm Lloyd, Deputy Commissioner of Tounghoo, has much interested himself with the resources of his district, and has furnished me with the following itinary from Tounghoo to Kay-mah-pew, from which the difficult nature of the intervening country may be inferred, since the actual distance from Tounghoo is probably not much over 45 miles. On the last march the British boundary is crossed about the fourth mile.

Route from Tounghoo to Kay-mah-pew.

	Miles.
Tounghoo to Khoung-nouk-kwa	18
Khoung-nouk-kwa to Paylawa	8
Paylawa to Bogallee	8
Bogallee to Nothedoe	10
Nothedoe to Mobwaydo	10
Mobwaydo to Ivoobo	6
Ivoobo to Kadowboe	16
Kadowboe to Kay-mah-pew	15
	91

The current price of tin ore in Tounghoo used not to exceed, as I am informed by W. Usher, Esq., Rs. 185 the hundred viss (about 375 lbs.); but latterly the price has risen to Rs. 205 and even to Rs. 230 for choice lots, the same realizing Rs. 250 in Rangoon. As the carriage from the mines to Tounghoo is at present wholly by coolies, it seems desirable to ascertain if no alternative route can be devised by the Salween to Moulmein, making use of water carriage for part of the way.

GALENA.—This ore is known to exist in numerous spots in Martaban and Tenasserim, and is usually argentiferous to the extent on an average of 12 ounces of silver per ton of lead, taking as a guide the first six analyses of the subjoined table. In this respect the galena from Bamo and Upper Burmah is far richer, the mean of three samples from Bamo, giving 78 oz. 17 dwts. of silver to the ton of lead, the poorest yielding 58, and the richest 104 ozs.

Table exhibiting the amount of silver in ounces per ton of lead, from samples of Galena from various parts of Burmah.

			oz.	dwts.	gr.
1.	Galena	Martaban	5	8	0
2.	Do.	do.	5	14	0
3.	Do.	do.	9	0	0
4.	Do.	Tavoy	16	7	19
5.	Do.	Moulmein	19	5	14
6.	Do.	Tounghoo	20	8	7
7.	Do.	Bamo	58	14	8
8.	Do.	Bamo (Ponsee)	73	10	0
9.	Do.	Bamo (Kyet-yo)	104	10	16

Nine localities where galena occurs are marked in the sketch map of Martaban by Mr. O'Riley, ranged generally on a north-north-west line of bearing, coinciding with the general direction of the hill ranges, and extending over a line of country some 90 miles in length. Mr. O'Riley describes the ore as occurring in the mountain-limestone formation of the district, which is that also to which the magnificent and picturesque limestone hills near Moulmein, and along the Salween belong, but he does not say if the ore occurs disseminated in the rock, or in the form of a true mineral vein or lode. From what I have remarked on the north-east of Tounghoo, at the spot whence Major Lloyd procured his galena, I am inclined to think that it may occur on both ways, as it is there rather doubtful if there is a true vein, whilst on the Salween valley, the accounts would certainly suggest the existence of lodes.

I am sorry I cannot give any account of the attempts which have been made by private parties to work the lead and silver of Martaban, but much reticence is naturally observed on such a subject, either from a feeling of distrust or of vexation at the unfortunate results of crude attempts and hasty speculation. Nothing that has as yet been done, however, can be considered as conclusive either for or against the practicability of bringing these ores into the market. At present the wild state of the country seems to me the main obstacle to arriving at a satisfactory conclusion on this subject, from the sparseness of population and consequent inability for any one to properly scrutinize these impenetrably clad hills.

COPPER.—Four specimens of copper ore were procured by M. O'Riley, three of them from the same localities as the galena, one of them from the hills east of the Sittoung River, and all consisting of "the ordinary copper pyrites, both arsenical and combined with sulphur and iron." I have not myself been so fortunate as to procure any undoubtedly Martaban copper ore, save pieces brought to me exhibiting traces of that metal in the form of green carbonate associated with iron or lead ore, to the extent, and no more, of implying the presence of a small portion of the more valuable metal in the mass. Not far from Moulmein on the Ataran River, I have seen heaps of slag which some believed to be old copper workings; but an analysis shows that the slag does not contain so much as a trace of copper, and indicates merely the former presence of iron works, abandoned before the memory of the existing inhabitants.

An extremely interesting specimen of copper ore of a somewhat novel composition was procured by M. O'Riley from some spot on the Yoonzalin River, said to be accessible for boats.

Mr. Waldie, who analysed it, describes it as a new mineral species under the name O'Rileyite, in the Proceedings of the Asiatic Society of Bengal for 1870, page 279. Two analyses of the samples were made as below, the first being that of a sample forwarded on the 24th July, the second, which differs slightly, a sample forwarded subsequently:—

Copper	17·000
Silver	0·096
Iron	36·470
Antimony	1·150
Arsenic	32·700
Sulphur	1·360
Earthy matter	0·560
Deficiency and loss	10·664
	100·00

The silver in the above sample is equal to 31⅓ ounces troy per ton. The large amount of loss, however, (presumed to be mainly arsenic) was unsatisfactory, and Mr. Waldie, therefore, made a careful analysis of a second sample of the same mineral, forwarded by M. O'Riley on the 10th of October, with the following results:—

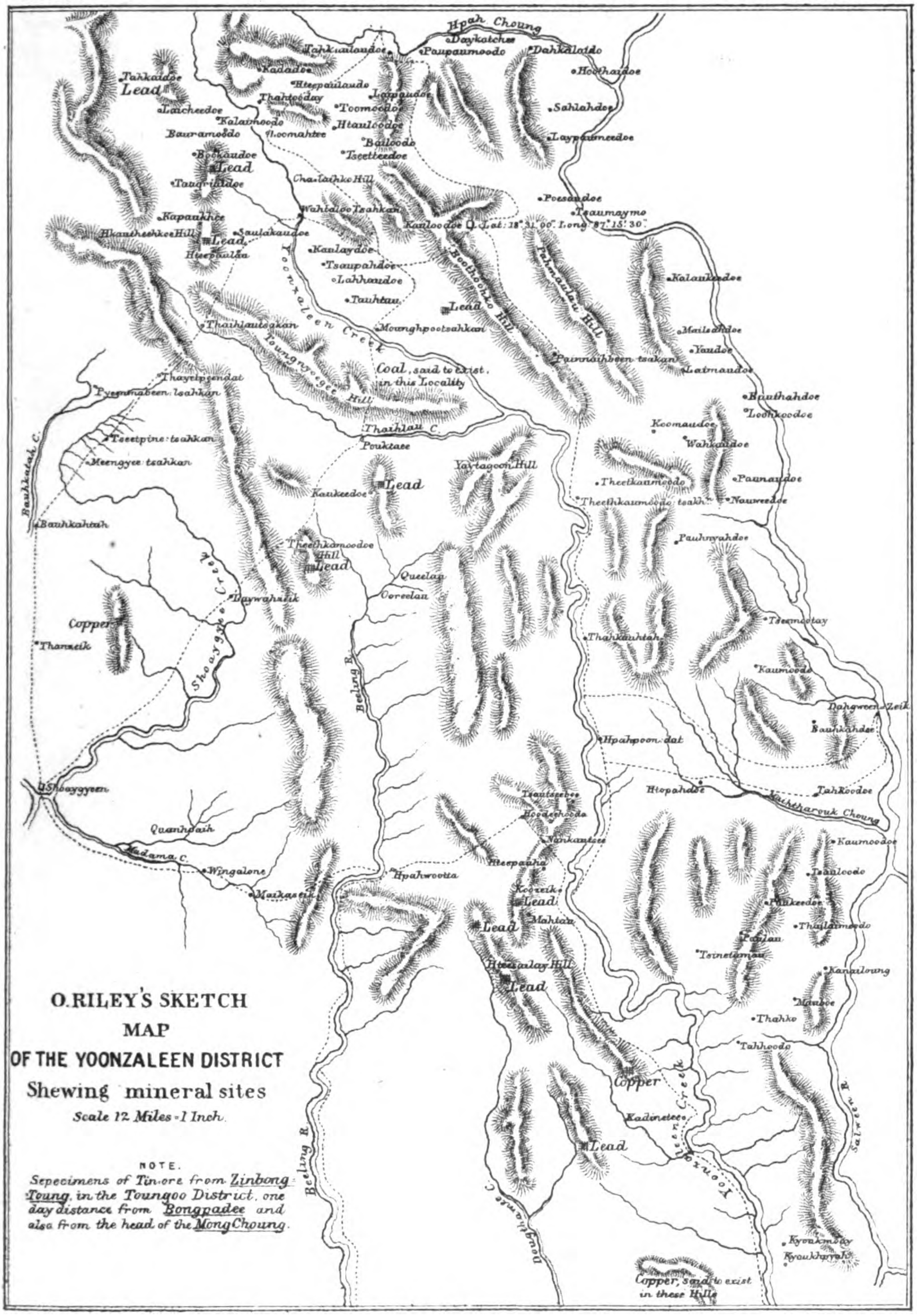
Specific gravity: In small pieces 7·343: In powder 7·428.

Copper	12·13	
Iron	42·12	
Arsenic	38·45	
Antimony	0·54	
Earthy matter	0·12	
Oxide of copper	1·21	Soluble in dilute hydrochloric acid.
" lead	1·89	
Arsenious acid	1·12	
Protoxide iron	1·97	
Loss	0·45	
	100·00	

Indications of the presence of copper, in the shape of stains of the green carbonate, are also occasionally met with; one such being recorded in the Geological Notes by Captain W. Foley, in the *Botoung* hills, 90 miles north-north-east from Moulmein (Maulamgeng); his words are: "Silver ore is said to exist in a limestone rock at this place; and judging from the numerous excavations that had been made by those in pursuit of the precious metal, no little labour has been used in the endeavour to discover it. I had neither time nor opportunity for ascertaining whether silver ore *does* so exist. Pieces of *copper green, iron pyrites,* and *lead ore* deemed useless and cast aside by those in pursuit of silver were strewed about the place, and for the first time, in this part of the world, I observed *anthracite* dispersed in thin seams through the limestone rock."

From this interesting passage, I should infer that extensive diggings for galena had been made here, as in a note the rejected lead ore is said to be the "*arseniate,*" possibly identical with phosphate of lead containing arsenic, which has recently been received in the laboratory of the Geological Survey for analysis from the Martaban district.

ANTIMONY.—Antimony occurs associated with galena in Martaban, but is nowhere worked in British territory. Metallic antimony, however, is imported to a small extent from the Shan States, and is probably used as an ingredient in the alloys of copper and silver which are worked up for ornaments by the Shans, who excel in all sorts of metal work. Antimony does not seem to receive much attention as a metal, though the powdered sulphide is largely used throughout the East as a collyrium under the name of *soormah,* the application of which along the eyelid, in the shape of a fine black powder, is supposed to enlarge the


O. RILEY'S SKETCH
MAP
OF THE YOONZALEEN DISTRICT
Shewing mineral sites
Scale 12 Miles = 1 Inch.
NOTE.
Sepecimens of Tin-ore from Zinbong Toung, in the Toungoo District, one day distance from Bongpadee and also from the head of the Mong Choung.
Hpah Choung
Lead
Copper
Coal, said to exist in this Locality
Copper, said to exist in these Hills
Beeling R.
Salween R.
Yoonzaleen Creek
Shoaygyeen

apparent size of the eye and add to its lustre and beauty. In India at least, however, no discrimination seems to be made between the sulphide of antimony and ordinary galena, which goes also by the name of *soormah*.

GOLD.—Though of slight economic importance, gold occurs in most parts of Burmah, but is very little worked within British territory, which I attribute to the higher and more certain remuneration there obtainable for agricultural or other labor; and gold working is, therefore, pursued mainly in bad seasons, or as an exceptional means of industry taken up merely now and again.

I am not aware of platina having been discovered in British Burmah, but as it is known in Upper Burmah under the name of Shwaybeen (white gold), it probably, I think, will be found in Pegu also, but perhaps in too fine a state of division to be independently separated.

In Volume III of the Gleanings of Science a very interesting analysis of a platina 'button' from Ava is given by J. Prinsep, which I here transcribe in proof of the actual occurrence of the metal, which might also be doubted:—

Platina	25
Gold	5
Iridium and osmium	40
Iron	10
Arsenic and lead	20
	100

The sole use the metal is put to is as an alloy, the only form of course in which the Burmese are capable of manipulating it. The proportion of the metals iridium and osmium is remarkable; and additional samples from Bamo are much wanted for analysis, but such are scarcely procurable save on the spot.

An impure earthy cobalt containing manganese was many years since procured by myself near Henzai, but I could learn no particulars beyond the above rather vague one of locality. It was a nodular mass of a black color enveloped in white clay, not more than an ounce in weight altogether.

The above remarks are all that I need offer on the subject, my intention being solely to point out in a brief manner what previous observers have recorded on the subject of the metalliferous wealth of Burmah.

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DEPARTMENT OF AGRICULTURE, REVENUE AND COMMERCE.

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MÜLLER, F. MAX.—The Hymns of the Rig-Veda in the Pada Text, (1873), 8vo., London.

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QUETELET, A.—Notices extraites de l'annuaire de l'observatoire Royale de Bruxelles pour 1873, (1873), 12mo., Bruxelles.

THE AUTHOR.

Report on the Progress and Condition of the Royal Gardens at Kew during the year 1872, (1873), 8vo., London.

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SLADEN, MAJOR E. B.—Official narrative of, and Papers connected with, the Expedition to explore the trade routes to China viâ Bhamô, (1869), 8vo., Rangoon.

WILLIAM THEOBALD, ESQ.

PERIODICALS.

American Journal of Science and Arts, 3rd Ser., Vol. V, Nos. 29 & 30, and Vol. VI, No. 31, (1873), 8vo., New Haven.

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The 8th October 1873.

RECORDS

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OF

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UNDER THE DIRECTION OF

THOMAS OLDHAM, LL.D., F.R.S.,

SUPERINTENDENT OF THE GEOLOGICAL SURVEY OF INDIA.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1874. [February.

Annual Report of the Geological Survey of India and of the Geological Museum, Calcutta, for the year 1873.

For the first time since the institution of the Geological Survey of India, it devolves upon an Officiating Superintendent to draw up the Annual Progress Report. Dr. Oldham, who may be said to have founded the survey, was compelled for the first time, after more than twenty-two years of continuous service, to take sick-leave to Europe early in April. For many months previously it had been strenuously urged upon him that rest and change of climate were necessary for his health. Even when he did leave India, it was to work hard in putting our collections into order in the Exhibition at Vienna; and the high merit officially awarded to those collections is largely due to his personal exertions on the spot as well as in India. The Superintendent's absence being only for a season, no change of method has been made or proposed, as unless permanently adopted such would only be mischievous. This report will therefore be as brief as possible.

It should be remembered that the progress reported on relates to the work accomplished during the field-season ending in April, May, or June, according to position, and brought into form during the recess for the monsoon; a preliminary notice being added of the distribution of the field work for the season opening in October and November.

I am unfortunate in having to chronicle a season of particularly slack work. Besides the absence of the usual number of the staff on sick-leave, several causes supervened to disturb what must be considered the normal work of the Survey. These interruptions were more or less unavoidable, and are to be taken as work done, under which head I have here placed them. In some cases at least the advantages gained, special or general, will compensate for any loss to our yearly tale of ground surveyed.

For the last half of the year six out of our small staff were absent. Mr. Blanford has been in Europe for the whole twelve months. Hard work in Persia made it necessary for him to take sick-leave; but he has been busily engaged in working out the very valuable zoological collections he took home with him from those little explored regions. He has also been mindful of Indian Geology in giving to the Society of Arts an excellent abstract of our work as illustrating the mineral resources of India, besides several papers of scientific interest read to the Geological Society and to the British Association. Mr. Fedden has been absent on sick-leave for the entire year. After a long struggle with an exhausting illness, Dr. Waagen was compelled to take sick-leave at the end of December 1872. Till the day of his departure he laboured at the description of the jurassic fossils of Kach, leaving the first portion of the work ready for publication, and a quantity of manuscript and plates in an advanced state of preparation. The Survey was especially fortunate in securing the services of Dr. Waagen for this work, as he had already achieved a sound reputation by his researches in formations of corresponding age in Europe. We have to lament that the tidings of his health are very unfavorable. As already noticed, Dr. Oldham had to go on sick-leave early in April. We may, perhaps, hope that improved health, and relief from the interruptions and preoccupation inseparable from the duty of directing widely scattered operations and correspondence, may give him leisure to mature the long expected introduction to the geology of India. The absence of Dr. Stoliczka, although depriving us for a time of our palæontological oracle, is not to be regretted when we consider the service he is engaged on. Every arrangement had been made for him to attend the gathering at Vienna as the rightful exhibitor of the most interesting part of our collections, and where there was so much to attract him, but he eagerly gave it all up to seize the opportunity of visiting a new field of research as naturalist with the Mission to Yarkand. In spite of the great suffering he endured in crossing the Korakorum range at so late a season, he has already contributed an interesting sketch of his observations of that ground. Before leaving, Dr. Stoliczka had just completed the publication in the Palæontologia Indica of his highly valued work on the Cretaceous Fauna of Southern India. The remaining absentee is unfortunately to be recorded as permanent: Mr. J. Willson, after his brief connection with the Survey, finding that the duties were more than his health was able for, transferred his services to the Educational Department, in March. The loss thus sustained by the Survey of an officer whose thorough training in science gave promise of high efficiency, is not to be made good; the Government having decided that the pay of this appointment is to be devoted to the experimental institution of native apprentices.

Although the staff of the Survey is nominally divided into three parties, under Deputy Superintendents corresponding with the three chief Presidencies, it has never been found convenient to adhere closely to this arrangement. Those who have studied certain formations must follow them out irrespectively of fiscal boundaries; and in so large a country, where communication is often difficult, it is commonly most convenient that each geologist should communicate independently with head-quarters in Calcutta. The work may therefore be most intelligibly noticed with some attempt at natural order, commencing with the formations to which our coal-measures belong.

In the south, Mr. King accomplished a very satisfactory season's work in the region of the lower Godavari. He revisited the Singareni coal-field, which he had discovered and described in the preceding season. Numerous trial borings had meanwhile been put down by the Nizam's officers, and a considerable amount of coal proved, although the seam was not found to be continuous throughout. The Beddadanole coal-field was fully examined; and although no outcrop was discovered, there is considerable hope tha coal exists. Mr. King gave full directions for prosecuting the search by borings, and orders have been given by the Madras Government for their being carried out. This field is not, like the Singareni field, circumscribed within very narrow limits by the older rocks. The actual area of measures exposed is not larger than that of Singareni; but the rocks are seen to pass beneath an extensive spread of a younger formation, and there is at least a chance of there being a considerable field, much of it in British territory. In this region we had hitherto only discriminated three members of this great rock-series; namely, the Talchirs, the Barakars, and the Kamthi sandstones, which Mr. Blanford had followed down the Godavari and Pranhita valleys from Chanda and Nagpúr, where he had, from the evidence of the fossil plants, ranked them in the Damuda horizon. From other fossil evidence, found in this confused upper sandstone series of the Godavari basin, it has long been considered that in part at least it represents formations younger than the reputed age of the Damudas. The obscurity regarding the correlation of this whole series of rocks with established formations has been owing to the failure hitherto to link any important portion of it with beds containing a distinctive marine fauna. Such a connection has long since been made for the Rajmahal group, through the Kach deposits; but the connection of the Rajmahal group itself in its typical area with the main rock-series is very uncertain. Mr. King has at last been so fortunate as to hit upon what may yield a clue to our puzzle—a fossiliferous zone of marine beds at Ragavapuram, thirty miles due west of Rajamandri, well intercalated with the upper sandstones, continuous with those overlying the Beddadanole coal-measures. In the same region, at Innaparaz Katapili, thirty miles north-north-east of Coconada, he also found fossils, in some detached sandstone beds along the northern margin of the Godavari delta. These latter fossils have been recognised by Dr. Stoliczka as on the horizon of his Oomia zone (uppermost jurassic) in the Kach series, the same which had long since been assimilated to the Rajmahal group. The Ragavapuram fossils did not reach in time for Dr. Stoliczka to examine them. They are at least specifically different from those of Innaparaz, and underlie a rock which Mr. King conjectures to represent that of the outliers. The facies of them, so far as a non-expert can pronounce, is jurassic. Above all these rocks, and underlying the trap, Mr. King discriminates a belt of sands with a thin limestone, characteristically similar to the Lameta or infra-trappean group of the Central Provinces, and which he conjectures to be cretaceous; the fossils in the limestone being distinct from those of the well-known Pangadi inter-trappean beds close by. The working out of all these suggestions is of the greatest importance to the geological history of India.

In this connection notice may appropriately be taken of a document quite recently published and circulated by the Government of Madras. It consists of a large-scale map, in divers colours, of a small area on the Kistna river about fifty miles south-by-east of the Singareni coal-field; with an explanatory text by Colonel Applegath, in which the old assertions are repeated regarding his discovery of coal there many years ago, with the addition that, having recently visited the coal-fields of the upper Damuda valley, he is in a position to assert the geological identity of the formations. It only needed this to complete the anomaly. Whatever possibility there might be of a coal being found in these rocks, quite distinct from that of the Indian coal-measures and unobserved by more recent explorers, it is really not within the range of possibility that several geologists of experience should so utterly confound rocks with which they are perfectly familiar. The ground referred to is the northern extremity of a large geological basin, of which a map with detailed description was published during last year in the Memoirs of the Survey. Working from the south, Messrs. King and Foote had no hesitation whatever in identifying these rocks on the Kistna as part of the connected series of Kadapah and Karnúl rocks, in the examination of which they had been engaged for several consecutive seasons. After the completion of that work Mr. King moved northwards, and found no difficulty whatever in recognizing the true coal-bearing series in the Singareni field, for the exploration of which by borings he gave indications which have proved successful. An account of this was also published during last year. Still we find the false prophets apparently in as great favor as ever with the authorities in Madras. Comment on such proceedings would be superfluous.

More to the north, in the Godavari basin, Mr. Hughes was engaged for the whole season in the Wardha coal-field; but frequent interruptions greatly retarded his progress towards completing the examination of the field. Several weeks were taken up in connection with Mr. Bauerman's deputation to examine the iron-deposits. Time was also spent in interviews with the mining officers of His Highness the Nizam, and in selecting sites for borings at Warora and Pisgaon. The chief independent result of the season was the demarcation of the small detached coal-field near Chimur, which may yet be of importance in connection with the iron ores of the neighbourhood. In examining the zamia-bearing zone on the south-west margin of the field, Mr. Hughes found a small coal-seam in it at Balanpur, which curiously repeats the characters of the seams on the same horizon in the Jabalpur group of the Narbada region. In the Wardha field two pits have been sunk to the coal, one at Warora in the Central Provinces, and one at Pisgaon in East Berar.

Mr. Medlicott took up his work in the Satpura, with the understanding that he was to carry out the examination of the formations so closely connected with the coal-measures there, and by which these are concealed; while at the same time he was to afford geological guidance for the borings he had recommended in the Narbada valley. The executive management of these was entrusted by the local Government to Mr. Collin, a mining engineer, or coal-viewer, sent out from England for the coal exploration in the Central Provinces. Both the personal and material provision for these trials proving utterly inadequate, Mr. Medlicott was afterwards called upon to supervise the execution of the work. Thus the geological investigation was stopped, in the vain hope of preventing the inevitable collapse, under existing arrangements, of the experimental work. The work Mr. Collin had executed was so bad that it had to be abandoned; while Mr. Medlicott, owing to this fruitless interruption, was only able to complete his examination of the lower Dudhi valley, with a view to fixing the sites for the borings there. Late in March the borings at Gadarwara and Sukakheri were recommenced under the immediate charge of Mr. Stewart, a very intelligent and trustworthy employé on the Great Indian Peninsula Railway, whose services were obligingly placed at the disposal of Government by the Agent, and under the supervision of Mr. Cooke, the Executive Engineer at Narsingpur.

These trials were undertaken upon the fully discussed possibility and a reasonable probability that the Satpura coal-measures might here extend from the Sitariva field beneath the alluvial plain. No depth could be assigned for these covering deposits. From 200 to 500 feet was given as the probable range. Considering the delays and difficulties to be contended with, the progress up to date must be taken as very creditable to those in charge of the work. Insufficient and defective piping has been throughout the chief difficulty. The boring at Gadarwara had to be stopped at the end of October, as the piping could not be driven beyond 226 feet, and there were no pipes of smaller diameter to sink within those that had stuck. The rods were put down to 251 feet, still in alluvial ground; but the hole could not be kept clear without the piping. At Sukakheri work was in progress at the close of the year, the piping having reached a depth of 330 feet, still in alluvial clay. Thus, of course, we as yet know nothing as to what rock underlies these deposits; the great thickness of which will prove a great impediment to mining enterprise should coal be found beneath them.

In view of the great extension of boring operations in all parts of India, it is to be regretted that there is still much misapprehension regarding the nature of the work, and consequently want of system and concert in the management. Next to the important object of these operations, the work of the Geological Survey is the chief sufferer from this defect. Among homogeneously civilized communities it is duly recognised that boring is a branch of engineering; that although the geologist might give the safest indications for the position and prospects of a boring, he would probably make a bungling attempt at executing the work. The mining engineer is supposed to, but very rarely does, combine these two branches of knowledge so radically distinct. In all new and intricate cases the greatest safety lies in the combined action of independent experts. This combination might no doubt be obtained in India as it commonly is in Europe, both elements being present. Such undertakings are, however, new to this country; and we have not got beyond the *primâ facie* point of view: because the majority of engineers will declare that they know nothing about boring, and the geologist cannot disown his connection with the business, it is assumed that the latter must be the best man for the whole job. The mistake is very similar to insisting upon a zoologist or a metaphysician performing the Cæsarean operation because a number of surgeons standing by chose to excuse themselves on the plea that they had never seen the thing done. No doubt a man of intelligence and education can always make some useful attempt at the supervision of mere skilled labour; and I have no doubt that Mr. Stewart would acknowledge his obligations in this way to Mr. Medlicott; but it is a fact that this geologist, when he was ordered to take charge of the borings he had recommended at Gadarwara, had only once before seen a boring in a casual way, and did not know the difference between a crab-winch and a jack-role, between a wrench and a spanner. I cannot but think that such important operations, depending entirely upon mechanical ingenuity and resources, should be under proper professional control and responsibility, and also that this should be forthcoming in some branch or other of the Department of Public Works.

In the Damuda basin Mr. J. Willson spent the season in retracing the lines of the Karanpura coal-fields on the newly issued maps of the Hazáribágh district.

Mr. Hacket was incidentally engaged upon these same formations, in adding to our collection of fossil plants from the Jabalpur group; but his chief occupation for the season was to trace the boundaries of the Vindhyan and older rocks on the new maps along the northern side of the Narbada valley in the Jabalpur, Narsingpur, and Hosungabad districts, and at the same time to add to our collections from the ossiferous valley deposits. Mr. Hacket filled in a large area.

In the same region, more to the north-east, Mr. W. L. Willson carried on the work of previous seasons, completing sheets 34, 35, 37, 47 and 48 of the new Topographical survey of Riwah and Bandelkand, including rocks of the Vindhyan, the Bijawar, and the gneissic series.

Mr. Mallet, having had much experience of the crystalline and metamorphic rocks in Bandelkand and the Són valley, took up an important section of the same rocks in South Behar, with the advantage of the new large-scale maps of Hazáribágh. So far as the comparatively small area of one season's detail-work can be trusted, there seems to be no marked stratigraphical break between the quartzite and slate series of Behar and the gneiss of Bengal. In the middle of the season Mr. Mallet was recalled for some weeks to Calcutta to prepare our mineralogical collections for the Vienna Exhibition.

Far to the south-west of the operations already noticed, Mr. Foote was at work in the South Mahratta country. A section was run across the gneissic area lying between Bellary and the Malparba river, a little to the north of which the south boundary of the Kaladghi series was crossed, and the previous season's work joined on. Various parts of the ground near Kaladghi were gone over again to clear up obscure points. The south-east part of the Kaladghi basin was then surveyed, including the line of outliers extending to Gadjandergarh. From this point the south boundary was carried west to Murgod in Belgaum district. So much of the gneiss area was gone over as was necessary to close in the north-east quarter of sheet 41, and to connect the several quartzite outliers with the general work. After completing the above boundary, work was carried on in the quartzite area around Toragal and Ramdurz, till it became necessary to move into Kaladghi to arrange and despatch the collection of geological specimens for the Vienna Exhibition.

The work remaining to be noticed is external to the rock-area of the Peninsula. In the extreme north-west, Mr. Wynne was engaged in working out the ground to the north of the Salt Range where the tertiary series occupies a large area and forms the outer ridges of the mountain region. The top and bottom horizons are identifiable with the Sivalik and Subathu groups of the sections far to the east, but the same marked divisions of the series are not expressed in the west as in the east. At the base here, although the purely structural features are remarkably like those in the Subathu region, upper secondary formations have been identified in sequence with nummulitic deposits, and of which no trace has as yet been found in the sections described to the east. The presence of such a close sequence of formations would in itself go far to negative here the interpretation that has been given of the features in the Simla region, and thus support Mr. Wynne in rejecting it for the ground he describes. But it is quite possible that both may be right. If widely different modes of action did not occasionally produce similarity of result, the art of observing would be much simpler than it is. These existing discrepancies of fact and of opinion can only be adjusted by the examination of the long stretch of intervening mountains between the Jhilum and the Ravi.

On the south-east side of India, Mr. Theobald completed the survey of Pegu. This work was commenced in the close of 1860 under Mr. Blanford, assisted by Mr. Fedden. In 1862 Mr. Theobald took Mr. Blanford's place; and since 1864 he has been alone at the work, and for eighteen months absent on furlough. On the north the limit of this work is a very broken one; all the formations have a north and south strike, and are thus absolutely cut off along the frontier. On the east the boundary is very regular and natural. At a little to the east of the Salwin in Martaban, along a very steady line, the tertiary formations rest against crystalline matamorphic rocks. The ground to the east of this has not been surveyed topographically. No one who has not made the attempt can form a conception of the difficulty of observing the rocks in a wild tropical region. Rank vegetation produces deep soil; and where the rocks themselves are not very hard, as is the case with much of these tertiary formations, one may march for days through a hill country without getting a fair section of rock in place. There thus remains a great deal to clear up in the geology of Pegu; but the description now published will form an admirable guide to further investigations. Fossils, too, seem to be very scarce. Enough only have been discovered to establish the presence of triassic, cretaceous, and nummulitic strata forming the Arakan Yomah, beneath the general mass of younger tertiary deposits on the east, forming the Pegu Yomah. The south-eastern districts of this province form a totally distinct geological field from that now completed by Mr. Theobald, as marked by the eastern boundary of this area. They are entirely formed of crystalline and sub-metamorphic rocks, in which there is much promise of metalliferous deposits. On this account the mining engineer appointed as mining geologist to the Survey has been deputed to examine those regions. Mr. Fryar reports directly to the Chief Commissioner of British Burmah.

Mr. Ball's work for the season has not yet been noticed: till the middle of February he was engaged in accompanying Mr. Bauerman to some of the coal and iron-fields of Bengal and the Narbada valley. It was quite out of the question that Mr. Ball could then take up his work in the distant wilds of Sirguja; so he occupied the time most usefully in completing the arrangement of our collections for the Vienna Exhibition.

Even if Mr. Bauerman's deputation to India had not so directly touched upon the work of the Geological Survey, it would call for notice here. He is the latest, and no doubt the most competent, of a series of experts sent out from England to report on the practicability of iron manufacture in India on European methods. His preliminary report containing the general result of his observations has been published; but the question seems to stand pretty much as before. Mr. Bauerman has simply restated the case in a more intelligible form than some of his predecessors, but no more so than it has all along been expressed by the Geological Survey—that, under existing circumstances, the Raniganj coal-field is the most promising place for a trial, the principal defect there being the flux; and the Survey has been called upon to furnish further data. The only good to be expected from Mr. Bauerman's visit is, to establish the opinion that actual trial must be the next stage of the enquiry. As an accomplished metallurgist he may also suggest what recent improvements in the art would be most suitable to the circumstances; but, of course, whoever may be entrusted with the conduct of the experiment would form his own opinion upon this point. Meanwhile further search is being diligently made by the Survey for means of surmounting the known material deficiencies.

In the foregoing paragraphs frequent mention has been made of the Vienna Exhibition as having caused interruption to work during the field season, which is already so restricted by the conditions of the Indian climate. This was duly noticed by Dr. Oldham in his last report; and it was shown how largely this circumstance was due to the present crowded and confined condition of our museum and offices, whereby we have been prevented from making even such collections for head-quarters as would sufficiently illustrate our field-work, and much less provide duplicates for distribution or for exhibition elsewhere. It is satisfactory to know that this disability will certainly be shortly removed by our removal during this and the ensuing year into the new Imperial Museum buildings. Once the drawback I have mentioned is removed, the occasional muster of a special collection for foreign exhibition will be altogether a gain—as an incentive to keep up to date, as a means of effecting valuable exchanges of specimens, and, not least, as an opportunity for selected officers to renew their acquaintance with men and things in more civilized regions, and to improve their knowledge in the highly progressive sciences with which we have to deal.

During the present season the distribution of the work is in continuation of that of last year except in the cases of the following officers: Mr. Theobald has been transferred to the North-West Provinces. One of the most interesting problems of Indian Geology awaits solution there—to get materials for unravelling the palæontological sequence in the immense series of deposits based (transitionally) upon the marine nummulitics, and ending above in the deposits containing the great mammalian fauna known as Sivalik. A first step in this enquiry will be to discriminate the proper horizons for the species of the numerous fauna now known as '*Sivalensis*,' derived from strata for which very different stratigraphical positions have been subsequently assigned.

On the urgent requisition of the Government of Bengal to have a mineral survey of British Sikkim and the fringe of the Himalayan range to the east, principally in the hope of discovering some serviceable coal deposit, Mr. Mallet has been detached for that duty. The chief expectation of success rests upon fact that rocks of the Damuda age, containing the well known fossil plants of the Indian coal-measures, are known to occur obscurely along the inner boundary of the tertiary sandstones flanking the mountain range. The occasional carbonaceous deposits in these younger formations themselves have nowhere, as yet seen, offered any encouragement to extended search.

Mr. Hughes has been deputed to carry out some special inquiries regarding the conditions for iron manufacture. He has already reported briefly upon the available deposits of Kumaon, and is now engaged in bringing together additional information to reduce the difficulties of the undertaking in the Raniganj field. It is hoped that there will still be enough of the working season left to admit of his completing the examination of the Wardha coal-field.

Mr. Ball has for the present taken up Mr. Medlicott's work in the Satpura region; and is to afford geological guidance for the boring operations. Mr. Hacket has resumed his work in Rajputana, which had to be suspended some years ago on account of the famine in that region. Mr. Medlicott is to devote what time he can spare for field-work to an examination of the coal recently discovered in the Garo hills. This coal can be certainly identified with the cretaceous coal of Siju and Maobilurkar in the same region. It appears to lie in an interior basin, the existence of which was not suspected. Until within the last five years these hills were as completely, on a small scale, a *terra incognita* as Central Asia, all approach being forbidden on account of the savage propensities of the inhabitants.

It remains to notice a new feature in the constitution of the Survey. It was said above that the last vacancy that occurred in the staff, by the transfer of Mr. J. Willson to the Educational Department, has not been filled up, the Government having decided to devote the pay of that appointment to the attempt to train native geologists. The scheme has in a way grown out of, though it can scarcely be said to be a development of, endeavours made by Dr. Oldham from time to time to establish teaching in certain branches of science in connection with the Geological Survey, that some general knowledge of these subjects might be diffused, and no doubt with the ulterior view that if this teaching bore fruit, the Survey might benefit by obtaining competent workers. Dr. Oldham's proposal would have involved some expense, in the shape of remuneration to the teachers. The present scheme avoids this objection, but is not free from others. It begins by curtailing the effective staff of the Survey; for years to come, moreover, these attached students must be a direct incumbrance; and there is small guarantee that they can ever be otherwise—that they will ever be fit for independent work. The superficial discrimination of stones that used to pass muster as geology, and does so still with the majority, is really of no kind of value in the present state of knowledge. Geological observations to be of any use or interest must include much that is not obvious to the naked eye. And in any country like India, where the means of locomotion are so cumbrous, a surveyor who cannot describe and discuss his observations, or who cannot be trusted to observe correctly, is comparatively useless, as it takes nearly the whole time of a competent man to check and direct his work. It is not here assumed either that natives cannot be taught geology, or that it requires a high order of intelligence to attain moderate proficiency as a geologist. It does, however, essentially require a modernized intelligence; the work being even in its lowest steps the rational interpretation of nature—the most elementary positions of the science being not statements of obvious fact, but inductive conclusions through a postulated causation. It is this that makes geology so singularly inappropriate for the initiation of the primitive cast of mind. Geology is pre-eminently a science having no corresponding art or practice in the proper meaning of the words, in which work can be done according to prescribable rules. Every geological act involves a deliberate judgment. The industrial undertakings occasionally based upon such judgments, involve only mechanical skill of a rough order, requiring no recognition of geological principles. These remarks may seem somewhat fine-drawn; but I think it right to represent this experiment for once under its essential conditions. The natives of India having as yet shown such little aptitude for acquiring physical knowledge in any of its branches, there seems small encouragement to force them directly into the application of one of the most complex developments of that knowledge. There are to be four native apprentices; one joined in March last, and three are about to join. They are all students of the Lahore College, no applicants having come forward from the North-Western Provinces. Their qualifications consist of a moderate knowledge of English and of elementary mathematics. It was at first prescribed that they should be immediately put into geological harness. But sanction has now been given to their attending one or more courses of physical science lectures at the Presidency College. The fact of their being already appointed to the Survey, though only as probationers, is not perhaps the most likely way to stimulate their studies. At the worst we may look forward to utilizing them as fossil-collectors.

PUBLICATIONS.—The quarterly RECORDS OF THE GEOLOGICAL SURVEY OF INDIA have been published regularly, containing numerous papers, both of general interest and of practical bearing. The first number, besides the annual report, contains a sketch of the geology of the North-West Provinces. This is the only province in India of which every part has been, more or less, cursorily visited. In the second number there is a map and description of the Bisrampur coal-field, which is about the centre of the extensive spread of these formations nearly continuous in the region of the upper Són and the northern tributaries of the Mahanadi. The coal-basins of this latter area will become of great importance when the direct route is established between Calcutta and Bombay. Mr. Mallet contributes additional mineralogical notes on the crystalline rocks of south Mirzapur. In the August number there is a brief discussion of the question of the geological age of our old river valley deposits, in which during the season's work in the Narbada valley Mr. Hacket had found a most symmetrically formed stone implement. The object of the paper is, by an examination of the stratigraphical features, and the comparison of them with those of established formations in Europe, to give a purely geological statement a most interesting question that had hitherto rested upon somewhat vaguely expressed palæontological surmises. A preliminary notice is given by Mr. King of the Beddadanole coal-field, about thirty-five miles north-west of Rajamundri, and by far the nearest known deposit to the sea-board of the Godavari delta. As yet nothing can be said of the prospects of the field. The trial borings are only commencing. Mr. Wynne contributes a sketch of the geology of the Rawal Pindi region, showing the enormous continuous development of the tertiary series. A comparative statement of the coal-measure areas of different countries, as compared with India, is drawn up by Mr. Hughes; and Mr. Theobald gives a description and list of the brine-springs of Pegu, the exploitation of which is now almost entirely superseded by the importation of salt and the manufacture of sea-salt. The fourth number contains a note by Mr. Hughes on some iron deposits of Chanda, Mr. Ball's description of Barren Island, and some memoranda by Mr. Theobald upon the metalliferous localities of British Burmah.

Of the MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA, the first part of volume X was issued early in the year. It contains a carefully written description by Mr. R. Bruce Foote of a large tract of country close to Madras, comprised in the eastern half of sheet 78 of the Indian Atlas. This is separately issued in two quarter sheets, geologically coloured. Besides the gneiss, the oldest formation occurring here is that well known in Indian geology as the Rajmahal group, the Oomia zone in Dr. Stoliczka's classification of the Kach rocks, and considered by this most competent authority to be of uppermost jurassic age. There are also several distinguishable deposits of tertiary and post-tertiary age, in some of which are found the rude stone implements described by Mr. Foote some years ago. This part also contains a tentative sketch with skeleton map of the Satpura basin of the coal-measure series by Mr. Medlicott. This ground seems to offer a fuller development of this great rock-series than any other area in India—from the zamia-bearing Jabalpur group, probably the same as the Rajmahal, through the Mahadeva strata and underlying beds presumably of Panchet and Damuda (Kamthi) affinities, to the typical Barakar and Talchir rocks at the base. Parts of the northern side of the basin were carefully examined, the lie of the coal-measures discovered, and indications given for trial borings. Part 2 of this volume, containing Mr. Theobald's description of the geology of Pegu, is also virtually published, the whole impression having been struck off in October, the delay being in the lithographing and colour-printing of the map.

The issue of the PALÆONTOLOGIA INDICA for the whole year was made in April and May. With a view to the Vienna Exhibition, and to admit of his going there himself, Dr. Stoliczka made great efforts to get in advance of his work. The parts then issued contain the Echinodermata, Anthozoa, Sponges, Foraminifera, Arthrozoa, and Spondylozoa, forming the fourth and last large volume of the Cretaceous Fauna of Southern India. The fullest testimony has been offered by the most competent authorities to the excellence and value of this work. For the same object an effort was made to prepare and issue the first fasciculus of the series describing the jurassic fauna of Kach by Dr. Waagen. It contains the Belemnitidæ and Nautilidæ, and was issued in June, being the number in advance for the first quarter of 1874. There is a quantity of manuscript and of drawings in an advanced state of preparation, and if either Dr. Waagen or Dr. Stoliczka is able to return, even late in the year, the publication can be readily brought up to date.

MAPS.—The first of the systematic publication of our maps on the scale of one inch to the mile, as recently sanctioned, was made this year by the issue of the twelve sheets of the district Dumoh; several sheets of the adjoining region are ready to send to press. I cannot but express my decided opinion that the publication of the greater part of our work on this scale is premature and wasteful, neither the maps nor the geology being worth it. I say this advisedly, and because I am quite prepared to defend the excellence of the maps to the degree of accuracy that can be expected in them. We have for the most part to deal with rocky and hilly ground, and tracts of this description generally come under the Topographical system of survey. It would altogether defeat the objects of this mode of survey, which are expedition and moderate cost, if it were to attempt the same accuracy of detail that is expected from the method of the Revenue Survey. For all ordinary purposes of geography, and for all rough practical purposes, as well as general geological structure, these maps are all that need be required. But close geological work is as severe a test as a map can be put to; and I have often had to give up the attempt to make the geological features agree accurately with the lines of these maps. I can speak even more positively of the geological objection. Take these very maps of Dumoh; they only represent the boundaries of the overlying trap, the divisions of the Vindhyan series (generally several hundred feet in thickness), and the outcrops of the inter and infra-trappeans, all in the simplest relation of horizontal superposition. There is no single feature of scientific interest or of practical utility calling for any minuteness of delineation, and that cannot be adequately indicated on the quarter-inch scale. It is certainly necessary that the field work should be executed on the one-inch scale if only to ensure all possible accuracy on the smaller map; but once this reduction has been carefully made, and with an explanatory text, it would be of small consequence if the field-maps were destroyed. The most complete geological map possible would be of no use in the hands of one who scarcely knows one rock from another; and for one who does, the quarter-inch maps will be sufficient guide over nine-tenths of the geological work likely to be done in India for many a year to come.

While on the subject of large scale maps, I would urge the importance of having really adequate working maps of certain tracts where the utmost amount of accuracy and of geological detail is called for. Such a map is now greatly needed on the scale of four or six inches to the mile for the Raniganj coal-field, where mining enterprise is so active.

Of the Atlas of India maps, quarter sheet 77 S. W. was published during the year; and several of the adjoining sheets are ready for the engravers. The printing of these has not been pressed on account of some uncertainty as to corrections, which could not be settled in the absence of Mr. King. This is of less consequence, as a skeleton map of most of the area was issued with the descriptive memoir published last year. As these Atlas sheets are to be our final and general form of publication, it is of great importance to decide upon a permanent scale of colours, so as to have the series uniform; and it is very difficult to do this safely while the scale of formations itself is under discussion. Once this difficulty is surmounted, we shall be in a position to publish a good number of these quarter sheets.

LIBRARY.—The library has received the addition of 614 volumes or parts of volumes during the year, of which number 477 were presented, and 137 purchased. This number would have been much larger, save for the unfortunate miscarriage of a large consignment of books from Berlin. It is hoped that the case has only gone astray and will be recovered.

It has now been several months missing. The detailed list of these additions has been regularly published in the RECORDS; and a list of the institutions from which presentations or exchanges have been received is annexed.

MUSEUM.—Occasional donations to the museum have been duly acknowledged in the RECORDS. Mr. Mallet was able, during the recess, to get through a considerable section of his descriptive catalogue of mineral collection. The preparation for the Vienna Exhibition entailed no small additional labour upon all hands; but the success achieved has been most gratifying to all. The parts of those collections to be received back have not yet arrived. The series of specimens in the museum are in good order.

H. B. MEDLICOTT,
Offg. Supdt. of Geol. Survey, India,
and Director of Geol. Museum, Calcutta.

CALCUTTA,
January 1874.

List of Societies and other Institutions, &c., from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1873.

BATAVIA.—Royal Society of Batavia.
BELFAST.—Natural History and Philosophical Society of Belfast.
BERLIN.—German Geological Society.
„ —Royal Academy of Science.
BOSTON.—Boston Society of Natural History.
BRUXELLES.—Royal Academy of Science.
CALCUTTA.—Asiatic Society of Bengal.
CAMBRIDGE-MASS.—American Academy of Arts and Sciences.
„ —Museum of Comparative Zoology.
CHRISTIANIA.—Royal University.
COPENHAGEN.—Danish Academy.
DRESDEN.—The Isis Society.
DUBLIN.—Royal Dublin Society.
„ —Royal Geological Society of Ireland.
EDINBURGH.—Royal Society of Edinburgh.
FLORENCE.—Geological Commission of Italy.
GLASGOW.—Philosophical Society of Glasgow.
GÖTTINGEN.—The Society.
INDIANAPOLIS.—Geological Survey of Indiana.
LAUSANNE.—Society of Natural Sciences.
LIVERPOOL.—British Association for the advancement of Science.
LONDON.—British Museum.
„ —East India Association.
„ —Geological Society of London.
„ —Royal Asiatic Society.
„ —Royal Institute of Great Britain.
„ —Royal Geographical Society.
„ —Royal Society.
„ —India Office.
MELBOURNE.—Royal Society of Victoria.

MINNEAPOLIS.—Academy of Natural Sciences, Minnesota.
MONTREAL.—Geological Survey of Canada.
MOSCOU.—Imperial Society of Naturalists.
MÜNICH.—Royal Bavarian Academy of Science.
NEUCHATEL.—Society of Natural Sciences.
NEW ZEALAND.—Geological Survey of New Zealand.
PARIS.—Geological Survey of France.
„ —L'Administration des Mines.
PHILADELPHIA.—Academy of Natural Sciences.
„ —American Philosophical Society.
ROORKEE.—Thomason College of Civil Engineering.
SALEM.—Peabody Academy of Science.
„ —Essex Institute.
STOCKHOLM.—Bureau Recher. Geol. Suede.
„ —Royal Academy of Science.
ST. PETERSBURG.—Imperial Academy of Sciences.
TORONTO.—Canadian Institute.
TURIN.—Royal Academy of Science.
VICTORIA.—Government Geological Survey of Victoria, Department of Mines.
VIENNA.—K. K. Geologische Reichsanstalt.
„ —Vienna Academy.
WASHINGTON.—Smithsonian Institute.
„ —Department of Agriculture of the United States of America.
„ —Department of State, Washington, D. C.
„ —United States Geological Survey.
WELLINGTON.—New Zealand Institute.
YOKOHAMA.—German Natural History Society.
ZÜRICH.—Natural History Society.

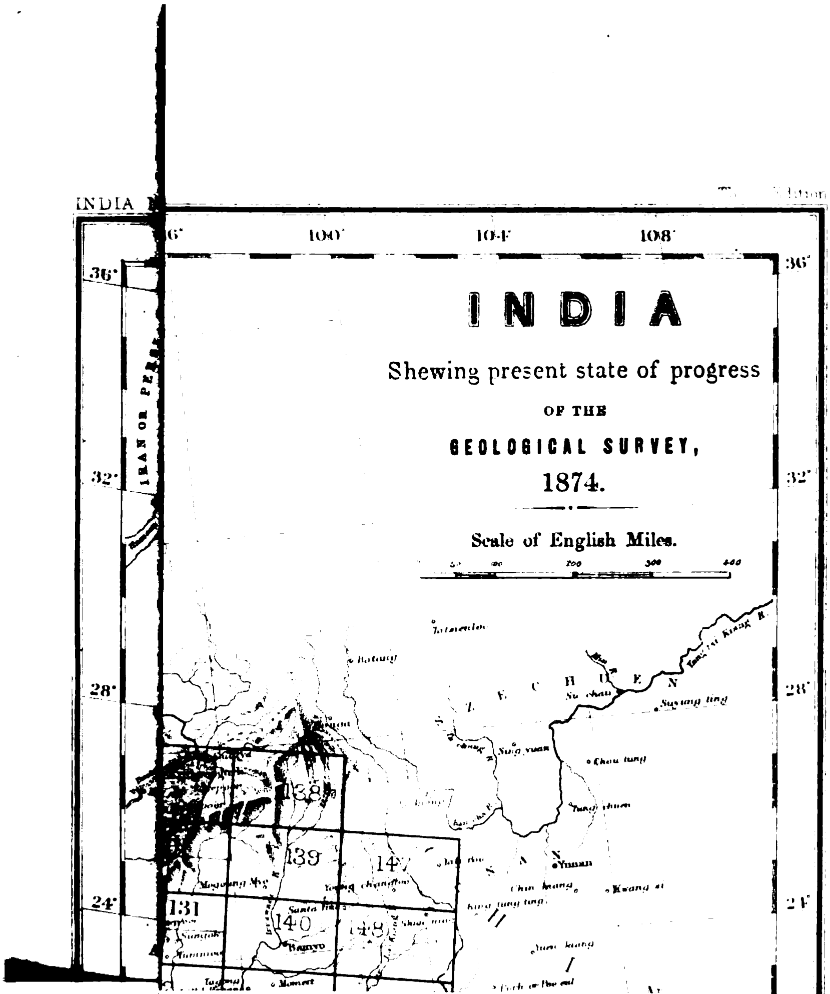
Governments of Bengal, Bombay, India, Madras, Minnesota, and North-Western Provinces; Chief Commissioners of British Burma, Central Provinces, and Mysore; the Surveyor General of India, the Resident, Hydrabad, and the Superintendent of the Great Trigonometrical Survey of India.

A BRIEF ACCOUNT OF THE GEOLOGICAL STRUCTURE OF THE HILL-RANGES BETWEEN THE INDUS VALLEY IN LADAK AND SHAH-I-DULA ON THE FRONTIER OF YARKAND TERRITORY, *by* DR. F. STOLICZKA, *Geological Survey of India, Naturalist attached to the Yarkand Embassy.*

The following brief notes on the general geological structure of the hill-ranges alluded to, are based upon observations made by myself* on a tour from Leh, *viâ* Changchenmo, the high plains of Lingzi-thang, Karatagh, Aktagh to Shah-i-dula, and upon corresponding observations made by Dr. H. W. Bellew, accompanying His Excellency Mr. Forsyth's camp along the Korakorum route to this place.

Before proceeding with my account, I will only notice that our journey from Leh (or Ladak) was undertaken during the second half of September and in October, and that we found the greater portion of the country north of the Changchenmo valley covered with

* As a member of a detached party, specially deputed by His Excellency the Envoy, Mr. T. D Forsyth, C. B., to explore the Changchenmo and Lingzi-thang routes.


INDIA
Shewing present state of progress
OF THE
GEOLOGICAL SURVEY,
1874.
Scale of English Miles.
100°
104°
108°
36°
32°
28°
24°
IRAN OR PERSIA
138
139
147
131
140
148
Yunan
Su chau
Chou tung
Bamyo

snow, the greatest obstacle a geologist can meet on his survey. While on our journey the thermometer very rarely rose during the day above the freezing point, and hammer operations were *not easily* carried out. At night the thermometer sank as a rule to zero, or even to 8° below zero in our tents, and to 26° below zero in the open air. Adding to this the natural difficulties of the ground we had to pass through, it was occasionally not an easy matter to keep the health up to the required standard of working power.

Near Leh, and for a few miles east and west of it, the Indus flows on the boundary between crystalline rocks on the north and eocene rocks on the south. The latter consist chiefly of grey and reddish sandstones and shales, and more or less coarse conglomerates, containing an occasional *nummulite* and casts of *pelecypods*. These tertiary rocks extend from eastward south of the Pangkong lake, following the Indus either along one or both banks of the river, as far west as Kargil, where they terminate with a kind of brackish and fresh-water deposit, containing *melaniæ*.

Nearly the entire ridge north of the Indus, separating this river from the Shayok, and continuing in a south-easterly direction to the mouth of the Hanle river (and crossing here the Indus, extending to my knowledge as far as Demchock), consists of syenitic gneiss, an extremely variable rock as regards its mineralogical composition. The typical rock is a moderately fine-grained syenite, crossed by veins which are somewhat richer in hornblende, while other portions contain a large quantity of schorl. Both about Leh and further eastward, extensive beds of dark, almost black, fine-grained syenite occur in the other rock. The felspar often almost entirely disappears from this fine-grained variety, and quartz remains very sparingly disseminated, so that gradually the rock passes into a hornblendic schist; and when schorl replaces hornblende, the same rock changes into layers which are almost entirely composed of needles of schorl. Again, the syenite loses in places all its hornblende, the crystals of felspar increase in size, biotite (or sometimes chlorite) becomes more or less abundant, and with the addition of quartz we have before us a typical gneiss (or protogine gneiss) without being able to draw a boundary between it and typical syenite. However, the gneissic portions, many of which appear to be regularly bedded, are decidedly subordinate to the syenitic ones. As already mentioned, the rock often has a porphyritic structure, and the felspar becomes pink instead of white, as, for instance, on the top of the Kardung pass and on the southern slope of the Chang-la, where large fragments are often met without the slightest trace of hornblende. To the north of the last mentioned pass the syenitic gneiss gradually passes into thick beds of syenite-schist, and this again into chloritic schist, by the hornblende becoming replaced by chlorite, while the other mineral constituents are gradually almost entirely suppressed. The syenitic and chloritic beds alternate with quartzose schists of great thickness. This schistose series of rocks continues from north of the Chang-la to the western end of the Pangkong lake, and northwards to the Lanker-la, generally called the Marsemik pass. On the western route Dr. Bellew met similar rocks north of the Kardung pass at the village Kardung, and traced them northwards across the Shayok, up the Nubra valley to near the foot of the Sussir pass.

Intimately connected with the metamorphic schistose series just noticed, is a greenish chloritic, partly thin-bedded, partly more massive rock, which very closely resembles a similar rock found about Srinaggar. Only in this case certain layers, or portions of it, become often distinctly or even coarsely crystalline, sometimes containing bronzite sparingly disseminated, and thus passing into diallage. This chloritic rock forms the greater part of the left side of the Changchenmo valley, and also occurs south of the Sussir pass. I think we have to look upon this whole series of schistose and chloritic rocks as the representatives of the *silurian formation*.

After crossing the Changchenmo valley to Gogra, we met with a different set of rocks. They are dark, often quite black, shales alternating with sandstones. Many beds of the latter have a comparatively recent aspect, and are rather micaceous, without the least metamorphic structure, while the shales accompanying them very often exhibit a silky, sub-metamorphic appearance on the plains of fracture. I observed occasionally traces of *fucoids* and other plants in these shales, but no animal fossils. On the Changchenmo route these shaly rocks forms the ridge of the Chang-lang pass, as well as the whole of the western portion of the Lingzi-thang; and they are met again after crossing these high plains and entering the Karakash valley, as far as Shinglung (or Dunglung). On the Korakorum route Dr. Bellew brought specimens of similar rocks from the Korakorum range itself. There can be but little doubt,—judging from similar rocks which I saw in Spiti, and from their geological relation to certain limestones, of which I shall presently speak—that we have in the shaly series the *carboniferous formation* represented.

In many localities along the right bank of the Changchenmo river, then at the hot springs north of Gogra, and on the southern side of the Chang-lang pass, we find the carboniferous beds overlain by *triassic limestone* which often has the characteristic semi-oolitic structure of the Krol-limestone south of Simla. At Gogra and several other places dolomitic beds occur; and in these, sections of *Dicerocardium Himalayaense* are not uncommon. In other places beds are met with full of *crinoid* stems. North of the Lingzi-thang plain—to the west of which the hills are mostly composed of the same triassic limestone—a red brecciated, calcareous conglomerate is seen at the foot of the Compass-lá, but this conglomerate gradually passes into the ordinary grey limestone, which forms the ridge, and undoubtedly belongs to the same group of triassic rocks. The last place where I saw the triassic limestone was just before reaching the camping ground Shinglung; here it is an almost white or light grey compact rock, containing very perfect sections of *Megalodon triqueter*, the most characteristic triassic fossil. On Mr. Forsyth's route Dr. Bellew met with similar triassic limestones on the northern declivities of the Sussir pass, and also on the Korakorum pass overlying the carboniferous shales and sandstones previously noticed. On the Korakorum the triassic limestone contains spherical corals very similar to those which had been a few years ago described by Professor Ritter von Reuss from the Hallstadt beds in the Alps, and which are here known to travellers as Korakorum stones. A description of these very remarkable corals will be given subsequently.

Returning to our Lingzi-thang route, we leave, as already mentioned, the last traces of triassic limestone at Shinglung, in the upper Karakash valley. Here the limestone rests upon some shales, and then follow immediately the same chloritic rock which we noticed on the Lunker-la, alternating with quartzose schists, both of which must be regarded as of upper palæozoic age.

At Kizil-jilga regular sub-metamorphic slates appear, alternating with a red conglomerate and red sandstones, and further on dark slate is the only rock to be seen the whole way down the Karakash, until the river assumes a north-easterly course, some fourteen miles west of the Karatagh pass. From here my route lay in a north-westerly direction towards Aktagh, and the same slaty rock was met with along the whole of this route up to the last mentioned place. Dr. Bellew also traced these slates from the northern side of the Korakorum to Aktagh. They further continue northwards across the Suget-lá, a few miles north of the pass, as well as in single patches down the Suget river to its junction with the Karakash. The irregular range of hills to the south of the portion of the Karakash river, which flows almost east-west from Shah-i-dula, on its southern side entirely consists of these slates, while on the northern side it is composed of a fine-grained syenite, which also forms the whole of the Kuenlún range along the right bank of the Karakash river, and also is the sole rock composing the hills about the camping ground Shah-i-dula. The slates of which I spoke are, on account of the close cleavage, mostly fine, crumbling, not metamorphic, and must, I think, be referred to the silurian group. They correspond to the metamorphic schists on the southern side of the Korakorum ranges.

Thus we have the whole system of mountain ranges between the Indus and the borders of Turkistan bounded on the north and south by syenitic rocks, including between them the silurian, carboniferous, and triassic formations. This fact is rather remarkable, for, south of the Indus, we have nearly all the principal sedimentary formations represented from the silurian up to the eocene, and most of the beds abound in fossils.

The only exception to which I can allude on the Changchenmo route is near Kium, in the Changchenmo valley. Here there are on the left bank of the river some remarkably recent looking sandstones and conglomerates, dipping at an angle of about 45° to north-by east, and at the foot of these beds rise the hot springs* of Kium. I think it probable that this conglomerate has eastward a connection with the eocene deposits, which occur at the western end of the Pangkong lake, and in the Indus valley south of it.

In the previous notes I have scarcely alluded to the dip of the rocks at the different localities. The reason is that there is indeed very great difficulty in directly observing both the dip and the strike. At the western end of the Pangkong lake the dip of the metamorphic schists is mostly a south-westerly one, but further on nearly all the rocks dip at a moderate angle to north-east, north-by-east, or to north. On the Lingzi-thang, just after crossing the Changlang, the shales are mostly highly inclined, but further on the limestones lie unconformably on them and dip to north-east. Wherever the hills consist merely of shales and slates, their sides are generally so thickly covered with débris and detritus that it becomes almost an exception to observe a rock *in situ*.

The débris is brought down in large quantities by the melting snow into the valleys, and high banks of it are everywhere observable along the water-courses. At a somewhat remote—say diluvial—period this state of things has operated on a far greater scale. Not only were the lakes, like the Pangkong, much more extensive, but valleys like the Changchenmo, or the Tanktze valley, sometimes became temporarily blocked up by glaciers, or great landslips, and the shingle and clay deposits were often accumulated in them to a thickness of two or more hundred feet. Near Aktagh similar deposits of stratified clay exist of about 160 feet thickness, and extend over an area of more than one hundred square miles. There can be but little doubt that when these large sheets of water were in existence, the climate of these now cold and arid regions was both milder and moister, and naturally more favorable to animal and vegetable life than it is now. A proof of this is given, for instance, by the occurrence of subfossil *Succineæ*, *Helices*, and *Pupæ* in the clay deposits of the Pangkong lake, while scarcely any land mollusk could exist at the present time in the same place.

NOTES ON SOME OF THE IRON-ORES OF KÚMAON, BY THEODORE W. H. HUGHES, A. R. S. M., F. G. S., GEOLOGICAL SURVEY OF INDIA.

In connection with the highly important subject of the establishment of iron works in this country on the large scale, I was called upon in October last by Government to investigate the mode of occurrence and to determine the quality of some iron-ores in the province of Kúmaon.

My attention was directed to no new localities; I was instructed to visit ground that had already been so reported upon, written about and discussed, that it possessed a literature of its own on the special subject of iron, of more than five hundred octavo pages.†

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* The temperature of these hot springs varies from 60° to 125°. They form no deposit of gypsum, like the springs north of Gogra, but there is a good deal of soda deposit round them.

† Selections from the Records of the Government of India, No. VIII, 1855.
" " " " " " " Supplement to No. VIII, 1855.
" " " " " " " " " XVII, 1856.
" " " " " " " " " XXVI, 1859.
Report on the Government iron works at Dechouree in Kúmaon, by Thomas Oldham, Esq., 1860.

There was no time, and perhaps no necessity, for me to make an exhaustive examination of the capabilities of the entire province; but my work would have been personally more satisfactory if, by more extended research, I had been able to assure myself that no essential points had escaped the observation of my predecessors.

Acting upon the orders conveyed by letter through Colonel Ramsay, C. B., Commissioner of Kúmaon—"to report generally upon the quantity and quality of the ores and fluxes in the neighbourhood of Rámgarh, Khairná, Káládhúngí, and Déh-chaurí"—I proceeded as soon after the cessation of the rains as possible to examine each locality indicated.

Colonel Drummond, Dr. Oldham, and Messrs. Henwood, Sowerby, Barret, Davies, Watson, and Bauerman have expressed views as to the prospect of Káládhúngí and Déh-chaurí furnishing ore and flux, and I find on comparing their opinions that with the exception of Mr. Henwood in 1855, and Mr. Bauerman in 1873, they entertain the belief that ore is very plentiful. In this belief I coincide. I have only to temper the too high estimate formed of the quality of the ore.

RÁMGARH.

Under this heading it will be convenient to refer to several places in the same geological region, but at some distance apart—namely, Páhlí, Loshgiání, Natúá Khan and Parwárá.

Pahlí.—This locality is near the Rámgarh suspension bridge and on the right bank of the Kálápání river. I am sorry to say there was no means of gaining any knowledge as to the existence or quality of ore other than by the examination of some waste heaps near the mouths of two deserted galleries. A sample of ore was brought in and analyzed. It yielded 42·93 per cent. of iron. This is but a low percentage, and may be accounted for by supposing that the waste mass from which the ore was picked out contained only poor specimens. At Natúá Khan and other localities where the same variety of ore (micaceous hæmatite) occurs the average percentage of iron is much greater.

Loshgiání.—Iron-ore has been extensively wrought near Loshgiání. There are two distinct beds, the Gwálákúrí and the Khánípáká. The ore, which is least rich in iron, is that of the Gwálákúrí bed.

Its outcrop is well defined, and by clearing away a little earth, I was enabled to obtain what I consider a fair sample of the ore, which is a rather dense brown hæmatite, yielding 52·4 per cent. of iron. The minimum thickness of the bed is 8 feet. I have not been able to find any reference to the quality of this iron in any of the books which I have consulted. I suspect that its external appearance, which is certainly not indicative of such a high percentage, as analysis shows it to contain, condemned it in the eyes of those to whom the soft, bright, micaceous hæmatites of the neighbourhood had recommended themselves.

The Khánípáká bed is distinct from that of Gwálákúrí, although on almost the same horizon. It has been largely mined by the natives, and the number of shafts that have been sunk to reach the ore is something extraordinary.

I was anxious to obtain access to some underground workings, in order to estimate the thickness of the bed; but when I saw that the only means of descent was by a rope down which one had to slide to a depth of 80 to a 100 feet, and then come up again hand over hand, and that the shaft was neither straight nor dressed, I was obliged to acknowledge that to gain my end would necessitate the performance of a feat somewhat beyond my powers. In consequence, I can merely repeat what the natives told me, that the bed varied from 6 to 8 feet in thickness. A large amount of the ore is stacked in the yard adjoining the partly erected furnace near the village of Rámgarh. It seemed unnecessary to have the percentage of iron determined, as it appears to be of quite as high a value as the Natúá Khan ore, the analysis of which will be found further on.

Natúá Khan.—This is one of the most celebrated localities for the ores, coming under the general heading of Rámgarh. It possesses, however, no claim to superiority over Loshgiání, either on the score of better quality of ore or greater thickness of bed. The accident of its propinquity to the main road between Naíni Tál and Almora renders it easy of access, and therefore brings it more into notice.

There is no outcrop of the bed visible; and, as in the case of Loshgiání, I have to rely on the statement of the natives who worked it underground, that its total thickness is 9 feet, including a parting that varies from 1 to 2 feet. A specimen of the ore, which I obtained near the old workings, yielded 61·33 per cent. of iron. Dr. Macnamara,* who analysed a sample forwarded by Colonel Drummond in 1855, gives the result of his examination as 70·72 of iron. This is, of course, a very high percentage, and the average is probably nearer the result obtained in our office.

Parwárá.—This locality is several miles from Rámgarh, but as I had heard of it spoken of as possessing a bed of good ore, I went there. I found on my arrival that there was no opportunity of inspecting the ironstone *in situ*, every pit that had been sunk having filled in. I tried to open out one of them, but two days' working convinced me that a month would be required to get down and expose the bed, and I contented myself by taking away a specimen of the ore from amongst a few pieces that the headman of the village had in his house. It was brown hæmatite, mixed with a great deal of calcareous matter. The result of analysis was 29·61 per cent. of iron and 43 per cent. of carbonate of lime. Although the quantity of iron is small, this ore would be valuable to mix with others, on account of the carbonate of lime with which it is associated.

There were several mines in the neighbourhood which I might have looked at, but as they were all abandoned, and there was nothing to see at the surface beyond the rocks in which the ironstone occurred, I wasted no time over them.

SUMMARY.—The examination of the few localities I have visited convinces me that in the Rámgarh area the *ores are rich, abundant*, and may be easily worked.

The Loshgiání and Natúá Khan beds have only to be mined upon some rational system to yield an enormous amount of ore. Dr. Oldham, in his report of 1860,† when referring to Rámgarh, says, "there is not the slightest possibility of the want of ore being felt; there is the greatest abundance."

Flux.—Lime-stone occurs in the immediate vicinity of the ironstone at Natúá Khan. It yields by analysis 67·6 per cent. of carbonate of lime, and the rest is chiefly clay. This is not equal to the purity of limestones generally in use in England, which contain 93 to 97 per cent. of carbonate of lime; but an impure limestone can be employed advantageously at times, when the ore of iron is of such a composition that it requires some foreign earths to be added. I am not aware of any purer limestone occurring near Natúá Khan or Loshgiání.

KHAIRNÁ.

From Rámgarh I proceeded to Khairná, and after examining the iron-ore there went to Tatail and Kalúágarh, which are villages in the valley of the Kosí, distant about three and seven miles respectively from Khairná.

Khairná.—A bed of quartzite, in which small veins of red hæmatite are found, occurs near to the old suspension bridge at the confluence of the Kosí and Khairná rivers. I cannot report favorably of this locality as a source of supply; for, though the ore considered

* Selections from the Records of the Government of India, Supplement to No. VIII, 1865, page 37.

† Report on the Government iron-works at Dechouree, in Kúmaon, by Thomas Oldham, Esq., 1860, p. 24.

merely as an ore is good, it is too much scattered through the matrix for profitable working. Mr. Sowerby speaks highly of Khairná, and says—"I have no doubt whatever but that the deposit is very considerable, and there is a good back (hill) to work upon." Our opinions differ.

Tatail.—Two veins of ironstone were pointed out to me near Tatail. One measuring eight to twelve inches in thickness, and dipping to the west at an angle of 30°, occurs in a hill to the south of the village, and is associated with Tálcose shale and dolomite. The amount of carbonate of lime in the dolomite is 65·1, and the remainder is carbonate of magnesia and clay.

I could not obtain a large sample of the ore, which is micaceous iron, as there are no longer any surface workings, but I was able to pick off a small piece from the side of the vein, and it yielded by analysis 48·77 per cent. of iron.

The other vein, containing magnetite, occurs west of the village and on the left bank of the Simrárá Gadhérá. It is of small size, and it has never been holed for the sake of the ore. The native agars merely collect the fragments that may be occasionally brought into the bed of the stream by slips of the bank. The assay of the ore gave 50·11 per cent. of iron.

Kalúágarh.—My visit to this place was labour entirely thrown away, as I could see nothing more than a small hollow in clay where iron-ore was once obtained.

SUMMARY.—Of the different localities which I have alluded to in the Khairná area, there is not one which gives promise of much ore. I cannot say what the valley of the Kosí might yield between Kalúágarh and the Bhábar; but in the section of it which I examined, there was nothing to justify the hope that Khairná was a valuable district for ironstone. It would be well if we knew what the capabilities of the Kosí valley were lower down, where the accessibility from the plains might render deposits of rich and abundant ore more than usually valuable, in order to mix them with the poorer varieties of the Bhábar.

Flux.—As there is no probability that any demand for limestone to be used in iron furnaces will arise near Khairná, the question as to its occurrence or not is not of much importance.

KÁLÁDHÚNGÍ.

Owing to the interest attaching to this well known resting place for people either going to or coming from Naíni Tál, as having once been the scene of actual smelting operations on the large scale, I went carefully over the ground with Mr. Matthews, the Secretary to the Kúmaon Iron Company, and examined the deposit of iron-ore which occurs between the two extreme points known as Loha Bhar Bhar and Dharíá Khérá. It is a much more recent formation than the iron-ores of Rámgarh and Khairná, being possibly of tertiary age. It occurs with the clays and sandstones of the Nahun group, which form the low fringing hills to the north of Káládhúngí, but whether interstratified with them or unconformable to them it is difficult to say. There is one section in the main road to Naíni Tál, about a mile from the dâk bungalow at Káládhúngí, where the ironstone has been cut through, and it appears to be conformable to the beds below it. This may, however, be quite accidental.

Mr. Medlicott informs me that further west, to as far as Nahun, similar beds of ferriferous clay occur, though not so rich as at Déh-chaurí, and undoubtedly forming an integral portion of the Nahun group, (tertiary). This is a point of considerable practical importance, for if the deposit be unconformable to, instead of being interstratified with, the clays and sandstones, the ironstone at the surface is to a considerable extent the measure of its quantity, whereas if it be a bed in the series, it will yield a much greater body of ironstone than is now exposed to view.

Even taking the most unfavorable view of the case, however, there is an immense mass of ore. I was somewhat sceptical at first as to the quantity being large, but half an hour's steady walking over a more or less continuous band of it, removed any doubts that I had entertained.

I cannot, however, speak very enthusiastically about the general quality of the ore. A sample, which I consider contains more than the average quantity of iron, yielded 49·91 per cent. of protoxide, or 38·82 per cent. of metallic iron.

On referring to the printed records on the subject, I find that in trial-assays made by Mr. Davies* the percentages of iron were 48, 47, 40, and 28; Piddington gives the maximum as 52 and 29. And Dr. Macnamara from best quality samples obtained 48·53 per cent.

SUMMARY.—No appreciation of the value of the Káládhúngí deposit can be made by merely reading a series of maximum and minimum percentages of samples sent in to an analyst. One must go over the ground as I did to see what the general proportion of rich to poor ore is—and I am of opinion that the poor ore predominates. At first sight this statement might appear to condemn the Káládhúngí ironstone, but this is not the case, for if the "getting" of it were properly supervised by some person who could distinguish the good from the bad portions, the deposit is so large that an immense amount of superior ore might be made available for smelting. Unless some plan of discrimination, however, is adopted, a mixture of high and low class ores will take place, and as the better class of ore is not extravagantly rich, it will do no more than just raise the entire mass above the standard of condemnation.

Flux.—Limestone blocks occur in several of the small streams near Káládhúngí, and notably in the Baur river. An estimate of quantity is scarcely called for, as the supply is more than ample for the wants of half a dozen furnaces.

DÉH-CHAURÍ.

The ironstone which occurs at Káládhúngí extends westward to Déh-chaurí. Mr. Sowerby spoke highly of the Déh-chaurí ore, and asserted that it was more abundant than the deposit at Káládhúngí. This latter statement was a point which Mr. Matthews, equally with myself, wished to investigate, and we spent three days in looking up every section that was to be seen, and we came to the conclusion that the deposit of ore was less extensive than that at Káládhúngí, but the quality was generally much better. Several different *beds* are spoken of by Mr. Sowerby as being *in situ*, but I can neither confirm nor disprove this assertion. None of the natural sections furnished me any satisfactory evidence, and to have opened out a shaft, or driven an adit, would have occupied two or three months. With only the quantity of ore, however, to operate with that I saw on the surface, there is enough to supply all the requirements of the number of furnaces that are ever likely to be kept in blast at Déh-chaurí, so that whether three beds or four beds exist is really not of much consequence.

The following analyses of Déh-chaurí and Káládhúngí ores exhibit side by side the composition of samples which are somewhat above the average quality:—

	Déh-chaurí.	Káládhúngí.
Loss in heating	4·58	7·67
Oxide of iron	70·88	49·91
Alumina	4·79	5·27
Lime	3·11	1·1
Phosphoric acid	1·67	·66
Silica and insoluble	15·81	36·62
	100·84	100·23
Metallic iron	55·13	38·82

There was no sulphur, and the amount of phosphorus is not excessive.

* Selections from the Records of the Government of India, Supplement to No. VIII, 1865, page 41.

Flux.—Limestone may be picked out of the channel of the river Baur, and in several of its minor tributaries. Enormous blocks are strewn on the same hill side in which the iron-ore exists; and I am informed that a tufa deposit occurs within a reasonable distance of Déh-chaurí.

GENERAL SUMMARY.—Summarising in a few words the result of my investigation regarding the iron-ores, I have to state—

Ores.—That in the Rámgarh circle, the ore is good and plentiful.

That in the Khairná circle, the iron-ores are not of much value.

That in the Káládhúngí circle, the ore is not as good as those occurring in the Rámgarh circle, but the supply is very great.

That in the Déh-chaurí circle, the average quality of the ore is superior to that at Káládhúngí, and the quantity is large.

Limestone.—No fear need be entertained about the supply of limestone for fluxing. Every authority agrees in testifying to its abundance.

Although my duty was only to report upon the quantity and quality of the iron-ores at the places indicated in my instructions, I would beg to make a few remarks in view of the possible resuscitation of the manufacture of pig-iron in the Bhábar, at Káládhúngí, and Déh-chaurí.

Such an attempt *cannot* fail through paucity of ore or flux. Water-supply is available throughout the driest season of the year, as is proved by the fact that the furnaces of the Kúmaon Iron Company were in blast until the 5th of June. The reproductive power of the forests has been tested in the severest manner, for I am informed by Mr. Matthews that in 1860 a considerable tract of land extending from the vicinity of the furnaces at Káládhúngí to the base of the hills was cleared, no trees being left for bearing seed; and now (1873) the whole area is so covered with well grown saplings that it is difficult to believe in the accuracy of Mr. Matthews' statement.

Comparing the conditions now with what they were ten years ago, when the Kúmaon Iron Company stopped operations, circumstances are much more in favor of the possibility of Indian-manufactured iron competing with home produce. The high price of coal in England has led to such an advance in the cost of iron of all kinds that there is now a prospect of India being able profitably to work her own raw material.

NOTE ON THE RAW MATERIALS FOR IRON SMELTING IN THE RÁNIGANJ FIELD, BY THEODORE W. H. HUGHES, A. R. S. M., F. G. S., *Geological Survey of India.*

As a result of Mr. Bauerman's preliminary report upon the iron-ores of the Ráníganj coal-field, the Geological Survey of India has been called upon for information on the subject.

Claim of the field recognised.—It is almost needless to say that the claim of this field to be considered the most advantageous position for the manufacture of iron in Bengal on an European scale was recognised years and years ago by the Survey, and that Mr. Bauerman, in recommending it as the locality offering the best prospects of success, has but confirmed the opinion held by every geologist and others competent to offer one.

The establishing of large iron-works was not urged at the time of the survey of the Ráníganj field, for it would have shown an utter disregard of the conditions essential to success to have done so. Since then, however, increased facilities of communication, discoveries of better coals, the possibility of making coke, and the steady rise in the price of imported iron, have tended to reduce the margin of probable failure to such proportions that the prospect of the successful manufacture of iron has emerged from the region of speculation. Nevertheless, the caution recommended by Mr. Bauerman to the Government of India before going into any projects for the erection of works is very judicious; it being undeniable that the subject of fluxes is a most essential point to enquire into.

Kunkur assays.—With a view to throw some light upon the application of *kunkur*, I have lately made a few trial assays at the Mint which I will refer to in detail farther on. I obtained a very fair slag; but it must be remembered that the assays were conducted under a favourable combination of circumstances unattainable in a furnace, and that before the practical adaptability of kunkur can be pronounced upon, experiments on a more extensive scale ought to be carried out. The result of the small trials in so far answers a useful purpose, that it indicates a possible substitute for rock-limestone, and can be accepted as some measure of the value of kunkur.

Proposed trials.—I propose at the end of the field-season operating upon a few tons of raw material, varying the proportionate quantities of kunkur, ore and coal; and I cannot but anticipate that the deductions from such experiments will be useful. I am happy to say that I have already received offers of assistance and the loan of a cupola from Hon'ble J. M. Robinson, of the Bengal Coal Company, and Colonel H. Hyde, R. E., to the latter of whom I am already indebted for facilities afforded me at the Mint during my preliminary assays.

Although my more special attention was directed to the subject of fluxes, I was in addition instructed to point out the most favourable position for erecting furnaces; to institute enquiries about furnace materials; to make some sort of estimate as to the quantity of iron-ore available; and to confirm or modify the opinion entertained of certain coals in the western part of the field. For the sake of convenient reference I propose to notice each section of my enquiry under these different heads. And first as to coal.

COAL.—I presume it is unnecessary to adduce evidence in proof of the enormous amount of coal which exists in the Ràniganj field. There is perhaps no area of similar size in the whole world which can compare with it for actual thickness of the seams. The coal, however, is not so good in quality as it might be; but I believe better will be discovered as the field becomes progressively developed.

Weak point of Indian coal: its ash.—The weak point of our Indian coal is the amount of inorganic matter that it contains as compared to good English and Welsh coal; but lately two samples have been received at the Geological Survey Office, one from Sánpúr near Nirsha, and the other from Báhmandihá, near Niámatpúr, which contain only 8·9 and 8·7 per cent. of ash respectively. The average percentage is 15.

Nothing more than an ordinary analysis of these coals has been made, and their composition is—

	Sánpúr.	Báhmandihá.
Carbon	64·3	57·8
Volatile matter (inclusive of water) ...	26·8	33·5
Ash	8·9	8·7
	100·0	100·0

Both are said to coke; and as they are remarkably clean, they ought to be brought more into use. At present I believe they are scarcely worked. The Sánpúr coal is burdened with a cartage freight of six miles and a toll; but the Báhmandihá seam has no serious drawback to contend against. It lies in the general strike of the Sanktoria seam, which is well known to be one of the finest properties in the field, and it may be the continuation of that bed to the north-east.

A very complete series of analyses of thirty different coals has lately been made by Mr. Tween under Dr. Oldham's direction, and I find that those samples furnished by the Dúmarkúndá, Banáli, Sanktoria, Mangalpúr, and Ráníganj collieries combined the greatest freedom from ash with high percentage of carbon.

Names of Collieries.	Carbon.	Hydrogen.	Oxygen and Nitrogen.	Sulphur.	Ash.	Percentage of coke in undried coal.
Dúmarkúndá	71·86	4·67	8·78	·69	14·0	76·8
Sanktoria	68·89	4·52	12·27	·82	13·5	74·6
Ráníganj	69·45	4·82	10·98	·35	14·4	72·2
Banáli	69·98	4·79	10·06	·37	14·8	69·4
Mangalpúr...	68·81	4·8	12·11	·88	13·3	67·8

The loss of water in the Dúmarkúndá, Sanktoria, and Ráníganj coal was 2 per cent., in the Banáli coal 4 per cent., and in the Mangalpúr coal 5·8 per cent.

Amount of sulphur small.—The amount of sulphur is in each instance considerably under 1 per cent.—a fact which will not readily be credited by those who think that Indian coals are always saturated with iron-pyrites.

I append a statement of the amount of sulphur in some good class British coals:—*

	Sulphur in 100 parts of coal.
NORTHUMBERLAND.	
Steam Burn coal (steam coal)	·55
Peareth coal (gas coal)	·86
Low main seam, Buddles Hartley colliery (steam coal)	1·51
NOTTINGHAMSHIRE.	
Shircoak colliery, belonging to Duke of Newcastle	·92
SOUTH STAFFORDSHIRE.	
Rooves	1·00
LANCASHIRE.	
Bushey Park seam	1·01
Pemberton yard	1·82
BLAINA, SOUTH WALES.	
Ellvein coal (steam coal)	·75
Three quarter vein (furnace coal)	·81
DOWLAIS, SOUTH WALES.	
Ras Las	1·01
Bargoed big-coal (blast furnace coal)	1·07
SCOTLAND.	
Argesline	1·23
Walls end Elgin	1·51

* Percy's Metallurgy, 1861, Vol. I, pages 90, 102.—Crookes and Röhrig, 1870, Vol. III, page 469.

Reverting to the Ràniganj coals, the following is the result of the analyses of their ashes, and for the sake of illustration I subjoin a selection of a few Welsh and Scotch coal ashes:—*

	Silica.	Alumina.	Oxide of iron.	Lime.	Magnesia.	Sulphuric acid	Phosphoric acid.
Dúmarkúndá	60·54	31·0	6·52	1·21	·94	·55	·54
Sanktoria	58·00	29·03	7·49	3·26	...	1·11	1·46
Banáli	62·77	30·48	3·32	3·18	...	·47	1·2
Ràniganj	61·41	28·84	5 31	3·18	...	·52	·35
Mangalpúr	59·66	26·72	8·08	2·92	...	1·2	1·18

	Dowlais.	Dowlais.	Dowlais.	Dowlais.	Poutypool rock vein coal.	Ebbw vale four-feet steam coal.	Fifeshire Fordel splint coal.
Silica	35·73	24·18	37·61	39·64	40·00	53·00	37·60
Alumina	41·11	20·82	38·48	39·20	44·78	35·01	52·00
Sesquioxide of iron	11·15	26·00	14·78	11·84			
Lime	2·75	9·38	2·53	1·81	12·00	3·94	3·73
Magnesia	2·65	9·74	2·71	2·58	Trace ...	2·20	1·10
Sulphuric acid	4·45	8·37	0·29	Traces ...	2·22	4·89	4·14
Phosphoric acid	0·99	0·21	2·00	3·01	0·75	0·88	0·88

It will be seen that the proportion of phosphoric acid in a hundred grains of the ashes of some of our Indian coals compares favourably with the English equivalents; but we must bear in mind that Indian coal is burdened, as a rule, with three to four times the amount of ash in English coal; and consequently for equal weights of coal the comparison is not so favorable.

Sanktoria coal caking.—Only one of the five selected coals, that of Sanktoria, is truly caking; the rest yield nothing better than bastard coke. Analysis shows that the Dúmarkúndá coal is a first class Indian coal; and I believe that it would produce a very fair description of coke provided the ovens were charged with freshly raised material.†

* Percy's Metallurgy, 1861, Vol. I, page 106.

† Since writing the above I have received from Colonel Hyde, R. E., a table showing the relative heating power of the several coals submitted for trial at the Mint; being of the same samples as those analysed in the laboratory of the Geological Survey by Mr. Tween. The Dúmarkúndá coal occupies the seventh place in a list of thirty.

Name of Colliery.	Heat units utilised per lb. coal.	REMARKS.
Ràniganj	9,788	Upper coal measures.
Babúsol	9,732	" " "
Nimcha	9,651	" " "
Sanktoria	9,622	" " "
Dhasal seam, Chowkidánga	9,584	" " "
Berodakatta	9,562	" " "
Dúmarkúndá	9,493	Lower " "
Mangalpúr	9,144	Upper " "
Sitárámpúr	9,013	" " "
Nigiá	8,962	" " "
Banáli	8,846	" " "

I cannot find any reference to the coal from the Belrúi colliery, but it deserves mention, as it cakes well, and looks bright and clean. The Belrúi seam, like the Báhmandihá, is on the same strike, and is possibly on the same horizon as the Sanktoria seam. In our present state of knowledge, one can only conjecture that such is the case; but an air of probability is lent to this opinion by the circumstance that the Belrúi coal possesses nearly the same qualities as the Sanktoria coal.

Freedom from ash important in connection with amount of flux required.—I have particularised the coals from eight different localities, because analysis shows that they are best adapted for smelting purposes. They are the coals freest from ash, and this is a point that must be borne in mind in connection with the amount of flux that will be required. For raising steam and for smithey works there are twenty other coals in the Ràniganj field that would answer nearly as well; and there is always the prospect that many of the collieries from which moderate or inferior coal is at present being raised may some day meet with better seams as their workings become deeper and new ground is opened out.

Best locality for coal.—The portion of the field which contains the most promising coals, east of the Bárákar, is decidedly that part of it limited in a north-west direction by the outcrop of the seams mined on the Sanktoria and Belrúi properties, and in a south-west direction by the Panchet formation marked on the geological map. Within this area is included, in addition to the collieries belonging to the Bengal and New Bírbhúm Companies, those owned by Messrs. Apcar and two or three quarries possessed by natives. Some of the land is, I am informed, held by Rani Sarná Móui, a Hindoo lady, whose religious principles are opposed to coal mining.

IRON-ORE.—The deposits of iron-ore are of two distinct geological ages. The older are associated with the coal measures, as a group in the series, while the more recent are connected with the rock known as laterite.

Laterite, as a rule, is not rich in iron;* and as it does not occur in any form west of the meridian of the town of Rániganj, I directed my attention principally to the ores of the coal measures. I did not restrict my observations to any one special locality: I visited the lands east of Básérá, and Madápúr, and the entire tract from Lalganj to Bagunia. I thought it possible that the Singaran valley might be a good locality for iron works; but it does not offer the same advantages as the western part of the field, where the iron-ores of the measures are in close proximity to the superior coals of Sanktoria, Belrúi, Dúmarkúndá, Báhmandihá, &c.

The only samples of ore that I considered it necessary to collect were from the lands of Aítura, Malákola, Chalbalpúr, Kúlti, Sibpúr, Jassaidih, Boldi, and Notanghar. They are fair representative specimens picked mostly from heaps, which had, conveniently for me, been collected by the contractors who supply ballast for the repairs of the Grand Trunk Road.

Mr. Tween has up to the present time only been able to complete the analysis of one sample. It came from Kúlti, and contains—

1.	Insoluble matter (silica 16·4)	19·6
2.	Sesquioxide of iron (metallic iron 42 per cent.) ...	60·4
3.	Alumina	5·8
4.	Lime	2·9
5.	Magnesia	·6
6.	Phosphoric acid	2·2
7.	Water	9·2
		100·7

* Laterite usually contains from 12 to 25 per cent. of iron. Some of it, however, is nothing more than clay with iron stains.

There is no sulphuric acid, but there is an appreciable quantity of phosphoric acid.

Ore hæmatite.—I was rather surprised at the absence of carbonic acid, being under the impression that the above specimen was a carbonate of iron. It appears, however, to be a sesquioxide. The amount of iron it contains is 42 per cent., which makes it a valuable ore.

The ironstones occur over an area of several square miles in thin beds varying in thickness from 2 to 8 inches, through a mass of carbonaceous shales, known geologically as the ironstone shale group. Mr. Blanford* estimates that they form about 1/17th of the whole group; and Mr. David Smith† considers that 6,400,000 tons per square mile will be the yield. My own measurements showed that the ironstones occurred in the proportion of 1 foot to 10 or 12 of shale, and taking the group as 1,000 feet (it is more than this), we have, roughly speaking, 200 millions of tons in every square mile. Assuming 5 feet only as workable, I think the figures will be assuring enough to set at rest all misgivings about quantity.

Small dip.—The dip of the strata with which the ironstones are associated is everywhere small in the neighbourhood of the Bárákar; and the contour of the surface is such that the conditions for mining by open work are all highly favourable. No difficulty can be experienced in winning the ore at a reasonable price.

Magnetic iron.—The advantage to be derived from mixing different varieties of ore is well known. Some very rich deposits of magnetic iron-ore are described by Mr. Blanford‡ as associated with metamorphic quartzites just beyond the boundary of the field near the village of Tituri, about two miles west of Beharináth hill. The ore occurs interlaminated with the quartzite and gneiss in bands varying in thickness from 3 inches to 2 feet. They are very pure, and contain from 60 to 70 per cent. of iron. Research may bring to light other similar deposits; but there is little probability of such a thing happening, as the natives are usually aware of the iron-ores that occur in their own district, and if any had existed, information about them could hardly have escaped the frequent inquiries that have been made.

The main dependence of any iron works must be upon the iron-ores of the coal measures.

FLUX.—As I have not been called upon to compile a treatise upon the manufacture of iron, I need not explain why the necessity for a flux exists. Many minerals might be used as fluxes, but in practice we are limited to a few, namely, limestone, clay, and silica. For such ores as occur in the Ránigunj field, limestone is most required; and limestone that is nearly pure has hitherto been considered as indispensable.

Impure limestone sometimes preferable.—In some instances, however, as in the case of the Kùlti ore, the analysis of which has been given above, a limestone containing some clay would be preferable. Impure limestone indeed is often advantageous, but its applicability depends upon the suitability of its own impurities to combine with those of the iron-ore.

In kunkur we have an impure limestone, containing from 70 per cent. downwards of carbonate of lime, and a varying proportion of free silica, clay, magnesia, iron and water. It would make in some instances a most economical flux if the amount of carbonate of lime in it were somewhat greater than it is. Kunkur, as a rule, however, rarely contains more than 60 to 65 per cent. of carbonate of lime, which leaves a large amount of impurity, out of which some is probably not required, and therefore it subtracts from the working value of the kunkur.

* Memoirs of the Geological Survey of India, 1861, Vol. III, Art. 1, page 76.
† Mr. David Smith's report on the coal and iron districts of Bengal, 1856, page 6.
‡ Memoirs of the Geological Survey of India, 1861, Vol. III, Art. 1, page 193.

Some specimens which I obtained in the Ráníganj field contain the following quantities of carbonate of lime:—

Sanktoria ...	...	...	...	66·12 per cent.
Rámnagar...	...	...	...	64·98 „
Barmúri ...	...	...	...	61·00 „

Mr. Tween has not been able to make a full analysis as yet of all the samples that have been sent in for examination, and without such analysis, it is impossible to estimate what proportion theoretically the kunkur should bear to fuel and ore, in order to produce a suitable slag.

Well fused slag and clean button.—I have, however, carried out some assays at the Mint; and the result is, that with equal quantities of kunkur and ore, and using wood charcoal or coke, I obtained a well fused slag and a moderately clean button of iron. I have not made the number and varieties of assays that I should like to, owing to the necessity of sending in a report at an early date; but the possibility has been demonstrated of using kunkur as a flux on a small scale.

The assays were performed in unlined plumbago crucibles. My first experiment was unsuccessful, as I could not get up heat enough in the small table gas furnace which Colonel Hyde placed at my disposal. My after attempts with the use of coke in a wind furnace were more fortunate.

No. 1.	Ore ...	...	100 grains	(Kúlti ironstone containing by wet assay 42 per cent. iron).
	Kunkur	...	100 „	(Rámnagar kunkur containing 65 per cent. carbonate of lime).
	Charcoal	...	30 „	(Wood charcoal).

Percentage of iron 45·0; slag perfectly fused, grey. Button of iron, dark-grey, crystalline, broke rather readily under hammer. Two or three sorts of metal embedded in the slag.

From the appearance of the iron, the ore will probably reduce easily.

No. 2.	Ore ...	...	150 grains.
	Kunkur	...	150 „
	Charcoal	...	40 „

Percentage of iron 44·7; like all dry assays, the percentage of iron is shown to be greater than it actually is. Slag, greyish-green, a few beads of iron adhering to outer surface. Button, dark-grey on fractured face. Does not split at first blow, but flattens somewhat.

No. 3.	Ore ...	...	100 grains.	
	Kunkur	...	100 „	
	Coke ...	...	30 „	(coke from Calcutta gas works).

This was put into a smith's fire, and the slag was not perfectly fused. It had a light green colour. Numberless shots of iron at bottom of slag. Fractured surface of button, white.

No. 4.	Ore ...	...	100 grains.	
	Kunkur	...	100 „	
	Coke ...	...	30 „	(coke from Calcutta gas works).

Slag, light grey, semi-translucent. Button on fractured face, white, compact.

No. 5.	Ore ...	...	150 grains.	
	Kunkur	...	150 „	
	Coke ...	...	40 „	(coke from unwashed Sanktoria coal-dust).

Slag, light amethyst colour, clear, translucent. Button, on fractured face, dark-grey, coarsely crystalline. The amethystine colour of the slag may be due to manganese.

No. 6.	Ore ...	...	150 grains.	
	Kunkur	...	130 „	
	Coke ...	...	30 „	(coke picked piece of Sanktoria coke).

Percentage of iron 44·0. Slag, slight amethyst colour, translucent. Button on fractured surface, not quite so dark as No. 5, coarsely crystalline.

I made several other assays which I need not refer to. My object was to see whether kunkur would do the work that was required of it. The less quantity, 130 grains in No. 6, answered quite as well as 150 grains in No. 5; but I would recommend equal quantities of kunkur and ore, because the coke contains sometimes a large amount of ash.

I have used throughout only the same flux that could be employed on the large scale. Pure limestone is not known to occur in any quantity in or near to the Rániganj field. My colleague, Mr. Mallet, however, has discovered a bed of it in the vicinity of the Madápúr Branch Railway; and it is quite possible that when investigations in that neighbourhood can be completed more may haply be discovered. The limestone is very pure, and is only ten miles from the station, so that if railway rates for carriage were only cheaper, it might be employed to supplement the kunkur of the Rániganj field. A large quantity might easily be removed. I have been informed of another bed south of the Damúdá and near to Rániganj; but I have not yet had an opportunity of visiting it. From the appearance of the sample sent to me for examination, I scarcely think that it can be of much importance.

It is not to either of these limestones, however, that we can look for a supply of flux; and Rotás stone is so dear comparatively to kunkur that I think we must depend upon the latter material.

Amount of kunkur.—On the question of the quantity of kunkur available within the field, I have consulted with Mr. Dejoux, Executive Engineer, who is at the head of the Special Department devoted to lime, kunkur, and limestones, and he assures me that there is an unlimited quantity. In this assurance Mr. Joll, who was for some time Executive Engineer at Bárákar, unites. Mr. Dejoux's experience and special knowledge is so much greater than my own that I prefer quoting his conviction to offering a decisive opinion of my own. I examined several of the localities where lime was being made, and judging by what I saw, I am inclined to think that there are very large deposits in the vicinity of Bárákar; both banks of the river are full of kunkur; and the quality of the material appears to improve at some depth below the surface.

One advantage that would be derived probably from the use of Rotás limestone is, that its average composition might be depended upon. As regards kunkur, I am not sure whether this would be the case. Again, quoting Mr. Dejoux, however, he says that out of numerous samples which he has analysed, he has found that its composition is much more constant than might be anticipated from the nature of its origin, and that 55 to 65 per cent. is the usual amount of carbonate of lime that it contains. If this be so,—and the analyses now being made in our office will confirm or disprove this point,—we shall be able to regulate the amount required for fluxing; but if the percentage of carbonate of lime be inconstant, the working of a furnace is likely to be variable and the outturn of iron irregular both in quality and quantity.

I trust I have made clear the case regarding kunkur: *1st*, that there is a large quantity available; *2nd*, that it can be used as a flux; but that unless its composition be pretty constant, there are difficulties in the way of its employment that might make the use of a more costly but a more reliable limestone advantageous.

Until full analyses of many specimens have been made however, we cannot pass judgment. Should they prove the composition of kunkur constant between certain limits, then I think we may, without actual experiments on the large scale, declare it to be an appropriate flux.

CHOICE OF SITE.—The tendency of the evidence brought forward has been to show that the country in the vicinity of the Bárákar is best adapted for a site. No locality offers the same advantages. It is nearer to the foreign sources of limestone at Rotás and in the Hazáribagh district than any other part of the field. The best quality coals occur there; easily workable ores may be got; an abundance of kunkur can be procured; sandstone quarries are in actual existence; the Grand Trunk Road, and the Bárákar branch, and Chord Line of the East Indian Railway are in the immediate vicinity of all requisite raw materials; and the land necessary for buildings, tipping room, &c., belongs, in great part I believe, to native holders, who would probably dispose of it at more favourable rates than British holders.

Any definite selection of a site must of course be postponed for the judgment of the manager who may be appointed, but the choice ought to be limited between the meridians of the Sítárámpúr and Bárákar Railway stations, and a short distance north or south of the Grand Trunk Road.

FURNACE BUILDING MATERIALS.—It is difficult to say off-hand whether certain stones will have the property of sustaining the temperature which the chemical process carried on in the furnace requires. In the selection of native stones, as also of artificially manufactured stones, we must be guided chiefly by experience. There are quarries near the Bárákar bridge, from which the sandstone of the lower coal measures are obtained, and if those that are fine-grained are selected, they will probably be found to withstand heat and the action of fluxes.

Soapstone.—Occurs in the Manbhúm district, and dishes made from it used formerly to be sold at Taldángá; source of supply is rather distant.

Fire clay.—Scarcely any attempt has hitherto been made to turn the fire-clay, which is found with many of the seams, to account. Messrs. Burn and Company, who possess pottery works at Ránigauj, have lately made a few bricks from the clay in the Ránigauj colliery of the Bengal Coal Company, and the manager, Mr. Cowhan, informed me that they were tested at Jamálpúr, and were found to withstand the treatment they were subjected to much better than English bricks. I believe fire-clay occurs at the Baséra colliery of the Ránigauj Coal Association, but it has not yet been tested.

Coarse sand.—This is required for mixing with other materials. It can be obtained from the rivers Bárákar and Damúdá.

Quartz.—This, like the above, may also be wanted for mixing. Large quantities are procurable a short distance up the chord line, about Jamtarah.

Moulding sand.—Some moulding sand of very pure quality is obtained near Ránigauj from the Damúdá. I know of no other place where it occurs, but equally good sand may possibly be found in the Bárákar.

CONCLUDING REMARKS.—Having shown that the materials essential for the manufacture of iron exist, I will now point out what the probable cost of coal, iron, and kunkur per ton will be.

Coal.—A very fair estimate is Rs. 2-8 to Rs. 3 a ton.

Iron-ore.—The price of ore delivered at the works will probably be Re. 1 a ton. The rates at present paid by the contractors who obtain ore from the Kúlti estate of the new Bírbhúm Coal Company is only 5 annas a ton, or Rs. 1-8 per hundred cubic feet loosely heaped; but as the ore is close to the surface, I have trebled the rate in order to cover extra expenses when deeper workings are opened out. Any information about the rate paid for assistance, although imparted to me by a contractor's Sirdar, may not be correct, as natives sometimes make misstatements. Whether this be so or not however Re. 1 a ton is a liberal estimate.

Kunkur.—This material ought to be procurable at Rs. 1-8 a ton, or Rs. 5 a hundred cubic feet.* Mr. Joll, Executive Engineer, roughly values unwashed kunkur at Rs. 1-6 a ton. In order to be on the safe side however, let the rate in all calculations be Rs. 2. I find that Rotás limestone, taking the very lowest estimates, will for equal quantities be exactly ten times the cost of kunkur when delivered at Sítárámpúr.

Thus, 100 cubic feet of limestone conveyed from Rotás to Lakiserai by water the whole way ...	... Rs.	18	0	0
Railway freight from Lakiserai to Sítárámpúr	... „	47	0	0
Unlanding and landing charges, and so on ...	... „	5	0	0
Total	... Rs.	70	0	0

or Rs. 20 a ton as compared to Rs. 2; but as Rotás limestone will probably do three times the amount of duty that kunkur will, the comparison is as Rs. 6 to Rs. 20. Considerable advantage would be derived from the use of Rotás or any other comparatively purer limestone, because in the employment of kunkur, there is an increase in the weight of material to be passed through the furnace for the same produce of metal.

Occasionally, as I pointed out before, an impure limestone may be more suitable for a flux than a pure one; but in kunkur the impurities are somewhat too great, not to make it advisable, bearing in mind relative cost, to substitute a better material.

Cost of manufacture.—The simple cost of the manufacture of pig-iron per ton, leaving out of consideration the interest on cost of furnaces, management, and so on, will, according to my figures, be—

			Rs.	A.	P.
Ore	...	$3\frac{1}{2}$ tons at 1	3	8	0
Kunkur	...	$3\frac{1}{2}$ „ at 2	7	0	0
Coal (large)	...	$3\frac{1}{2}$ „ at 3	10	8	0
Coal (small)		... ...	0	8	0
Wages		... ...	2	8	0
			24	0	0

I have allowed liberally both in the amount of material and in the matter of cost. Mr. David Smith, who made very careful calculations in 1856, showed that with the price of home manufactured iron as it then ruled, and with the estimated cost of pig-iron at Rs. 20-8 per ton,† there would be a considerable profit. I think there can be but little doubt

* The ton is calculated as 27 "*mans.*"

Iron-ore	... 100 cubic feet = 135 *mans* = 5 tons.
Kunkur	... 100 „ „ = 94 „ = $3\frac{1}{2}$ „
Limestone	... 100 „ „ = 94 „ = $3\frac{1}{2}$ „

† Mr. David Smith's report on iron districts of Bengal, 1856, p. 19. His figures are for simple cost of manufacture as mine are.

that if there is demand enough in Indian markets, iron may be manufactured in this country and sold at a much cheaper rate than imported English iron can be bought for.

There are always difficulties inherent in the starting of new undertakings; but we have the beacons of past failures in other parts of India to steer our way by. If any of the Companies at Ràniganj who possess their own coal, iron-ore, and kunkur were to take up the project of iron smelting, they would have immense advantages over Government in respect of cost of raw materials; should, therefore, the present attempt be in the least degree successful, it will be a guarantee to all Companies of the value of their own resources.

THEODORE W. H. HUGHES.

NOTE ON THE HABITAT IN INDIA OF THE ELASTIC SANDSTONE, OR SO CALLED ITACOLUMYTE.

Although within the last twenty years members of the Geological Survey have frequently passed within sixty miles of this interesting locality, no one has been able to visit it—so great is the difficulty and loss of time involved in making the shortest excursion off the main highways in India. At last an amateur has come to the rescue; and it is to be hoped the example will be followed elsewhere, for official geologists, having to work by rule and measure, can rarely supply the place of the genuine amateur in the repeated contemplative observation of local conditions. Geology has boasted of several distinguished and devoted amateurs in India. The recent comparative scarcity of such labourers must be due to the greatly increased activity of official life, and not to any growing distaste for recreation in scientific pursuits. Colonel McMahon, Commissioner of Hissar, has sent a box of specimens and some very interesting notes illustrative of the only known position of the elastic sandstone. The description is given as far as possible in his own words.

Kaliana is five miles west from Dadri, a town in the Jheend state, sixty miles nearly due west from Delhi. The hill, which is one of the Trigonometrical Survey Stations, is 1,477 feet above the sea, and about 740 above the plain. It consists of a long ridge, running for some miles in about a north-north-east direction; one of the many such ridges which in this region of the Punjab stretch far into the plains, the alluvial areas between them being confluent with that of the Indo-gangetic deposits. These ridges are prolongations of the Aravali mountain system, and are approximately on the line of the Indo-gangetic watershed. The ridge of Futehpur Sikri, running north-north-east to within a few miles of Agra, is the most westerly member of the Aravali system of disturbance; it is formed of up-turned Vindhyan rocks, being the western limit of the great spread of these ancient deposits, stretching from here round by Saugor to Sasseram in Behar. In examining the ground to the west of Agra, the Survey geologists have been a little puzzled by the position of the elastic sandstone; this name, and the superficial appearance of the stone, leading one to expect a recurrence of some unaltered rock-group, perhaps an outlier of the Vindhyan series. It is an excellent illustration of the way in which deeper geological meanings become attached to words based originally upon superficial characters, involving of course a reciprocal restriction of the extension or denotation of the term. This stone is in reality only a very local and modified condition of a massive quartzite, which is the general name for metamorphic sandstones.

The highest part of the ridge immediately overhangs the village of Kaliana. It is here double-crested, the projecting ribs being formed by two strong beds of ironstone, a quartzite strongly impregnated by massive specular iron (black hæmatite) and some magnetic iron, strings of pure ore occurring locally in the mass. These bands of ferruginous quartzite are regularly interstratified with the mica and hornblende-schists; and the earthy cellular quartzite so largely quarried for millstones is distinctly an intercalated member of the same series, all being nearly vertical. The elastic sandstone is only found in patches in this band of millstone quartzite. There is no regular bed or seam of it; the stone-cutters, of whom there is quite a colony at Kaliana, come upon it suddenly when cutting out slabs of the ordinary stone. Often the rock in immediate contact with a nest of elastic sandstone is highly indurated and quartzose. The stone-cutters declare that they sometimes find it in the line of the bedding, and sometimes along the joints. Their idea of the matter is, that it is a mere local peculiarity of the sandstone rock caused by the percolation of rain water and *miti* (earth) from the surface. If the *miti* had been omitted, the native explanation is probably the correct one. The only superficially noticeable difference between the two is the greater porosity and friability of the elastic stone, owing probably to the removal of some thinly permeating cement to which the strong rigidity of the quartzite is due. Among the rocks sent by Colonel McMahon there is a variety of this pseudo-metamorphic rock in which the earthy ingredient prevails largely over the quartzose. Its aspect is somewhat like that of a half-baked fire-brick; and it would seem as if it had only needed a modicum of some alkaloid base to have converted the whole into a form of gneissic rock.

There are two myths connected with these elastic sandstones which it is desirable to discredit. One is its supposed connection with diamonds. In India at least there is no shadow of such connection. All the widely scattered diamond localities seem somehow connected with members of the Vindhyan series of rocks. And, on the other hand, there is no tradition of diamonds at Kaliana. The idea comes from Brazil, whence also the fancy name Itacolumyte; it is probable that the connection is quite imaginary.

The other notion is, that the elasticity is attributable to talc, or mica. However this may be true of the Brazilian variety, there is no pretence for it in the Kaliana rock; the few small plates of mica in it are quite isolated, the rock not having any schistose (foliated) structure. The only tenable account of this property of elasticity is that given by Professor Haughton, whose name is a full guarantee of correctness:—"A most remarkable circumstance sometimes occurs in the formation of these sandstones, which are not composed of pure particles of quartz, but of clay mixed with them, namely, that the particles of quartz mixed in this clay or paste are permitted a certain amount of motion. If you take an ordinary sandstone, it is like any other rock; and with a lens you can see the separate particles, and that each separate particle is touched on every side by a number of other rounded particles that hold it in its place, and it in turn contributes to hold them in their places, so as to form of the whole a rigid rock like any other. But, occasionally, in some rare cases—which, as far as I have any knowledge of them, are confined to Brazil, South Carolina, and Delhi—you have a rock composed of particles of sandstone, which are not in contact with each other, but lie in a paste of felspathic clay, which paste permits a certain amount of motion between the particles of the mass." (Haughton's Manual of Geology, Lecture II, p. 51). It would seem that in the Kaliana rock, doubly metamorphosing conditions were concerned in its production—a solidifying process to give tenuity to the earthy paste, and a partial dissolution to remove the rigidity of its first solidification.

Elasticity, in its vernacular sense, is a misleading name for the character of this stone. It bends without the least sensible increase of resistance up to a certain limit, where it comes to hard stop. Mr. F. R. Mallet found that a slab of the Kaliana stone 24·5" × 6·7" × 1·8", resting on supports 24" apart, gave a deflection of 0·7"; and that after saturation with water the deflection was reduced to 0·65.

On the west side of the Kaliana hill and not far from the top there is an old mine cut into the ironstone. It is said that three generations ago it was worked for copper. In a piece of schist sent from this spot, there is not the slightest trace of copper staining; but the mica has a very decided copper colour, which may have been the beginning and end of the mining experiment.—H. B. M.

GEOLOGICAL NOTES ON PART OF NORTHERN HAZÁRIBÁGH, *by* F. R. MALLET, F. G. S., *Geological Survey of India.*

In an early number of these Records (Vol. II, p. 40, 1869,) a brief notice was given of the metamorphic rocks of Bengal, in the northern part of their area, from the Karakpur hills at the north-east corner of the rock-area of the Peninsula, along the lower valley of the Ganges and the Sôn valley, into the valley of the Narbada, where all the older formations pass under the Dakkin trap. Throughout that distance, in a west-south-west direction, and corresponding with those very marked orographical features, the gneiss is fringed by less metamorphosed rocks—schists, slates, and quartzites. To give shape to the study of these rocks, more than from any compulsion of decided views, a tentative classification was then attempted, upon general stratigraphical reasoning, occasionally against the apparent (*primá facie*) evidence of local sections. The series thus indicated consisted in chronological order of—1*st*, a fundamental gneiss (undiscriminated); 2*nd*, gneissic schists and quartzites (of Mahábar) corresponding to the less metamorphosed slaty schists and quartzites to the north (Rájgir); 3*rd*, massive gneissoid (foliated) granite, mostly forming domes; 4*th*, flaggy schists and gneiss with quartzites and amorphous pseudo-gneiss, sometimes conglomeritic (Lakisarai, Betia, Sukri, infra-Bijáwars of Bandelkand); 5*th*, intrusive invasion of pegmatite; 6*th*, Bijáwars (of Bandelkand and the Agori zone of the Sôn valley).

The hazardous points of this scheme were known to be—the doubtfully granitic (exotic) character of any of the dome gneiss, and principally, the supposition of gneissose rocks (No. 4) greatly younger than the schist and quartzite series (No. 2). Both positions were placed primarily upon the same general evidence—the universally intense folding, with cleavage of the schist and quartzite series, compared with the frequently moderate disturbance in a portion of the gneissic rocks, which, moreover, seemed to occupy a position of general superficiality as regards the main body of the gneiss and to contain locally débris of the quartzite series.

The detailed survey of which these notes are a first instalment was undertaken in the hope of working out some more definite views upon rocks forming so broad a feature in the geology of India. The observations refer to what seemed to be a key to the position, where the schists and quartzites of Mahábar are well exposed in connection with the gneiss. The area especially referred to is contained in sheets Nos. 7 and 8 of the new topographical survey of Hazáribágh district, on the scale of one-inch to the mile, of which sheets this note may be taken as a description; some observations, however, referring to the adjoining ground where the geological mapping was incomplete. As the survey of this region has been interrupted by orders of Government, in order to take up the examination of some supposed coal-bearing ground at the base of the Eastern Himalaya, it is well to make a record of the work so far done. Thus far the views suggested by the sketch-survey have not been upheld as applicable to the section here; the massive dome-gneiss, of which some magnificent examples occur, is not proved to be in any special sense intrusive, or foreign to the rocks with which it is associated; and the flaggy schists with quartzites of the Sukri seem to be an irregular basal member of the Mahábar series, rather than a much later and independent group; however this relation may still be maintained for the conglomeritic pseudo-gneiss of Lakisarai and Bandelkand.

Immediately to the south of the above-mentioned area (that included in sheets 7 and 8) spreads the comparatively level highland of Karrakdiha, the extreme edge of which invades sheet 8 in one or two places, as at Gajhandi and Simmeria. To the north again of the Mahábar and Bhiaura ranges, the alluvial planes of Bihár stretch to the horizon, save here and there where some outlying hill breaks the continuity of the prospect. The area under discussion, therefore, comprises a part of the jungly and hilly country which marks the descent from the open and cultivated Hazáribágh plateau to the Gangetic plains. This broken interval varies very much in breadth; in the south-west corner of sheet 8 we have Sídwatánd and Bishanpur respectively on the plateau and alluvium and separated by less than a kos, whilst from Simmeria some fifteen miles must be crossed before the alluvium comes in sight along the northern base of the Mahábar hills.

Only two prominent groups of stratified rock are present: the metamorphic composed mainly of gneiss, with runs of hornblende rock, and the submetamorphic* which is made up almost entirely of mica-schists and quartzites, with some hornblendic bands. It is scarcely necessary to say that the quartzites and the more granitiform varieties of gneiss form the highest and most imposing masses of hill, *e. g.*, the Bhiaura and Mahábar ranges, Durbásha and Máramoko Hills, whilst instances are not uncommon in which the lines of drainage have been scooped out of the softer schists, as in the western part of sheet 8.

METAMORPHICS.—Lithologically the gneiss presents few characteristics differing from the ordinary ones which have been so often described elsewhere. The actual gneiss itself is usually composed of felspar having commonly a red color, although sometimes white, quartz, and uniaxial mica in small dark green or black scales. Hornblende rock and schist are very abundant, varying in texture from a compact stony variety to one in which the foliation is very prominent. Subordinate runs of mica-schist also occur, some of which are composed of a mixture of black mica and hornblende with quartz, others of silvery mica with quartz; the latter variety is similar in appearance to some of the mica-schists of the submetamorphic series, although clearly interbanded with and passing into the gneiss.

Seldom are more perfect examples of the dome-shaped form of hill into which the gneiss sometimes weathers to be found than in the present area. Two cases are more especially prominent; the hills which run along the north side of the Bhiaura range and those which internally fringe the quartzite ridge north of Gáwan. In the former instance the domes extend from Bélchaki eastwards to north of Dhubni, the rock throughout being a very homogeneous† compound (viewed on the large scale) of white felspar, quartz and black mica, containing also ill-formed porphyritic crystals of similar felspar. Nearly vertical foliation is almost everywhere clearly marked, even on the smooth rounded faces of the hills, running parallel to the quartz ridge on the south. In the previous notice of these rocks already alluded to, while the foliated character of the rock forming the Bélchaki domes, and the absence of dykes ramifying from it into the adjacent quartzite, is noticed, the possibility of its being, notwithstanding, of a truly granitic character is suggested, partly on stratigraphical grounds and partly from the appearance of reaction of the rock in question and the quartzite on each other. My own more detailed examination, however, has led me to regard it as belonging to the metamorphic series. It certainly is more homogeneous on the large scale than the mass of the gneissose rocks; it does not include subordinate bands of other rocks such as hornblende or mica-schist. I think, however, that this is due, not to the homogeneous and the mixed rocks being distinct in origin, but to the fact (as I take it) that homogeniety is a necessary element in the production of the domes, and hence that it is only such portions of the gneiss as possess this homogeniety that weather into domes. The gneiss north-west of Churki for instance, and again at Pokriamo, is itself exactly of the Bélchaki type, but it is interbanded with layers and beds of hornblende schist, and in neither case have prominent domes been formed.

* The prefix 'sub' is used here, as in previous papers in these volumes in the same connection, to denote an inferior degree of metamorphism, and has no reference to the stratigraphical position of the rocks in question.

† In the valley south of Bélchaki there is a low hillock formed of what I take to be hornblende rock, although possibly trappean. This is the only exception I have observed, and it is in the valley between the domes, not in the domes themselves.

Small veins of segregitic pegmatite, having the same composition as the surrounding rock, from which they only differ in largeness of crystallization, are not uncommon in the gneiss; they seldom exceed two or three feet in thickness, are sometimes short and lenticular, in other cases traceable for some little distance. It is sometimes not easy to distinguish these from the granite veins to be described further on.

Limestone.—Calcareous rocks are very rare in the metamorphics of this region. In fact I have observed none in sheets 7 or 8 except a thick band of dolomitic limestone at Dhelwa (north of Gáwan), which may, however, belong to the submetamorphic series, and a few thin layers of the same rock close to Gáwan.

In the bed of the Patru nadi, north-east of Gulgo, (east side of sheet 3) the following section is exposed:—

a.—Hornblende schist overlaid by

b.—Largely crystalline white limestone containing scales of light green mica here and there; this bed is about 6 feet thick, and is covered by

c.—A peculiar mixture of garnet and coccolite containing traces of galena and copper. In places the two minerals are well intermixed, in others the garnet occurs in a pure massive form (so called calderite); only a few feet of this rock (*c*) is seen.

The beds in this section, which is on the south side of the stream, dip at about 15° to east-north-east, and the same strata are seen on the opposite side also, the distance from bank to bank, or length of visible outcrop, being perhaps 50 yards. An analysis of the limestone by Mr. Tween yielded—

Carbonate of lime	88·80
" magnesia	3·07
Oxide of iron and alumina	·61
Insoluble	7·18
	99·66

The locality is worth notice, as being within fifteen miles of Mahishmon station on the Karharbári branch of the East Indian Railway, over a country traversable by carts; more especially so in the event of iron works being started at Rániganj, the distance of which from Mahishmon is seventy-nine miles by rail. The bed is thin no doubt, but it may extend a considerable distance, and perhaps increase in thickness along the strike, and there is further the possibility of its being brought to the surface elsewhere in the neighbourhood by rolls in the strata. These points can only be determined by a close survey of the ground, which is beyond the limits of the area at present completed. A limited supply of very good mineral, either for burning or as a flux, can, however, undoubtedly be obtained there, whilst there is the possibility that if the bed were opened out, it would prove of considerable value. The nearest known locality where limestone occurs plentifully is Rhotásgarh on the Són, the transport of stone from which to Rániganj would involve over eighty miles of river and 236 miles of railway carriage; a bed, therefore, like the above, although it may perhaps not prove to be of much importance, is still well worth a trial.

Lead-ores.—Galena is sparsely disseminated here and there through the garnet and coccolite rock mentioned above, as overlying the limestone; and minute specks of copper pyrites and blende are also visible, the rock in one or two places being stained bright green by copper.

On the north bank of the river the beds are cut through by a nearly vertical granite vein, which also contains traces of galena, and the felspar in which is partly amazonstone, the color being probably due to copper. Both lead and copper, however, merely occur very sparingly disseminated through these rocks. There is no indication of a lode, or any reason for supposing the ores to exist more plentifully in the vicinity. The locality was pointed out to me by the agent of the zemindar to whom the land belongs as one in which lead had been found. He had caused some excavations to be made in the hope of finding more, which I advised him to discontinue.

I was also informed that some loose fragments of lead-ore (cerussite apparently from the description) had been found loose on the surface of the soil just east of Mehandádi (sheet 3) about a year ago, and also to the south of the village; and that on digging in the latter locality some more was found two or three feet below the surface.

Cerussite was found by some Santhâls, from one of whom I obtained a specimen, under similar circumstances at Barhamasia (sheet 3), some five or six years ago, and a small quantity of lead smelted from it, after which it appears they closed the hole up in order to keep the discovery a secret. About two years ago also a Sonár was looking for pieces of kankar, to make lime for pán, near the village of Nauwáda, south-west of Dhurgaon (sheet 9). On putting some pieces of what he supposed to be such in the fire in order to burn them, he was rather surprised to find globules of lead to have resulted from the operation. He then searched the locality for more, but failed in finding any at the time. In the rains, however, when the earth had been washed away from the loose surface stones, he found a few pieces, aggregating about half a sír, from which he obtained a small quantity of lead. The ore in question is a dark red cerussite, like that of Barhamasia; and similar fragments are said to have been found close to Khesmi (sheet 9). In all these localities they probably indicate the existence of lead-ore somewhere in the vicinity, but not necessarily at the immediate spot, as they appear in every case to have been found either loose on the surface or embedded in the surface soil. They furnish no evidence of the presence of lead in workable quantity, although there is of course the possibility of the existence of such. It would perhaps be worth while to expend a small sum in examining the localities at Barhamasia and south of Mehandádi.

Tinstone.—Tin-ore was worked some years ago at Nurgo, a village just south of the Barákar and about three miles from Leda (eight miles west of Karharbári). The original discovery of the tin appears to have been purely accidental on the part of some Kols, who having dug up the ore and smelted it as one of iron, were surprized to see what they took for silver, flow from the tap-hole. They endeavoured to dispose of it as such at Rániganj, and there learnt its true nature. They then abandoned the pit, and after a few years the exact locality where it occurred was forgotten. Subsequently a Mr. Lord determined to work the ore, and after several trial sinkings succeeded in hitting upon the right spot.

The ore occurred in three or four lenticular beds or nests in the gneiss, the cross section being lenticular and seldom more than a foot or two across, although at one or two points as much as thirteen, while the nests extended over 20 yards in a direction nearly parallel to the foliation of the gneiss, from the outcrop to the limit of the workings. The gneiss (which is of a thinly foliated, rather rotten variety, including a few thin segregitic seams of pegmatite) dips at about 25° to E. 10° N., the nests consequently having a similar direction. The ore consisted of gneiss through which crystals and grains of tin were thickly distributed. Mr. Deveria, Mr. Lord's manager, followed these tin-bearing nests for about 20 yards by an inclined gallery;* the tin was then decreasing rapidly in quantity, while the rock was harder, and a large quantity of water draining into the mine; and hence the gross receipts being less than the working expenses, the mine was abandoned.

During the time it was worked, the ore after being brought to the surface, was broken up while still fresh (as it hardened considerably by exposure) with a common country dheki.

* My friend Mr. T. H. Hughes had an opportunity of seeing the mine when open, and it is from his notes that this brief account is given.

The pounded ore was then placed in a basket and washed by hand, by which means most of the lighter impurities, chiefly quartz and felspar, were removed. Subsequently after drying, it was sifted in a chop (winnowing basket) to separate the remaining sand. When a sufficient amount of ore had been accumulated, it was smelted with charcoal in an ordinary aguriá's furnace, the charges being the same as those used in iron smelting. The tin, after being run out and cooled with water, was broken up, the clean metal laid aside preparatory to casting, and the rest, which was much mixed with charcoal, returned to the furnace. The clean tin was re-melted in a large open iron vessel and ladled out into moulds, holding about 40 lbs. of metal each. Altogether only about twelve maunds of tin was produced, as I was informed by a native of the place who had worked under Mr. Deveria.

Magnetic iron.—There are a few ferruginous bands scattered through the gneiss, containing a certain proportion of magnetic iron. I have not observed any very rich ores, although poorer ones are often smelted by the native "aguriás." Magnetite is also sometimes disseminated through the gneiss itself in small quantity, and collects in some of the stream beds to a trifling extent.

SUBMETAMORPHICS.

Relations to Metamorphics.—The difficult question of the relations between the metamorphics and submetamorphics is one which must eventually be decided by a review of the entire area, or at least of a large portion thereof, unless, indeed, we are fortunate enough to obtain some crucial sections which will prove a key to the solution of the problem. Such sections, however, are not available in our present ground.

Starting with the identification of the Mahábar schists and quartzites with those of Rájgír and Karakpur as suggested by Mr. Medlicott, we shall find that whatever may be the case elsewhere, there are no indications here of strongly marked unconformity to the gneiss. Taking, for instance, the line of junction between the quartzite and gneiss north of Gáwan, we see that it bends round successively from N. W. to N. E., E., S. E. and E. N. E., the strike of each rock being throughout parallel to the boundary; and not only do they agree in strike, but also in dip. Along the greatest portion of the above line the gneiss underlies the quartzite; but near Gáwan, and also at Hardíha, the reverse is the case (the strata here being inverted); throughout also, whether the dip be natural or inverted, it is equal in both at any given point.

Individual sections are also obtainable in which the same absence of unconformity is apparent. Thus, where the stream cuts through the quartzite ridge due north of Momankhitán, the last gneiss seen is well foliated, dipping 60° to N. 20° E., and composed of reddish felspar, quartz and schorl, the last being aggregated in places into large masses of crystals. Twenty yards lower down stream (higher in the section), and with similar dip, is granular quartzite composed of translucent grains; a little lower it contains small innate crystals of schorl and mica. Beyond this is more quartzite with a small included band of mica-schist, and the Dadho range is entirely of the latter rock. North-east of Birne, again, the gneiss is schistose, and the quartzite somewhat felspathic near the junction, so that the two rocks have the appearance of passing into each other within a few yards across the strike.

The same parallelism of strike is also observable on the large scale along the Bhiaura junction, from Bélchaki to Dhubni, in the dome gneiss. South-east of Belghati, however, the strike is not sufficiently regular to allow one to say whether, as a whole, it is parallel to that of the quartzite or not. The gneiss here is much mixed with hornblende schist, &c., and I do not think the beds are the same as those which form the domes. Here, then, is perhaps a case of unconformity, although it might also be explained by faulting.

Micaceous quartzite is again seen in the hills west of Manjne, being, I believe, the same as that to the east; but the junction with the gneiss is here somewhat different. From Deothan to Pacharídi the dip is mostly under 30°, the rocks in the southern part of the section being schistose hornblendic gneiss (dome gneiss in the hill north of Deothan) with hornblende schist and rock; these become more schistose to the north-east and pass into mica-schist, above which again is schistose quartzite.

Quartzite is again found to overlie the gneiss in the western part of sheet 8, whilst in the centre of the same the mica-schists are in immediate contact. It may, perhaps, be suggested that the quartzite should be included with the gneiss, and the boundary between the two series drawn above the former, the absence of quartzite in places being thus due to unconformity. It will be found, however, when describing the submetamorphics, that while there is generally, at least, a well-marked junction between the gneiss and quartzite, none such is obtainable between the latter and the schists; it is, however, to be observed, that the junction of the schists with the gneiss is also everywhere one of passage, sometimes gradual, sometimes tolerably sharp, but still a passage; and the foliation of each rock is always, as far as my observations extend, parallel to the common boundary: at least, if there be any deviation it is so slight as to escape detection.

Some local cases have been mentioned above, in which the gneiss overlies the submetamorphics at high angles. Such are, undoubtedly, invertions of the strata, the metamorphics being clearly the lower series. Amongst other examples in which the true superposition of the submetamorphics is apparent, I may mention the Deothan section, the band of quartzite north of Gáwan, and the schists flanking the gneiss hills north of Bhuládi.

Although no unconformity is discernible between the two series in the present area, this does not necessarily militate against the unconformity which has been supposed to exist elsewhere. In the Vindhyans of Central and North-Western India, we have an example of a great formation, which, notwithstanding its age, is undisturbed over large tracts of country; whilst in other areas, like the Dhár Forest, the strata are highly contorted. If on such a formation another great series were deposited, the two would clearly be unconformable to each other, although such unconformity would not be discernible in many places; and if at some subsequent epoch both were greatly disturbed, the resulting relations of the two series to each other would perhaps bear some resemblance to those of the metamorphics and submetamorphics.

Stratigraphy.—If a section be taken from north to south across the Bhiaura range, a little to the west of the trigonometrical station, the following succession of strata is passed over in ascending order—the dip throughout being to the south at high angles, but decreasing somewhat from north to south, the gneiss *b* being nearly or quite vertical, while the mica-schists *k* are inclined at 60° or 70°—

a.—Gangetic alluvium of Bihár.

b.—Gneiss forming dome-shaped hills.

c.—Small band of mica-, with probably some hornblende- schist, fragments of the latter being strewn about.

d.—Quartzite forming the ridge on which the trigonometrical station is situated; some portions are a hard, finely granular rock, breaking with a sub-vitreous fracture, and occurring in beds from one to two or three feet thick, in which no schistose structure is developed; others are coarse-grained and micaceous, and micaceous flaggy beds are also met with.

e.—Hornblende rock and schist, with mica-schist and interbanded layers of quartzite. In some of the hornblende schist the foliated structure is well developed; elsewhere the rock has sometimes a very trappean aspect, and I am not sure that some of it is not trap, either contemporaneous or more probably in dykes parallel to the foliation. A very clear-cut line of demarcation between it and the quartzite is sometimes visible, and that there is more or less trap hereabout is certain from an observation on the top of the ghât which crosses the quartzite ridge north of Phulwaria. Here a band of greenstone, about 15 inches broad, is seen running N. 10° E., or nearly at right angles to the strike of the quartzite. It can only be traced for 10 or 15 feet, but is clearly a dyke.

f.—Quartzite similar to *c.*

g.—Hornblende rock and schist with mica-schist, &c., similar to *d.*

h.—Quartzite similar to *c.*

i.—A very thick band of hornblende rock and schist. Much of it is of the former variety; but the schistose structure is very common also, and the rock sometimes contains a considerable amount of quartz in seam-like nests here and there.

j.—A broad band of schistose, micaceous quartzite. It is coarsely granular, and much softer than the quartzites to the north, so that it does not, like them, rise into a lofty ridge. It contains a good deal of interbanded mica-schist, and the mica-schist to the south (*k*) contain subordinate layers of quartzite, the two rocks not being clearly demarcated from each other.

k.—Mica-schist, passing in places into arenaceous schist, and thence into micaceous quartz schist. No distinct line can be drawn between these, but the main mass of the rock is mica-schist. Along the southern face of the hills it is full of small crystals of garnet and andalusite, the latter sometimes so plentiful as in weathering out to cover the surface with gravel.

l.—Gangetic alluvium of the Sakri valley.

The quartzites *d, f,* and *h* of the above section form three lofty parallel ridges (the valleys between being occupied respectively by the beds *e* and *g*), and the possibility of their being in reality the same beds repeated by folding at once suggests itself. Detailed examination of the range, however, did not lead me to adopt this view.

In following the strata towards the west, *e* and *g* are found to disappear, and the three quartzite ridges join into one, in which *d, f,* and *h,* may be, and probably are, all represented. The hornblendic band *i* also thins out in the same direction, and where the Sakri river cuts through the range, nothing but quartzite rises above the level of the alluvium, forming a ridge of greatly reduced elevation. A few miles further on, Mr. Medlicott found it gradually to come to an end also.

To the east, again, we find a great twist in the strata at Dhubni, and *e* and *g* can only be traced a short distance beyond this point; hornblende rock, however, is again visible on the top of the ridge east of Mokrumo; *i* and *j* also thin out to the east, so that at Nurpáni H. S. and beyond, the range is again reduced to a single band of quartzite.

It will be observed that all along the Bhiaura range the strike of the foliation of the schists corresponds with the direction in which the different alternations of rocks themselves run. Generally speaking, the bedding and foliation of the mica-schist lie in the same plane, although instances are not unfrequent in which they do not do so. In the former case, the rock has a tendency to weather into more or less slab-like pieces, whilst we find it to split much less easily where the foliation and bedding differ, and to weather into featureless hillocks, like those of Dumduma (sheet 7).

The section across the Ghagra valley is a synclinal, the band of quartzite north of Gáwan being clearly the same as that at Nurpáni. It turns round again in sheet 2 (as observed by Mr. Willson), and re-enters sheet 8, near Gáwan, where it again bends round sharply to south-east. It is here interbanded with hornblende- and mica-schists, the section in this respect resembling that of the Bhiaura range.

There appears to be another synclinal in the Sakri valley below Birne, the quartzites on both sides being, I believe, the same; that on the left, however, is softer and more micaceous, much of it, in fact, verging towards a micaceous quartz schist, and passing insensibly into the mica-schist below. The same rock much mixed with mica-schist, and even gneissose beds, is found again north-east of Píhra, the boundary between it and the metamorphics being a faulted one, indicated along the greater portion of its length by a line of hornstone.

Further south still, the mica-schists are most commonly, but not always, found in direct contact with the gneiss. The rock in the neighbourhood of Rajpura is of a very indefinite character, every gradation from quartzite to mica-schist being found, but too much mixed up to admit of separation. In the western part of the sheet, as I have previously pointed out, the quartzite makes its appearance again, but in the Ratanpur area the schists are the contact rocks, there being here, as elsewhere, a passage, sometimes gradual, sometimes tolerably sharp, into the gneiss. North-west of the above-mentioned village the mica-schist contains abundance of staurolite.

In Mahábar Hill we have the highest member of the series present in this part of the country: a great thickness of quartzite overlying the mica-schists. At the mouth of the Mangraun gorge the junction of the two rocks is well seen, there being a complete passage from one to the other in about 20 yards; half-way between thin layers of both are interstratified. The quartzite forms a great synclinal, dipping everywhere (at the ends of the hill as well as on the flanks) into the hill at angles mostly from 30° to 80°. In the central part of the range the rock is so crushed, that the bedding is sometimes quite obscured. In some cases also, planes of what appear to be cleavage, are visible, having a direction different from that of the bedding. This peculiar trough-like conformation, and the high inclination of the strata, is remarkably favorable to the retention of water, and the volume flowing from the densely forest-clad gorges which wind in amongst the hills, strikes one as exceptionally great.

The absence in the Patru valley of the large thickness of mica-schists, which is present immediately to the south-west, must, I believe, be attributed to a fault with northern downthrow. The junction of the quartzite with the schists however, and of the latter with the gneiss, is natural, so that the fault must occur in the schists themselves. It is apparently by another fault running north and south with western downthrow, that the quartzite is brought almost in contact with the gneiss in the valley north of Kotiyár.

According to the above view, it will be seen that in Northern Hazáribágh the submetamorphics include three main subordinate groups, *viz.*:—

Mahábar quartzite.

Mica-schists, including subordinate bands of arenaceous and hornblendic schists.

Bhiaura quartzite, sometimes wanting, in other places attaining a great thickness, and sometimes interbanded with hornblende- and mica-schists.

PEGMATITE GRANITE.—Through both gneiss and submetamorphics, but especially in the latter, there is a large development of pegmatitic granite,* penetrating the older rocks in

* In most English standard works on geology pegmatite is defined as consisting essentially of quartz and felspar, with little or no mica; and in some, as identical with graphic granite. Delesse, however, and Naumann describe it as a very coarse mixture of quartz, felspar, and silvery mica, often containing tourmaline. It is in the latter sense that the word is used here.

innumerable dykes and veins, as well as in larger masses. The rock is generally a very coarse quaternary compound, composed of quartz, felspar, mica, and tourmaline, united in very varying proportions.

The quartz is white and translucent to semi-transparent, and never, so far as I have observed, presents any approach to crystallization. The felspar is sometimes orthoclase, sometimes albite, the latter having an opaque white color: the orthoclase is also generally white, but of a less pure tint; occasionally it is more or less reddish. The mica (muscovite) generally has a smoke brown color in plates of moderate thickness, although colorless in thin laminæ. When perfectly unaltered and free from internal foreign matter, it is highly transparent, but where decomposed, it loses some of its diaphaniety and acquires a more silvery lustre. The plates occur of every size, up to 18 inches diameter or more, but such very large ones are much less common as those of a few inches across. Occasionally, two minor cleavages are apparent (∞P and $\infty \breve{P} \infty$), parallel to the latter of which more especially, the mineral divides into narrow ribbons, and fibres like asbestos, or, where both are present, it is divided by them into equilateral triangles. Greenish-gray beautifully plumose mica is also not uncommon, weathering out in small irregular masses above the general surface of the rock. Dark-brown and olive-green biotite sometimes occurs, but even where most plentiful, it is quite subordinate to the muscovite, which it never altogether replaces. Occasionally the plates are some inches across, and include smaller interlaminated ones of muscovite.

Tourmaline is rarely entirely absent from the pegmatite, and most usually forms an important ingredient in it. The crystals often attain a large size; those of two and three inches across are common, and in some dykes they are met with over six inches diameter. Owing to the great brittleness of this mineral, in comparison to the felspar and quartz in which it is imbedded, crystals approaching perfection are rarely obtainable; the few I did secure were of the common form $\infty P2. \infty R. — \frac{1}{2}R.$ Sometimes the prisms lie parallel to each other and perpendicular to the walls of the vein, but this is far from being universal, or even common, and it seems, as might be expected, to be more usually observable in dykes of a few feet in thickness. The tourmaline is jet black with brilliant lustre, and the large lumps often met with in the mica mines are superficially not unlike anthracite; some of the miners who have seen the Karharbári coal-field take them to be coal, but few of them have any idea of what real coal is like. Small crystals of tourmaline are sometimes found imbedded in plates of mica, with their principal axis parallel to the cleavage of the latter; crystals are again observable penetrating others of the same species. It appears that the tourmaline was generally the first to crystallize, the mica next, afterwards the felspar, and the quartz to have resulted last.

The relative proportions of the different minerals vary greatly; generally all four are present, but in some places the rock consists chiefly of felspar and mica with little quartz, in others it is made up entirely of quartz and mica, and the latter again diminishes in amount until the rock passes into micaceous or into pure vein quartz. Graphic granite, composed of felspar with a little quartz, is another variety occasionally met with. Sometimes the tourmaline is absent, in other cases it is one of the most prominent constituents of the rock.

The pegmatite, as a whole, is very largely crystallized, but one of its most marked characteristics is its *unevenness* of texture. In one place it may be comparatively fine, but here within a few feet a great mass of pure felspar, with cleavage faces a foot long, occurs, and there another of translucent quartz, or perhaps these contain plates of mica over a foot across. It is worthy of note that the coarsest pegmatite often occurs in dykes of only a few yards in breadth, not in the large granitic masses, and it is in the dykes consequently that nearly all of the mica mines have been sunk.

Occasionally the granite occupies considerable areas, as south of Píhra, where in a large mass of irregular hills no other rock is seen, and again south of Gáwan; for a mile below Sánkh the Sakri river flows continuously through it. Most commonly, however, it is found penetrating the older rocks in dykes and veins, varying from 50 yards or more in thickness, down to less than an inch. These are more usually roughly parallel to the foliation of the rocks they penetrate, but by no means universally so. Many cut through quite obliquely and irregularly, and ramify in various directions. They are mostly vertical or hade at high angles (agreeing in this respect with the foliation), but instances occur where they are nearly horizontal. Such horizonal dykes of greater thickness than usual may perhaps, in some cases, give rise to the larger granitic areas.

The surrounding rocks seldom present much appearance of alteration in the vicinity of the granite; generally the junction is quite sharp, and the beds in immediate contact not different from what they are at a distance. It is to be remembered, however, that these beds had perhaps already undergone metamorphism before the introduction of the granite. Sometimes there is a rapid passage of a few inches from one rock to the other, as if the strata in immediate proximity had been fused or greatly softened. South of Píhra, the mica-schists south of the large spread of granite there, pass into gneiss near the junction; but as there is always a gradation from the mica-schist into the true metamorphics in this portion of the country, it does not follow that the above passage is in any way connected with the granite.

After an examination of the granite in the innumerable dykes and veins, presenting every appearance of having forced its way in uneven and ramifying courses through the circumjacent strata, one can scarcely avoid feeling satisfied as to its truly intrusive origin, and the fact of its maintaining a constant mineral character amongst the different rocks through which the dykes occur, whether these be gneiss, mica-, hornblende-, or quartz-schist or even limestone, some of which are rocks from which the granite could not possibly have been produced by any mere chemical re-arrangement, leaves no escape from this view. It is, however, on the other hand, not easy to explain the occurrence of thin strings of granite of an inch or half an inch thick, running exactly parallel to the foliation of the including mica schist for many yards, and at a distance from any visible dyke, and of lenticular pockets (also parallel to the foliation) completely isolated to all appearance in the surrounding rock. Such cases are so very common, that I scarcely think it is always a sufficient explanation to say that they are offshoots of some dyke hidden beneath the surface, or were once connected with a dyke above, which has since been removed by denudation. I have already alluded to the passage of the granite into vein quartz. These are points requiring elucidation, but that the granite is really intrusive is beyond question.

The dykes are far more plentiful in the submetamorphic than in the metamorphic series, and their distribution in the former is very unequal. In some areas they occur, large and small, by hundreds; in others they are entirely wanting.

Mica Mines.—It is in this granite that the well-known mica mines of Bihár* and the neighbouring districts are situated. I have previously said that the coarsest pegmatite is frequently found in dykes of moderate thickness, in which, therefore, plates of mica of the largest size occur, and it is such dykes that the miners generally select for their operations. They pay from one to two rupees each per annum, according to the richness of the yield, to the owner of the land for the privilege of mining. The usual mode of working is simply to excavate a trench along the course of the dyke, which in the Gáwan neighbourhood is seldom carried deeper than 20 or 25 feet. Sometimes where there is a considerable thickness

* A paper by Captain Sherwill on the mode of working the mica mines in the Bihár district may be found in the Journal Asiatic Society, Bengal, vol, XX, p. 295.

of decomposed mica near the surface, rude shafts are sunk to the fresh and uninjured mineral, and excavations carried on laterally from the bottom. In a few cases also, rough horizontal galleries are driven in from the side of a hill. In the last methods of course artificial light is necessary. No precaution is taken to support the roof, and accidents are not unfrequent from its falling in.

The plates of mica are generally brought to the miners' village, and there, after being slightly trimmed with ordinary grass-cutting knives, (which are not particularly well adapted for the purpose, but are probably the only ones the people are able to purchase,) they are sorted into different heaps according to quality and size. The quality depends on the mineral being in a perfectly unaltered condition, its transparency and freedom from cloudiness caused by internal foreign matter, the absence of minor cleavages which render it liable to split into ribbons and triangles, and the planeness of its fissile surfaces. Six kinds are recognised according to the size of the plates, *viz.*:—

1st.—Sanjhla.	*4th.*—Karra.
2nd.—Manjhla.	*5th.*—Urtha.
3rd.—Rási.	*6th.*—Admalla.

Some of the miners intercalate failurtha between urtha and admalla, and speak of another size (barka) still larger than admalla. All these terms are used rather vaguely in respect to the absolute size of the plates indicated thereby. At Dháb and Jamtára I induced the miners to separate a quantity of the mica into the different grades, and measured an average specimen of each, with the following results:—

	Dháb.	Jamtára.
Sanjhla	5″ × 4″	4″ × 3″
Manjhla	7 × 5	5 × 4
Rási	9 × 6	6 × 5
Karra	12 × 9	8 × 6

The above four sizes include the greater portion of the mica found, it being only in the best mines that urtha and admalla are procurable. The largest plates I have myself seen measured 19″ × 14″ and 20″ × 17″ inches, but I was informed that considerably larger ones are sometimes obtained.

The mica is sold by the load, which is built up of the plates, either into one frustrum of a cone and carried on the head, after being bound together with cord, or into two such, and carried in a bánghi. A load equals 6 paserís, one paserí being equal to 5 kacha sírs of 12 chatáks each, or to 3¾ paka sírs of 16 chatáks; the load, therefore, being 22½ sírs paka, or 46lbs. avoirdupois. The miners informed me that the prices paid to them by the mahájans were as follows:—

	Per load.
Sanjhla	3 annas,
Manjhla	5 „
Rási	7 „
Karra	12 „
Urtha	2 to 6 rupees,
Admalla	4 to 9 „

the selling prices being about double the above.

The value of the large plates more especially varies greatly with the quality. I was informed by Colonel Boddam that plates of first quality of 18 inches diameter fetch as much as 60 rupís a månd in the market, or about 30 rupís a load.

Accessory Minerals: Lepidolite.—Accessory minerals are not very numerous. Amongst those which occur, the most abundant is lepidolite, which, although not widely distributed, exists in considerable quantity where it does appear. I first observed it in a dyke a little to the south-west of Píhra, where the granite is composed of white felspar, quartz, and irregular masses of lepidolite occurring as a scaly aggregate, varying in color from violet-red to greyish-violet. The mineral is also found of a lead-grey and violet-grey color, mixed with quartz. An analysis of the violet-red variety by Mr. Tween yielded the following results:—

Silica	50·39
Alumina	31·63
Oxide of Manganese	tr.
Lithia	3·71
Potash	1·40
Soda	5·80
Fluorine	5·00
Loss on igniting	4·23
	102·16

Small black grains and crystals of tinstone are occasionally discernible in both the above varieties. Lepidolite is also met with in a dyke a little to the south-east of this locality; also just north of Bhuládi, and again about a mile south of Manimundar, where the sides of a hillock are strewn with blocks, one of which was estimated to weigh about 8 cwt.

Green and blue Tourmaline.—At the two first-mentioned localities associated with the lepidolite is tourmaline, which varies in color from green to indigo-blue; some crystals being blue in the interior and green externally. The prisms chiefly traverse, parallel to the cleavage, the plates of a silvery mica (altered muscovite?) which is present as well as the lepidolite; they also penetrate the quartz.

Beryl, garnet, apatite, leucopyrite.—Small crystals of yellow beryl are abundant in a large dyke which crosses the Tendwáha Nadi south of Mahábar hill; and garnets, generally much decomposed, are not unfrequently met with here and elsewhere. The few obtained, in which the form was apparent, were trapezohedrons. In three or four dykes a crystal or two of green apatite was observed; and from a dyke crossing the Sakri above Sánkh I obtained a mass of leucopyrite, weighing about three-fourths of a pound.

Tin.—Most of the above minerals being frequent associates of tinstone, their occurrence led me to keep a sharp look-out for such, both in the granite itself and in the river beds. With the exception of that disseminated through the lepidolite of Píhra, I only observed the mineral in one locality however. This was in a lenticular pocket of granite, included in mica-schist, at Simratari, west of Píhra, through which a few crystals of ½ inch across and less were scattered. The occurrence of tin, even in such minute quantity however, is interesting, as showing that the same mineral association which has been observed in other parts of the world obtains here also; and indicates at least the possibility of the ore being found in larger amount in the granite of the area yet to be examined. I fear the chance is but small of its being obtained in workable quantity. The tin-ore of Leda, as previously mentioned, occurred as a bed in the gneiss of the metamorphic series.

Galena.—Galena is very sparsely disseminated through a granite vein, penetrating the limestone and associated beds in the Patru Nadi as well as through the latter beds themselves.

Trap Dykes.—Two or three trap dykes were observed intersecting the granite south of Gáwan. Whether these be of the same age as those which traverse the metamorphic and submetamorphic series is not certain, although there is no assignable reason for supposing them different.

TÁLCHÍRS.—In the Sakri Nadi, south of Dábar, there are some small patches of slightly micaceous buff sandstone, rather fine-grained, but containing abundant rolled pebbles and small boulders of granite, gneiss, mica-schist, &c. In parts, the greater portion of the rock consists of pebbles, in other places it is quite free from them. The beds, which are not more than 20 feet thick in all, are level as a whole, but rolling on a small scale, and are lithologically perfectly similar to Tálchírs. Mr. Willson, however, higher up the same stream, as well as in other places, found *two* sandstones, the upper resting unconformably on, and containing numerous pebbles of the lower, which is clearly Tálchír. It is not perfectly certain to which of these the sandstone in question belongs, but as I observed no sandstone pebbles in it, it is most probably Tálchír. Small patches of similar rock are found south of Deothan and east of Píhra.

DESCRIPTION OF PLATE.

Fig. 1.—Granite dyke resting on, and including a folded mass of, quartz-schist: Section—Tendwáha Nadi, south of Mahábar hill.

„ 2.—Mass of quartz-schist nearly enclosed by granite: Section—Tendwáha Nadi.

„ 3.—Junction between hornblende-schist and granite dyke: Plan—Tendwáha Nadi.

„ 4.—Granite dyke in mica-schist: Section—Sakri Nadi east of Sánkh.

„ 5.—Lenticular pockets of granite, running parallel to the foliation of the surrounding mica-schist: Plan—Simratari.

„ 6.—Granite dyke, in hornblende- and quartz-schist: Section—Tendwáha Nadi.

„ 7.—Granite overlying mica-schist, both of which are faulted against Tálchír sandstone; the newer rocks being covered by alluvium: Section—Sakri Nadi, south of Dábar.

„ 8.—Granite vein in quartzite: Section—S. S. E. of Lakráhi.

„ 9.—Granite dyke cutting obliquely through gneiss, into which it sends strings parallel to the foliation: Plan—E. of Gidhaur hill.

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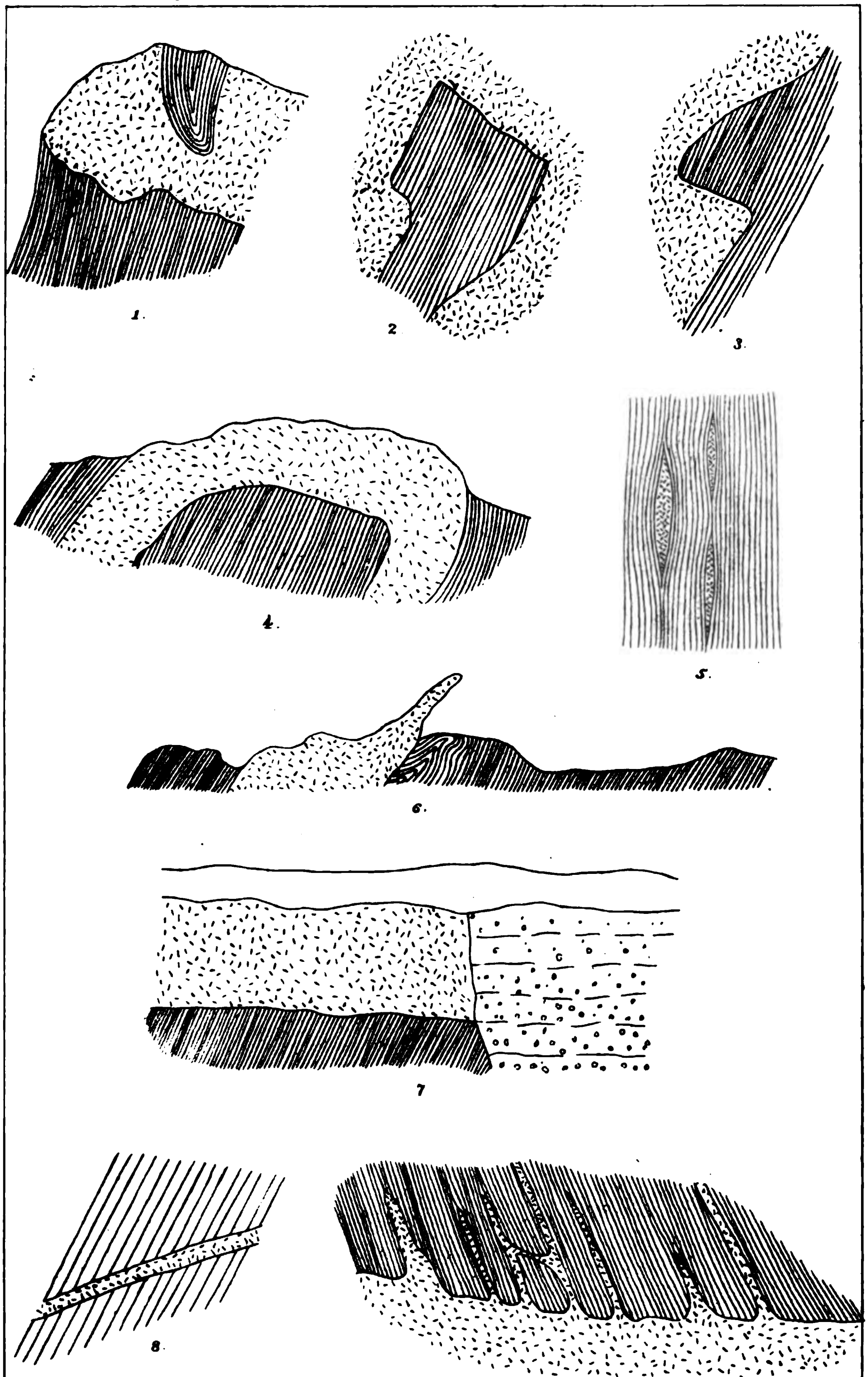
1 piece weighing	...	...	...	8,296 grains.
1 „ „	...	...	...	1,393 „



Granite and Schist: Contact-Sections.

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January 5th, 1874.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1874. [May.

Geological notes on the route traversed by the Yarkand Embassy from Shahidula to Yarkand and Kashgar, by Dr. F. Stoliczka, *Naturalist attached to the Embassy*.

In a former communication I had already occasion to notice, that the rocks composing the Kuenlún range near Shahidula, chiefly consist of syenitic gneiss, often interbedded, and alternating, with various metamorphic and quartzose schists. Similar rocks continue the whole way down the Karakash river for about twenty-four miles. After this the road follows, in a somewhat north-westerly direction, a small stream leading to the Sanju-(or Grimm-) pass. Here the rocks are chiefly true mica schist, in places full of garnets. Near, and on, the pass itself chloritic and quartzose schists prevail, in which veins of pale green jade occur, numerous blocks containing this mineral having been observed near the top of the pass. All the strata are very highly inclined, often vertical, the slopes of the hills, and in fact of the entire range, being on that account rather precipitous, and the crests of the ridges themselves very narrow.

To the north of the Sanju pass we again meet with metamorphic, mostly chloritic schists, until we approach the camping place Tám, where, distinctly bedded, sedimentary rocks cap the hills of both sides of the valley. They are dark, almost black, silky slates, resting unconformably on the schists, and are overlain by a grey, partly quartzitic sandstone, passing into conglomerate. The last rock contains particles of the black slates, and is, therefore, clearly of younger age. Some of the conglomeratic beds have a remarkably recent aspect, but others are almost metamorphic. In none of the groups, the slates or sandstones or conglomerates, have any fossils been observed; but they appear to belong to some palæozoic formation. They all dip at from 40° to 50° towards north-east, extending for about one and a half miles down the Sanju valley. Here they are suddenly cut off by metamorphic schists, but the exact place of contact on the slopes of the hills is entirely concealed by débris. The schists are only in one or two places interrupted by massive beds of a beautiful porphyritic gneiss, containing splendid crystals of orthoclase and biotite; they continue for about eighteen miles to the camp Kiwáz. On the road, which often passes through very narrow portions of the valley, we often met with old river deposits, consisting of beds of gravel and very fine clay, which is easily carried off by only a moderate breeze, and fills the atmosphere with clouds of dust. These old river deposits reach in many places up to about one hundred and fifty feet above the present level of the river, which has to be waded across at least once in every mile.

At the camp Kiwáz the hills on both sides of the valley are low, composed of a comparatively recent looking conglomerate, which in a few places alternates with beds of reddish, sandy clay, the thickness of the latter varying from two to five feet only. These rock strikingly resemble those of the supra-nummulitic group, so extensively represented in the neighbourhood of Mari. They decompose very readily, covering the slopes of the mountains with loose boulders and sand, under which very little of the original rock can be seen. Near the camp the beds dip at about 40° to north-east, but about one mile and a half further on a low gap runs parallel to the strike, and on the other side of it the beds rise again, dipping with a similar angle to south-west, thus forming a synclinal at the gap. Below the conglomerate there crops out a grey, often semi-crystalline limestone, containing in some of its thick layers large numbers of *Crinoid* stems, a *Spirifer*, very like *S. striatus*, and two species of *Fennestellæ*. Following the river to north by east, this carboniferous limestone again rests on chloritic schist, which, after a mile or two, is overlain by red sandstone, either in horizontal or very slightly inclined strata. Both these last named rocks are very friable, easily crumbling between the fingers, particularly the latter, from which the calcareous cement has almost entirely been dissolved out. At Sanju the red sandstones underlie coarse grey calcareous sandstones and chloritic marls, some beds of which are nearly exclusively composed of *Gryphæa vesicularis*, many specimens of this most characteristic middle cretaceous fossil being of enormous size. The *Gryphæa* beds and the red sandstones are conformable to each other, and although I have nowhere seen them interstratified near their contact, there is strong evidence of their being both of cretaceous age. Both decompose equally easily, and the *Gryphæa* beds have indeed in many places been entirely denuded. They have supplied the greater portion of the gravel and beds of shifting sand, which stretch in a north-easterly direction towards the unknown desert-land.

On the road from Sanju to Yarkand, which first passes almost due west and after some distance to north-west, we crossed extensive tracts of those gravel beds, and of low hills almost entirely composed of clay and sand, though we only skirted the true desert country. Locally, as, for instance, near Oi-tograk and Boria, pale reddish sandstones crop out from under the more recent deposits, but they appear to be younger than the cretaceous red sandstones, underlying the *Gryphæa* beds; the former most probably belong to some upper tertiary group. Among the sandy and clayey deposits I was not a little surprised to find true *Loess*, as typical as it can anywhere be seen in the valleys of the Rhine or of the Danube. I might even speak of 'Berg' and 'Thal-Löss,' but I shall not enter into details on this occasion; for I may have a much better opportunity of studying this remarkable deposit. At present I will only notice that commonly we meet with extensive deposits of *Loess* only in the valleys. Its thickness varies in places from ten to eighty, and more, feet; a fine yellowish *unstratified* clay, occasionally with calcareous concretions and plant fragments. In Europe the origin of this extensive deposits was, and is up to the present date, a disputed question. Naturally, if a geologist is not so fortunate as to travel beyond the 'Rhine' or 'Donau-thal,' and is accustomed to be surrounded with the verdant beauty of these valleys, he might propose half a dozen theories, and as he advances in his experience disprove the probability of one after the other, until his troubled mind is wearied of prosecuting the object further. Here in the desert countries, where clouds of fertile dust replace those of beneficial vapour, where the atmosphere is hardly ever clear and free from sand, nay occasionally saturated with it, the explanation that the *Löss is a subaerial deposit*, is almost involuntarily pressed upon one's mind. I do not think that by this I am advancing a new idea; for,—unless I am very much mistaken,—it was my friend Baron Richthofen who came to a similar conclusion during his recent sojourn in Southern China.

Yarkand lies about five miles from the river, far away from the hills, in the midst of a well cultivated land, intersected by numerous canals of irrigation; a land full of interest for the agriculturist, but where the geological mind soon involuntarily falls into repose. And what shall I say of our road from Yarkand to Kashgar? Little of geological interest, I am afraid.

Leaving Yarkand we passed for the first few miles through cultivated land, which, how ever, soon gave way to the usual aspect of the desert, or something very little better. A few miles south-west of Kokrabad a low ridge runs from south-east to north-west. If we are allowed to judge from the numerous boulders of red sandstone and *Gryphæa* marl, some of considerable size and scarcely river-worn, we might consider the ridge as being composed of cretaceous rocks. But one hardly feels consoled with the idea, that in wading through the sand he should only cross a once cretaceous basin, and that the whole of this country should have remained free from encroachment of any of the kainozoic seas. It is very dangerous to jump to conclusions regarding the nature of a ground untouched by the geological hammer. The answer to any doubt must for the present remain a desideratum. On the fourth day of our march, approaching Yangihissar, we also crossed a few very low ridges, but these consisted entirely of gravel and marly clay beds, most of them dipping with a very high angle to south by east, the strike being nearly due east and west. South of Yangihissar the ridge bent towards south-west, and there was also a distant low ridge traceable in a north-easterly direction, the whole having the appearance of representing the shore of some large inland watersheet. From Yangihissar to Kashgar we traversed only low land, as usually more or less thickly covered with a saline efflorescence, but still to a considerable extent cultivated. Here in Kashgar the distant heights of the Kuenlún, of the Pamir and Thin-shan ranges are ready to unfold their treasures, whether we go in a southerly, or westerly, or northerly direction; geological ground is even nearer to be found in some of the low ridges from twelve to thirty miles distant, while the Moral-bashi forests, lying eastward, invite the zoologist and sportsman. I trust we shall soon be able to see and relate some novelties from our neighbourhood.

Kashgar, 20th December 1873.

NOTE REGARDING THE OCCURRENCE OF JADE IN THE KARAKASH VALLEY, ON THE SOUTHERN BORDERS OF TURKISTAN, *by* DR. FERD. STOLICZKA, *Naturalist attached to the Yarkand Embassy.*

The portion of the Kuenlún range, which extends from Shahidula eastward towards Kotan, appears to consist entirely of gneiss, syenitic gneiss, and metamorphic rocks, these being quartzose, micaceous, or hornblendic schists. On the southern declivity of this range, which runs along the right bank of the Karakash river, are situated the old jade mines, or rather quarries, formerly worked by the Chinese. They are about seven miles distant from the Kirghíz encampment Belakchí, which itself is about twelve miles south-east of Shahidula. I had the pleasure of visiting the mines in company with Dr. Bellew and Captain Biddulph, with a Yarkandee official as our guide.

We found the principal jade locality to be about one and a half miles distant from the river, and at a height of about five hundred feet above the level of the same. Just in this portion of the range a few short spurs abut from the higher hills, all of which are, however, as usually, thickly covered with débris and sand, the result of disintegration of the original rock. The whole has the appearance as if an extensive slip of the mountain-side had occurred. Viewing the mines from a little distance the place seemed to resemble a number of pigeon-holes worked in the side of the mountain, except that they were rather irregularly distributed. On closer inspection we saw a number of pits and holes dug out in the slopes, extending over a height of nearly a couple of hundred feet, and over a length of about a quarter of a mile. Each of these excavations has a heap of fragments of jade and rock at its entrance. Most of them are only from ten to twenty feet high and broad, and their depth rarely exceeds twenty or thirty feet; only a few show some approach to low galleries of moderate length, and one or two are said to have a length of eighty or a hundred feet. Looking on this mining operation as a whole, it is no doubt a very inferior piece of the miner's skill; nor could the workmen have been provided with any superior instruments. I estimated the number of holes at about hundred and twenty; but several had been opened only experimentally, an operation which had often to be resorted to on account of the superficial sand concealing the underlying rock. Several pits also which were probably exhausted at a moderate depth were again filled in; their great number, however, clearly indicates that the people had been working singly, or in small parties.

The rock, of which the low spurs at the base of the range are composed, is partly a thin bedded, rather sandy, syenitic gneiss, partly mica- and hornblendic schist. The felspar gradually disappears entirely in the schistose beds, which on weathered planes often have the appearance of a laminated sandstone. They include the principal jade-yielding rocks, being traversed by veins of a pure white, apparently zeolitic mineral, varying in thickness from a few to about forty feet, and perhaps even more. The strike of the veins is from north-by-west to south-by-east, or sometimes almost due east-and-west; and their dip is either very high towards north, or they run vertically. I have at present no sufficient means to ascertain the true nature of this vein-rock, as it may rather be called, being an aggregate of single crystals. The mineral has the appearance of albite, but the lustre is more silky, or perhaps rather glassy, and it is not in any way altered before the blowpipe, either by itself, or with borax or soda. The texture is somewhat coarsely crystalline, rhombohedric faces being on a fresh fracture clearly traceable. It sometimes contains iron pyrites in very small particles, and a few flakes of biotite are also occasionally observed. This zeolitic rock is again traversed by veins of nephrite, commonly called jade; which, however, also occurs in nests. There appear to be two varieties of it, if the one, of which I shall presently speak, really deserves the name of jade. It is a white tough mineral, having an indistinct cleavage in two different directions, while in the other directions the fracture is finely granular or splintry, as in true nephrite. Portions of this mineral, which is apparently the same as usually called white jade, have sometimes a fibrous structure. This white jade rarely occupies the whole thickness of a vein; it usually only occurs along the sides in immediate contact with the zeolitic vein-rock, with which it sometimes appears to be very closely connected. The middle part of some of the veins and most of the others entirely consists of the common green jade, which is characterized by a thorough absence of cleavage, great toughness, and rather dull vitreous lustre. The hardness is always below 7, generally only equal to that of common felspar, or very little higher, though the polished surface of the stone appears to attain a greater hardness after long exposure to the air. The colour is very variable, from pale to somewhat darker green, approaching that of pure serpentine. The pale green variety is by far the most common, and is in general use for cups, mouth-pieces for pipes, rings and other articles used as charms and ornaments. I saw veins of the pale green jade fully amounting in thickness to ten feet; but it is by no means easy to obtain large pieces of it, the mineral being generally fractured in all directions. Like the crystalline vein-mineral, neither the white nor the green variety of jade is affected by the blowpipe heat, with or without addition of borax or soda. Green jade of a brighter colour and higher translucency is comparatively rare, and, already on that account, no doubt much more valuable. It is usually only found in thin veins of one or a few inches; and even then it is generally full of flaws.

Since the expulsion of the Chinese from Yarkand in 1864, the jade quarries in the Karakash valley have become entirely deserted. They must have yielded a considerable portion of the jade of commerce; though no doubt the workmen made a good selection already on the spot, taking away only the best coloured and largest pieces; for even now a great number of fair fragments, measuring 12 to 15 inches in diameter, form part of the rubbish; thrown away as useless.

The Belakchí locality is, however, not the only one which yielded jade to the Chinese. There is no reason to doubt the existence of jade along the whole of the Kuenlún range, as far as the mica- and hornblendic schists extend. The great obstacle in tracing out the veins, and following them when once discovered, is the large amount of superficial débris and shifting sand, which conceal the original rock *in situ*. However, fragments of jade may be seen among the boulders of almost every stream which comes down from the range. We also observed large fragments of jade near the top of the Sanju pass, which on its southern side at least mostly consists of thin-bedded gneiss and hornblendic schist.

Another rich locality for jade appears to exist somewhere south of Kotan, from whence the largest and best coloured pieces are said to come; most of them are stated to be obtained as boulders in a river bed, though this seems rather doubtful. Very likely the Chinese worked several quarries south of Kotan, similar to those in the Karakash valley, and most of the jade from this last locality was no doubt brought into Kotan, this being the nearest manufacturing town. A great number of the better polished ornaments, such as rings, &c., sold in the bazaar of Yarkand, have the credit of coming from Kotan; possibly they are made there by Chinese workmen, but the art of carving seems to have entirely died away, and indeed it is not to be expected that such strict Mahomedans, as the Yarkandees mostly are, would eagerly cultivate it. If the Turkistan people will not take the opportunity of profiting by the export of jade, or if no new locality of that mineral is discovered within Chinese territory, the celestial people will feel greatly the want of the article, and good carved specimens of jade will become great rarities. The Chinese seem to have been acquainted with the jade of the Kuenlún mountains during the last two thousand years, for Kotan jade is stated to be mentioned* "by Chinese authors in the time of the dynasty under Wuti (B. C. 148—86)."

Yarkand, 14th November 1873.

NOTES FROM THE EASTERN HIMALAYA.

While Dr. Stoliczka is applying his palæontological master-key to discover the secrets of the rocks of the Kuenlún, on the extreme north-west of the great Tibetan mountain-area, investigations of scarcely less interest are going on at the south-eastern base of the same, in the Sikkim and Bhután Doars. It may indeed be said that the geology of the remote and inaccessible regions of the Himalaya have for some time been better known to us than that of the nearer ground to the south of the great snowy range. A series of well-known formations have long since been identified beyond the passes; while the rocks of the broad belt of mountain region to the south of the main range have remained indeterminable. Nummulitic rocks have been locally found along the southern fringe of that belt, corresponding stratigraphically to the Flysch of the Northern Alps. And upon very scanty fossil evidence it has been conjectured that the limestone of the outer ridges in the Simla region are triassic; but for the rest all is darkness. There is, of course, a very good excuse for this in the highly metamorphosed condition of the strata in the greater part of that region, and in the sterility everywhere in fossil remains—difficulties which greatly enhance the value of any promising clue to a solution of the mystery.

From the point of view of local geology this state of ignorance has been specially depressing. That same nummulitic formation—crushed and upheaved on the outer fringe of the Himalayan region, and resting undisturbed upon a deeply denuded surface of the great

* Yule's Marco Polo, Vol. I, p. 177.

Dakhin trap—has been almost the only positive link between the rock-areas of the Peninsula and of Central Asia. Of the other Indian rock-formations—the Vindhyan series of unknown age, and deeply rooted in the fundamental rocks; or the great sandstone formations supposed at present to range from permian to latest jurassic, and holding a comparatively superficial relation to the supporting rocks—no assignable equivalent had been made out in the neighbouring Himalayan provinces.

The press of work elsewhere may be offered to account for this; for the clue which is now promising such interesting revelations has been within reach at any time for the last twenty years; since Dr. Hooker discovered at the base of the Sikkim Himalaya rocks containing plant-fossils characteristic of the coal-measures of Bengal.*

The illustrious naturalist did not assign any stratigraphical position for the rock in that section; perhaps the only locality where he noticed it, near the Pankábári rest-house, did not admit of such a determination. This is indeed most likely the case; for, the passing observation made in the same spot by so practised a geologist as Mr. W. T. Blanford left the question still in doubt, the suggestions gathered being that the Damudas may occur there only as fault-rock between the schists of the mountains and the tertiary sandstones at their base; or even that the stones containing the Damuda plants may only occur as blocks in the tertiary sandstones. A regular survey of that region is now in progress. Mr. F. R. Mallet took up work there early in December; and already important results have been obtained, both practical and scientific. A band of Damuda coal-measure rocks has been traced for many miles along the base of the mountains, and in places as much as one mile in width, inside the fringing bed of tertiary sandstones. Besides the familiar Damuda plants, several seams of coal occur, in a condition approaching anthracite in composition—having 79·3 of carbon, 7·6 of volatile matter (dry), and 13·1 of ash—but in a flaky granulated (graphitic) state from crushing. The chief point of interest, however, is that there is no marked stratigraphical break between these beds and the slaty and schistose rocks forming the mass of the mountains; on the age of which they will thus give very important evidence. Mr. Mallet has not yet been able to satisfy himself upon the complicated structural questions involved in the section, as to inversion, faulting, &c., but it is hoped that before the close of the season some definite view may be made out. Meanwhile this notice is given of so important a step in the geology of India.

While Mr. Mallet was making these observations on the ground, an independent suggestion to the same effect was received from Mr. H. F. Blanford, whom we consider virtually, as he formerly was officially, a colleague in the study of Indian geology. Mr. Blanford was at Darjeeling on a tour of inspection of the meteorological stations in that part of the province. Ever mindful of his first love, and aware, of course, of Dr. Hooker's original discovery of Damuda fossils at the base of the mountains, it appeared to him that the frequent bands of graphitic matter in the schistose and gneissic rocks of the higher regions might indeed be the greatly transformed equivalents of the carbonaceous deposits of the Peninsula. If this criterion be confirmed by the close study of the stratigraphy, it promises to be of very wide application; for these graphitic bands are as abundant in the Lower Himalaya of the north-west as about Darjeeling. The suggestion too fits in well with the little we know on both sides of the question: Dr. Oldham has always maintained that the coal-measures of India are palæozoic; and the Krol limestone, the uppermost group of the Lower Himalayan rock-series in the north-west, is considered by Dr. Stoliczka to be triassic.

H. B. M.

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* Himalayan Journal, Vol. I, page 403.

PETROLEUM IN ASSAM, *by* THEODORE W. H. HUGHES, A. R. S. M., F. G. S., *Geological Survey of India.*

In looking through the literature relating to petroleum, I have not met with any record of the composition of oils occurring in Assam. Burmese-oil, which is perhaps better known under the name of Rangoon-oil, has, on the contrary, been the subject of frequent investigation, and one of the later and most highly interesting papers referring to it is to be found in the Memoirs of the American Academy* for 1867, under the heading of "Examination of Naptha obtained from Rangoon Petroleum," by Warren and Storer.

Having been fortunate enough lately to procure a few notes† showing the result obtained by submitting some Assam petroleum to distillation at varying temperatures, I propose taking this opportunity of placing them on record.

The petroleum experimented upon was obtained from a spring in land granted to Mr. Goodenough, a member of the firm of McKillop, Stewart and Company. The tract, as specified in a letter to the Board of Revenue, embraced "both sides of the Boree Dehing river from Jaipore to the effluence of the No Dehing river to a distance of ten miles on each side of the Boree Dehing, including the lands near the Cherraphong hills, Jaipore, the Makoom river, the Namchik Poong, the Terap river, the Namchik river, the Jugloo river, and the Terok river."

Which spring the petroleum that was tested came from I am unable to say; but it was probably from one struck near Makoom,‡ as the springs in that neighbourhood surpassed any others in the copiousness of their discharge, and evidently attracted most attention.

The first of the systematic borings for oil was commenced at Nahore Poong§ in November 1866; but it does not appear to have been successful, and it was abandoned after having been sunk to a depth of 102 feet. In addition to several other hand-borings, a Mather and Platt steam-boring machine was set working in the latter end of December, and a hole was carried down 195 feet; but with the exception of a few signs of gas, there were no good results.

It appears from the records placed at my disposal that a blue clay was invariably met with, not only in the Nahore Poong borings, but in those at Makoom and elsewhere. It would have been interesting to know whether this clay, independently or in association with some other rock, was a good index to oil; but on this point there is nothing clear.

Whilst the borings at Nahore Poong were proceeding, others were begun at Makoom. Oil was struck in one hole on the 26th March 1867 at 118 feet, and it immediately rose 74 feet in the bore, being 44 feet below the surface. About 300 gallons were drawn, after which it was found not to flow continuously, a circumstance which it was hoped would be remedied by sinking deeper.

As many as eight holes seem to have been put down in the Makoom area, and they were nearly all successful in tapping oil. The yield varied in each.

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* Vol. IX, Part 1, New Series, page 208.

† I am indebted for these notes and for much useful information regarding petroleum and coal in Assam to my friend Mr. J. Jenkins.

‡ Lat. 27° 18' North, Long. 95° 40' East.

§ The places recommended during the progress of the borings were—Nahore Poong, Makoom, Borhaut, Namcheck, and Bapoo Poong.

In January 1868, 100 to 125 gallons a day were collected from No. 4, while 550 to 650 gallons were collected from No. 5. The action of No. 5 bore was intermittent. Pure water was spouted for 3 or 4 hours, then almost pure oil for 15 to 30 minutes, after which all action ceased for an hour, or sometimes longer; and then activity set in again. Great difficulty was met with in storing the oil, and it is stated that wooden tanks failed to keep it in. The most copious discharge was from No. 5; and as there was not sufficient storage room, the flow was diminished by fixing a valve to the well-pipe. The pressure was very great, being 30 lbs. to the inch.

The following is a very interesting table showing when the blows of oil commenced, the time the oil continued running, and the quantity of oil given from No. 5 bore at Makoom. The depth at which oil was struck is not given in the returns made by the person in charge of the borings, but the hole was most probably a shallow one like the others.

BORE NO. 5.—MAKOOM.

Table showing when the blows of oil commenced, the time the oil continued running, and quantity of oil given.

Date, 1868.		Commenced to run.	Day and hours running.	Gallons per day of 24 hours.	Remarks.
January	8th	9 A. M.	6 days 15 hours.	530	Stopped gradually.
„	16th	11 „	12 „	1,500	1,500 gallons in 12 hours (very strong blow).
„	17th	11 „	14 „	2,100	2,100 gallons in 14 hours (very strong blow).
„	20th	Midnight	9 „	500	5 0 gallons in 9 hours.
„	21st	10 A. M.	20 „	480	480 „ „ 20 „
„	23rd	11 „	1 day 13 „	300	300 gallons per day (ran slowly).
„	27th	9-30 „	23½ „	300	„ „
„	29th	9-30 „	6 days 15 „	250	Running very slowly.
February	5th	9 „	19 „	500	500 in 19 hours.
„	7th	9 „	2 days	700	
„	13th	2 P. M.	19	1,400	In 19 hours 1,400 gallons.
„	16th	9 A. M.	1 day 6 „	1,600	1,600 in 30 hours.
„	27th	11 „	1 „ 5 „	900	In 29 hours.
March	2nd	9-30 „	1 „ 6 „	1,700	In 30 hours.
„	7th	9 „	2 days	3,000	3,000 in 48 hours.
„	11th	9 „	1 day 11 „	3,500	In 35 hours, very strong—burst pipes.
„	31st	10 „	31 days 22 „	500 per day.	Valve very little open, to reduce the flow as much as possible.
May	14th	6 P. M.	60 „	450 per day.	
July	14th	11-30 A. M.	3 „ 22½ „	400	
„	19th	9 „	4 „ 21 „	550	
„	27th	1 P. M.	15 „	600	In 15 hours.
„	28th	10-30 A. M.	3 days 1 „	700	A strong blow.
August	8th	9 „	3 „	500	In three hours, very strong flow.
„	11th	2 P. M.	3 days 10 „	1,500	
„	22nd	9-30 A. M.	8 „	400	In 8 hours.

Here the man who kept the account fell ill, and the one who relieved him never kept any.

The temperature is not recorded.

Mr. Goodenough was not successful in establishing a petroleum-industry. The undertaking failed, as so many others in this country have done, owing to the difficulty of transport. But the prospect of an abundance of mineral-oil in Assam has been proved; and if this splendid province should ever be opened up, fortunes will yet be made in this branch of mining.

Analysis of petroleum.—The sample of petroleum operated upon was black, perfectly liquid, and of rather strong odour. Specific gravity ·971. Water 1·000.

One thousand parts were submitted to distillation, first by the heat of a water-bath, but that being insufficient, it was then heated by direct fire. It began to boil at 460° F.—

Collected	1.	20	parts below	500° F.		
	2.	96·5	between	500°—525°	of sp. gr.	... ·873
	3.	126·5	„	525°—550°	„	... ·882
	4.	100·0	„	550°—575°	„	... ·892
	5.	133·5	„	575°—600°	„	... ·900
	6.	166·5	above	600°	„	... ·918
	7.	133·5	„		...	... ·936
	8.	166·5	„		turned solid on cooling.	
		943·0				

There was a small residue of coke.

The first six portions would do for lamp oil, although of rather higher specific gravity than that obtained from American petroleum.

Seven and 8 contain solid paraffin, which can be separated, and the liquid-oil used for lubricating; or, after the first six portions have been distilled off, the whole of the residue in the retort can be used as lubricating-oil.

For the purpose of comparison, I give the result of an experiment upon *Pennsylvanian petroleum.*

Sample.—Greenish black, rather thin oil. Sp. Gr. 882. One thousand parts yielded on distillation—

16·5	parts at	212° F.		
85·5	„	284°-302°	of sp. gr.	·733
95·5	„	302°-320°	„	·752
125·0	„	320°-338°	„	·766
56·0	„	338°-356°	„	·776
52·5	„	356°-392°	„	·800
56·0	„	392°-428°	„	·848
39·5	„	428°-518°	„	·854
526·5				

all the residue would be for lubricating-oil.

Rangoon-oil.—According to Warren de la Rue's researches yields per thousand parts—

110 parts of oil below		...	212° F.	
100 „	between	...	230°-293°	
200 „	„	...	293°-600°	
310 „	above	...	600°	which solidifies on cooling.
210 „	„	...	600°	dark oil at the greatest heat.

The paraffin contained in portions 7 and 8 of the Assam petroleum might be manufactured into candles. As compared with a few other substances, the following table shows the number of grains required to give equal quantities of light:—

Paraffin	98 grains.
Spermaceti	120 „
Wax (bee's wax)	138 „
Stearic acid	144 „
Composite candle (made of stearine and stearic acid)	156 „

The discovery within the last few years of enormous quantities of petroleum in Canada and the United States, has influenced considerably the manufacture of coal-oils in Great

Britain and other countries. But there are places where coal and bituminous shales may be profitably submitted to distillation, and I believe that our Indian coal-fields offer a fair chance.

The yield of crude oil from a ton of ordinary coal* does not usually exceed a maximum of 75 gallons, and a coal which will yield 50 gallons may be regarded as an excellent article, provided it affords coke enough to supply heat for its own distillation.

RANIGANJ,
1st *December* 1873.

COAL IN THE GARO HILLS, *by* MR. H. B. MEDLICOTT.

The reported discovery of a new coal-field in the interior of the Garo hills, backed up by the proposal to run a railway through them into Assam, led to a very urgent demand to have the rocks of that region examined. Although nearly encircled by long-settled and fertile districts of the upper deltaic plains of Bengal, that hill-tract has, till within the last three years, remained perfectly secluded in primitive savagery. Partly to remove such an anomaly, and partly to put a stop to the occasional practice of the Garos capturing slaves and taking trophies of human heads among the bordering plains people, it was decided to bring the hill-men under control. This intention was carried out without serious difficulty. The people had of course been long acquainted with the character and power of the white men holding sway over the plains, and submitted to their supremacy almost without resistance. This year I had the pleasure to march through the length and breadth of the land in the company of an English lady, the wife of the Deputy Commissioner of the district, Captain Williamson, the subduer and friend of the Garos, who made his tour of inspection through his dominions to fit in with my geological explorations. In the previous season topographical surveyors had accompanied the several expeditionary parties sent in to take possession; and had succeeded in completing an excellent sketch map of the whole area. One of these officers heard of the coal, and brought it to notice. It would seem that no European actually visited the spot; indeed the description first given of the position could hardly have proceeded from an eye-witness; but samples were procured, and thus the bare fact of coal being there was sufficiently authenticated. The confirmation of the existence of a considerable coal-field in the position thus indicated, warrants brief notice of the situation.

It will probably be remarked that Garo-hill coal is at least familiar by name. In 1841, Mr. Bedford, engaged on the revenue survey of the Goalpara district, brought to notice what he called the Kurribari coal-field, at the extreme west end of the Garo hills, close to Singmari on the old Bramaputra. Some attempt was, I believe, made at the time to work it; and the failure of the experiment does not seem to have been fairly attributed to the failure of the deposits. Again, about two years ago, the civil officers of Mymensing brought to the notice of Government the occurrence of coal on the Sumesary river at the south base of the main range of the Garo hills. The extension of the Eastern Bengal Railway towards Assam was then a pressing question; and I was deputed to report upon the prospects of the coal deposits, particularly those of the Kurribari region, the position of which, close to the great river, gave them special importance. In April 1868 the result of my observations was reported to the Government of Bengal: the existence of a fair seam of useful coal at Siju on the Sumesary was confirmed, the present value of it being questioned, on account of difficulty of access from the plains across some ten miles of low rugged hills. Of all the known outcrops in the Kurribari region, at Mirampara and Champagiri, a most unfavorable account had to

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* Cannel coals and bituminous shales yield as much as 120 to 180 gallons of crude oil per ton, but they produce no coke of any value.

be given: the deposit was indeed the same as at Siju, and more favorably circumstanced for working, the measures being quite horizontal, and close to the surface; but the seam contained only a few irregular little strings of coal in a thick bed of clay, resting almost directly upon a platform of gneissic rocks. The only apparent prospect of useful coal there lay in the possible development of the deposit on the same horizon to the deep of the formation in its main basin, on the south of the barrier of crystalline rocks; and I suggested that this point might be determined by a boring in the neighbourhood of Harigaon. The present revival of the question has been as stated above.

THE DARANGGIRI COAL-FIELD. *The coal.*—The sample of the newly found coal, sent for opinion, could at once be recognised as the cretaceous coal of this geological province: the same as that known at Siju, and as that of the tiny field at Maobilarkar on the Shillong plateau from which the supply for the station is obtained. It is a very peculiar coal, having less the appearance of ordinary coal than the younger nummulitic coal of the same region it has a decided brown colour when crushed, and gives a wooden sound when struck: it is moreover impregnated throughout by small nests or minute specks of a resinous amber-like substance. It is thus, of course, a light coal, but a very excellent fuel as shown by its composition—

Fixed carbon	47·7
Volatile	44·6
(Moisture)	(11·5)
Ash	7·7

The position.—Viewed from the south, the main range of the Garo hills is continuous with the face of the Kasia hills to the east, although the aspect is different. Instead of the bare mural precipices of massive sandstone, there is the steep rugged slope formed on contorted crystalline rocks, and thickly wooded throughout. The chief orographical difference, however, is that whereas from the scarp of the Kasia range the ground still rises for some distance, passing into the elevated plateau of Shillong, the western range is only a narrow-crested ridge, descending rapidly, though much less precipitously than on the south, to a broad region of steeply undulating hills of much less elevation. The Sumesary river, the Semsang of the Garos, passes through the main range by a deep gorge just above Siju. At the head of this gorge there is a fine waterfall, close to Jankaray; and half a mile further on, just above the confluence of the Rengchi, the river crosses the south boundary of the Daranggiri coal-field, which thus at present lies in a true rock-basin, passing below the main drainage level. The elevation here may not be more than 300 to 400 feet above Siju. The Sumesary flows for six miles through the coal-basin, the north boundary being about one mile below the village of Dobakhol. For the greater part of this length, the river is here the boundary, as recently laid down, between the Garo and Kasia hill districts. The range of the field to the east has not been determined. To the west it extends at least four miles from the lower reach of the Semsang, up to and beyond Daranggiri.

Outcrops.—Several fine outcrops are freely exposed; the one originally reported being by no means the most conspicuous. It occurs in the Garigithem stream, a furlong or so above the confluence with the Semsang. It is 6 to 8 feet thick, with a steady southerly dip of about 4°, the floor of gneissic rock appearing at a short distance higher up the stream. In the main river, about half a mile above the same confluence, the seam appears again in equal force, with a low easterly dip. The correct inference, that the seam would be found continuous through the intervening spur, led to the original announcement of the discovery as of "a mountain of coal." It was close to Daranggiri village that I observed the finest outcrop; it is well exposed for many score yards at the base of the cliff along the right bank of the stream, almost horizontal, and with a thickness of full 7 feet throughout, being at the same time very free from shaly partings. Near the south boundary of the field, along the base of the permanent rise of the main range, the coal was found in two places; but here it has the disadvantage of having undergone much disturbance. In the stream a little to the west of the lower village of Baduri, a few yards below the Daranggiri path, the coal is thus seen in full force, but nearly vertical. On the same strike, within a mile of the Semsang, on the path between Baduri and Jankaray, the approximate position of the seam is marked by large and abundant débris.

On the evidence of these facts, it is, I think, safe to conclude that there is here a coal-field of considerable extent. The coal-measures are certainly continuous within the area demarcated by the localities I have mentioned, covering roughly about twelve to fifteen square miles; and although the coal itself is probably not co-extensive with the measures, the total quantity must be very large; and it is favorably circumstanced for mining. It lies, however, in the very heart of the Garo hills; but on the most favorable line for a railway, through the gorge of the Semsang, should it ever be thought advisable to undertake such a work. The nummulitic formation with its limestone caps the high ground in the centre of the basin.

The Rongrenggiri basin.—Some miles up the valley of the Semsang, to the west, there is another considerable basin of the coal-measure rocks, occupying the valley above and below the Rongrenggiri outpost for a direct distance of seven miles, from a little below Sarramphang Haut to below Shemshanggiri. Locally it is five miles wide. I could nowhere find an outcrop of the coal within this area; but there are stratigraphical features (see further on) suggesting that it may exist within the basin at greater depths than the present surface.

The Kalu basin.—On the Upper Kalu, north of the main gneissic range, about Chipagiri, there is a small basin of the coal-measure rocks; but no trace of coal has been observed. Here, too, it may possibly be found at greater depths by boring; but the field would seem to be shallow and closely circumscribed by the gneiss. Even if found, there would be several miles of difficult transit to get the coal to market.

The main basin.—Every other observed appearance of the coal-measure rocks to the north of the Tura range (excepting one narrow strip in the valley at Lenkra, in the far east), consists only of patches of variable extent and thickness, resting on the ridges and spurs of the crystalline rock, some occurring locally near the Semsang even on the crest of the main range. In so steeply eroded a country, these cappings of sedimentary rocks are freely exposed on all sides to denuding action, and the presence in quantity of any peculiar material could scarcely escape detection; where, too, at any time a shallow trench down the hill side across the bedding would lay bare the whole contents of the section. Yet in none of the very many places where I crossed the measures in this position did any symptoms of coal appear. With the single exception of a small patch on the north shoulder of the ridge below the village of Sokadam, every observed outlier of the cretaceous formation occurs within the basins of the Semsang and the Kalu, in the neighbourhood of the main axis of elevation; the whole stretch of hills for twenty miles on the Goalpara side being, at least on the two tracks crossed by me, entirely formed of gneiss. The original sites at the extreme west end of the hills, at Champagiri and Mirampara, remain as the only known cases of the seam being represented in a mere remnant of the measures on a low platform of gneiss. Thus, excepting in the very doubtful project of a railway through the Semsang gorge and the Daranggiri basin, and also in the unlikely possibility of still finding a detached basin within easy reach of the Goalpara boundary, the only prospect of a coal-supply still lies in the main basin of the formation, to the south of the Tura range.

The chances of this prospect are briefly as follows: It is demonstrable in the Khasia hills and here, that the portions of the cretaceous rocks found on the gneiss or within its southern limit are only the marginal deposits of a formation expanding greatly in thickness to the south. Even within that marginal area, coal seems to have been formed only in local depressions of the old land-surface. The important question then occurs—how was it in the main depression of deposition? For the Khasia portion it can positively be said that the conditions for the accumulation of vegetable remains did not exist to the deep of the formation. The whole expanded series is fully exposed in a nearly vertical position at the base of the range; and marine fossils occur throughout. Even the horizon of the coal near the base of the series can sometimes be determined here by the presence of plant-markings and fragments of the resinous substance so common in this cretaceous coal, but here mixed with marine shells. The change to the westwards has not been traced out continuously along the strike; but at the Sumesari it is already very marked: there is a strong seam of coal, well up from the bottom beds; it is brought up twice by contortion of the strata, showing its extension to some distance from the rise; and no marine fossils have been detected in the associated beds. This, it will be recollected, is close on the same meridian as the Daranggiri field, only to the south of the main range. To the west of the Sumesari a very great change takes place in the mechanical circumstances of the strata: instead of being thrown on end at their junction with the gneiss, as is the case everywhere to the east, the boundary here is, what is called, overlapping—the strata being banked against the flanks of the mountain, each succeeding layer overlaps and conceals the one below it. There has been here too some elevation, compression, and waving of the strata; but, on the whole, the formation is only exposed to the depth to which the local streams have cut through the superposed strata. All this is admirably exposed in the ravines below Tura; each layer being for the short space of its overlap the local bottom layer of the formation. In some of them sticks and strings of coal occur, as under Machakholgiri; but it seems likely that none of these streams touch the true horizon of the coal deposit; so that this may be in full force to the deep of the basin. In none of the beds of this region have any marine fossils been detected; and there is very abundantly here a white fine clay-rock,* that hardly appears in the Khasia sections. On the whole, I think the question of coal or no coal in this position ought to be set at rest by a trial boring. I have recommended Dipkai, about two miles to north-east of Putimari Haut, as a suitable spot.

GEOLOGY.—I would add a few remarks of a more general nature to bring my recent observations into connexion with what I have previously said on the geology of this region (see Mem. Geol. Sur., India, Vol. vii, p. 151). The difference of the structural features of the sections in the Khasia and the Garo divisions of this continued mountain-mass is greater than was then surmised. In the Shillong region, the elevation of the plateau took the form of an equable rise of the whole area—the gentle slope of the cretaceous strata from the edge of the scarp, passing into perfect horizontality as they extend northwards, is perfectly unbroken. In the features then observed along the outer base of the range, there was nothing to suggest its being otherwise in the Garo region; a gradual diminution of the elevatory and contorting action being the only change apparent. It would seem, however, that, besides a general decrease in vertical effect, the elevating action here was almost confined to the axis of the range, corresponding with the line of the scarp to the

* This rock may yet be found valuable as a pottery-clay. It contains 52·8 per cent. decomposable by sulphuric acid, and free from alkali iron and lime, with a residue of 47·2 per cent. of pure fine silica.

east; and even, that special local depressions took place to the north of that axis: not only are the same geological horizons found at about the same level on both sides of the ridge, upon which intermediately remnants of these very beds are found at much higher levels, but also, as is very clear in the case of the Rongreng basin, steady local sinking took place, the nummulitic limestone being found in the middle of that small area at the river's level, while the cretaceous sandstone passes up to a considerable height on the spurs of the adjoining hills, no high dips being introduced.

It is interesting to trace the apparent connection of these effects of disturbance with pre-existing conditions. The manner in which the coal occurs in the Darang basin strongly suggests that its limits are to some extent aboriginal, and therefore that the Semsang valley itself was lined out in precretaceous times. At the Garigithem outcrop and also in the Semsang there are about fifty feet of sandstone between the seam and the gneiss. But as it rises along the spurs to the north and west, one finds a far greater thickness of sandstone without any sign of the coal, which is thus simply overlapped; the beds on the high ground, even in contact with the gneiss, being of a higher horizon than the coal. Half a mile above the main outcrop in the Semsang there is on the right bank a cliff of sandstone resting on gneiss, and at forty feet from the base there is a highly carbonaceous shale representing the coal seam.

The manner in which the sandstones are banked up against the Tura range, and fill up inequalities in its surface, is quite conclusive on the same point. The spur on which the station of Tura stands has a midrib of gneiss, packed in sandstone, through which the old ravines have been re-excavated. On the section through Siju and Baduri this would not appear, the crushing having assumed a peculiar and intense form; the separating rib of gneiss, here representing the Tura range, is only four miles wide, and at the base on both sides the coal measures lie at nearly vertical angles against the gneiss and parallel to its surface, while high on the intervening ridge patches of the same rest flatly. Thus it would seem that elevation by lateral compression takes effect by increasing existing inequalities; as would indeed result from the crushing of a series of inverted arches.

ON THE DISCOVERY OF A NEW LOCALITY FOR COPPER IN THE NARBADA VALLEY, *by* V. BALL, ESQ., M. A.

The Bijour or submetamorphic rocks of India have, as has been predicted from their character, proved the principal source of the useful and precious metals which have hitherto been found in this country. The slates, quartzites, and schists which compose the Bijour formation resemble in their lithological characters those metamorphic rocks which in all countries are the most productive of metalliferous deposits.

The discovery of a deposit of copper now to be recorded was made towards the end of last year, on a small island in the Narbada river close to the Birman ghát. The gentleman to whom the sole credit of this discovery belongs is Mr. Charles Maynard, agent of the Narbada Coal and Iron Company. Being well acquainted with the appearance of the ores of copper, some stains of the blue and green carbonates upon the rocks attracted his attention. He at once determined to open up the ground with the view of ascertaining, so far as possible, the extent and character of the deposit.

On the 11th of January, I visited the scene of operations and found that a 'drift' had by that time been driven down to a depth of nine or ten feet. This gave me an opportunity of examining the character of the deposit. The rock in which the ore occurs is an argillaceous schist associated with quartzites. In some of the beds of the latter the component grains are very distinct. These rocks belong to the Bijour series.

I found that the underlie of the deposit corresponds to the dip of the strata, amounting to from 50° to 55° north, the strike being at this particular point east and west. The ore, I believe—as I found also to be the case in Singbhum*— does not occur in what can be truly called a lode, but as a constituent of the schist which it permeates throughout a thickness of at least six feet. This was the thickness exposed at the time of my visit; but according to Mr. Maynard's calculation this should be increased by eight feet; thus making in all fourteen feet as the thickness of the schist permeated by the ore.

There is, as usual, in such deposits, a tendency to the formation of nests and pseudo-lodes; but this, I believe, to be due to subsequent action—seggregation—and that the copper should be regarded as a constituent of the schist as originally deposited.

The ores on the back of the lode, as is generally the case, consist principally of the blue and green carbonates (*Azurite* and *Malachite*). As the mining progresses, nests of the grey oxide become more abundant, and there are also some traces of the red oxide. Pyrites (the yellow metal of mining phraseology) has not yet been reached, nor can it be until a depth sufficient to have ensured its protection from the decomposing effects of atmospheric action has been arrived at.

The extension of the ore downwards or "to the deep" can only be determined by mining. As to its lateral extension we found some stains of the carbonates on the same bed of schist fully 100 yards to the east of the present drift.

Trenches cut across the strike of the rocks to a depth of three or four feet would probably be sufficient to prove the lateral extension sufficiently for all present purposes.

As to the quality of the ores, the assay of five specimens by Mr. Tween yielded the following percentages of copper: No. 1, 47·8; No. 2, 21·2; No. 3, 32·0; No. 4, 25·4; No. 6, 12·6.

Two specimens sent to the mint gave the following result:—

	A	B
Copper	32·75	23·1
Iron	2·50	5·4
Earthy matter	64·75	71·5
	100·	100·

These results must be considered eminently favorable. The quantity in which the ore occurs, the cost of its extraction and transmission to market,† are the elements which now remain to be ascertained in order to determine the full importance and value of the discovery.

The last accounts which I received from Mr. Maynard represent the mine as progressing favorably. Under his energetic management there is a prospect thus of a new industry being started in the Narbada valley.

* See Records of the Geological Survey of India, Vol. III, pt. 4, p. 94.

† It does not of course come within the scope of this notice to discuss the question as to whether it would pay best to export the ore in the form of 'regulus,' or attempt the manufacture of copper on the spot.

POTASH-SALT FROM EAST INDIA.*

A novelty which has become known here through this year's Universal Exhibition is the discovery of Potash-salt bearing strata in the Mayo mines in the Salt-range in the north of the Punjab.

Dr. T. Oldham, who provided and arranged the very interesting exhibition of East Indian mineral products, has already made a communication upon the position of the rock-salt in those hills in a notice published in the *Ver. der Geol. Reichsanstalt,* from which it appears that this rock-salt group is considered to belong to the Silurian formation, and accordingly is the oldest among the known deposits of salt.

Recently attention was drawn at the above-named salt-works to the occurrence of a salt which, by its exceptional hardness, and the more searching examination of the resident chemist, Herr Warth, revealed the presence of a considerable proportion of Magnesium and Potassium.

Specimens from this deposit now in the Exhibition, consist of a white or reddish granular mixture of Sylvine (Chloride of Potassium) and Kieserite (Sulphate of Magnesium).

The Sylvine and the rock-salt can be at once recognised by the cleavage and blow-pipe reaction. The Kieserite appears in grains which have a maximum diameter of 12 mm. It is colorless, and possesses the same hardness and cleavage as that given by me for the Hallstadt mineral.† In places the Kieserite appears also to be compact.

The contained water amounts to 12·99 p. c. exactly, thus agreeing with the calculated amount 13·04.

From the Kieserite in a moist atmosphere changing into Epsomite, the samples in which that ingredient predominates become quite disintegrated at the surface, and exhibit a constantly deciduous coating. Many pieces consist almost exclusively of Sylvine. Whether also some Kieserite occurs in these samples, as may be conjectured in such an association, does not yet appear, since I have only been able to submit small pieces to examination.

The discovery of this Sylvine-bearing salt-band cannot fail to arouse attention in England, since, in spite of the difficulties of transport, a profitable exploitation is possible.

T.

NOTES ON THE GEOLOGY OF THE NEIGHBOURHOOD OF MARI HILL STATION IN THE PUNJAB, *by* A. B. WYNNE, F.G.S., &c.

The outer Himalayan hills on the borders of the Northern Punjab present a marked alteration in the general direction of the Indian frontage of these mountains. The prevalent north-westerly strike of the Western Himalaya is here lost, and this most northerly corner of the Indian Empire is embayed between the approaching masses of the Himalaya, Hindoo Koosh, and Suliman ranges, the outworks of which have various westerly and northerly directions. On the Himalayan side, as noticed by Mr. Medlicott (Mem. Geol. Sur., Vol. III, pt. 2, p. 90), in the valley of the Jhilam river, the hills to the eastward possess the normal north-westerly strike, while on the opposite side of the valley they run in directions nearly at right angles to the former. On one of the most lofty of the minor ridges closing in this Jhilam valley to the west is situated the hill station of Mari, at an elevation of more than 7,000 feet above the sea.

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* Translated from the Jahrbuch der K. K. Geologischen Reichsanstalt, XXIII, No. 2, p. 136.—V. B.

† Sitzungsber. J. Wiener, Akad. Bd. LXIII, p. 305.

Besides the features noticed, the mountains on either side of the Upper Punjab embayment are more or less united by two lower ranges of hills, of which the most southern is the Salt Range, dividing the broken undulating Potwár or Ráwal Pindi plateau from the lower deserts and 'Doabs' through which the five great rivers of the Panjab pass towards Sind. The other less defined group of hills stretches from the Hazára mountains, by the Chita Pahár ridge to the Affrídi hills, towards Kohát, separating the Ráwal Pindi plateau from the Peshawar plain. Within this cluster of hills are large open spaces of low ground cut up by ravines similarly to the Potwar plateau,* partaking somewhat of the direction of the two last named ranges and closely flanking the Hazara portion of the most northern group of the two. The Mari ridge rises among numerous other hills near the village of Chattar Síla, then passing in a north-easterly direction by Trét to Mari culminates there at Pinacle hill (7,467 feet) overlooking a spur called Kúldanna, which unites the main ridge with the more massive Murchpuri mountains to the north.

From Pinacle hill the Mari ridge bends to the east by south for a couple of miles, separating the head waters of the Sohan, a tributary of the Indus, from those of the stream which occupies the *khud* between Murchpuri mountain and Dewal, falling into the Jhilam near Kohala. At Topa summit the ridge regains its north-easterly direction, and passing by Dewal inclines still more to the north, descending gradually till it reaches the banks of the Jhilam river.

Southward from this Mari ridge the hills on the same side of the Jhilam valley consist of four or five other ridges, all having the same general direction, starting from the Potwar plateau with a general strike of E. 30° N., but bending northwards as they rise, and where they decline into the valley of the Jhilam having a bearing still more to the north than north-east. Most of these elevations are sharp-crested, the hill country presenting a succession of deep steeply sided khuds or valleys, but southwards the lofty plateaux of Narh and Karor are striking exceptions to the rule.†

Northwards from Mari the same north-east and south-westerly run characterizes the hills; but for some distance both north and south of the station the ridges seem to branch east and westerly from a crooked back-bone or mid-rib rudely parallel to the course of the river Jhilam. This is less prominent to the south, but coincides with the most lofty summits to the northward, carrying the watershed between the Indus and Jhilam away to the northern side of the Kaghán valley.

Another feature of the hills immediately near Mari may be noticed, namely, the occurrence of small nearly horizontal patches of ground at high elevations formed of unstratified light-coloured clay. Advantage has been taken to level the surfaces of two of

* These open spaces and the adjacent hills afforded the site of the military operations connected with the Northern Camp of Exercise in 1873 near Hassan Abdal.

† It is said that when the sanitarium was being formed at Mari there had been some intention of adopting the Narh plateau as its site instead. The reason given against this is want of water at the latter site; but the natives have another legendary one connected with the displeasure of the local Pir or spirit, who is said to have caused such inconvenience to the inhabitants of the first hut built at Narh that the '*Saheb log*' departed and left the Pir in peace.

The elevation of the Narh plateau is only about 1,000 feet lower than Mari; the form and size of the plateau, which is cultivated in places, would seem to offer a much more capacious and better building ground while the size of the catchment area and disposition of the strata are vastly more calculated for retaining a supply of water. The distance from Rawul Pindee station is rather less than that of Mari. The road-making difficulties are less, so far as the hardness of the rocks is concerned, but this renders them less suitable as building stone; snow lies here much shorter time. The plateau is not covered by forest; timber, however, abounds on the northern slopes of the neighbouring valleys. There is a well-made country road now for more than half the distance from Ráwal Pindi, and as permanent quarters for troops, the site appears to possess, on the whole, natural advantages superior to those of the hill of Kuldanna, at the same elevation, where extensive barracks are in course of construction at present.

these, so as to form the cricket-ground at "the Flats," three miles below the station on the Kashmir road, and for the croquet or archery ground south-west of Pinacle hill. Both of these localities are situated on the very back of the ridge; near the former rises the summit of Topa; but the latter, at a much greater elevation, is commanded by no greatly higher ground in its immediate neighbourhood. The clay in both cases is evidently water-washed detritus, and it is not easy now to suggest where the ground was once situated which formed the catchment area to cause these deposits, though they indicate clearly enough a former different configuration of the hills, and point to adjacent masses above them having been entirely removed by meteoric denudation. Such facts as these, and the constant occurrence of landslips on the slopes of these steep ridges, all more or less 'dressed' to a uniform inclination, force upon the observer a recognition of the slow but enormous atmospheric erosion by which these khuds and ridges have been formed, here doubtless largely aided by the periodic rains and winter snows.*

The rocks of which the Mari ridge itself is formed, and all those for a long distance southwards, present a sameness amounting to monotony. They belong to a vast series of alternating gray or purplish sandstones and deep purplish-red clays, with occasional finely concretionary pseudo-conglomeratic bands. The series forms one of the lowest sub-divisions of the great outer tertiary zone of sandstones, clays, and conglomerates, coincident and co-extensive with the southern frontage of the Himalayan mountains. It is evidently the same group of rocks as one of the lower divisions of Mr. Medlicott's sub-Himalayan series, in the Simla country, apparently corresponding to the Dagshai beds of that section; but this being still debateable, it has here been called provisionally after the station—'The Mari Group.' Its thickness is difficult to estimate owing to the contorted positions of the beds, but it must be very great; indeed, from an observation where the same rocks were locally less disturbed in Kashmir, the group may considerably exceed 5,000 feet.

To the south the Mari rocks are succeeded by very similar red clays and grayer or bluish sandstones passing upwards into soft light gray sandstones, having local strings of lignite, and alternating with rusty orange clays. The latter are succeeded by conglomerates as described in a previous paper in these Records (Vol. VI, part 3).

The strata composing that half of the Mari ridge descending towards the Ráwal Pindi plateau are either contorted or present a steep inclination towards the north-west, as though to pass beneath the limestone hills forming the opposite side of the khud in that direction. This feature is nowhere more marked than towards the south-west end of the Mari station, where it may be seen in sandstones and clays all round and over the observatory hill, the outcropping edges of other strong sandstones underlying these beds being traceable along the adjacent side of the khud to the south-east; and the same strongly marked dip being plainly visible from side to side of the ridge in the height overlooking the Lawrence Asylum and the Mari brewery. It occurs again on the road to Kashmir and in other parts of the station; but is not universal, for towards Kashmir point there are many inclinations to the westward and southward of west, chiefly on the northern side of the ridge, while over the continuation of this, towards Dewal and Kashmir, the latter and other dips in different directions indicate the contorted state of the beds. It is perhaps owing to this circumstance

* The well known Himalayan feature of the forests being confined to one aspect of hills, particularly those in which the *Paluder* tree, (*Pindrao*, or *Pinus Smithiana?*) predominates is well marked about Mari. Here the densely wooded slopes are those presented most to the northwards or north by west, the opposite or sunny side being often nearly bare of trees. The forest at Mari ends sharply at the summit of the ridge, and yet Paluder forest may be seen creeping down the south-western slopes of Chumba peak above Khairagali on the upper road to Abbottabad as if the exception were necessary to prove the rule.

and to the less steep form of the ground that this north-easterly half of the Mari ridge possesses its strongly marked red colour, the red clays having a larger surface exposure and being less liable to rapid removal by the action of rain.

The prevailing dip of the Mari rocks, towards the higher hills adjoining, is a strikingly abnormal feature in the structure of the country, and not to be relied upon in estimating the relations as to succession among the rocks of these hills. Notwithstanding this, it is a feature remarkably prevalent along hundreds of miles of the junction between the outer tertiary belt and the nearest of the other rocks of the Himalaya ranges.—It is also to be found along the foot of the Alps in a similar relative situation. (See Mr. Medlicott's report previously quoted, and his "Alps and Himalaya, a comparison,"—Jour. Geol. Soc., Lond., February 1868).

If this north-westerly dip were to be looked upon as indicating the succession, and unconnected with faulting or other complexity (see Geol. Sur. Records, Vol. VI, pt. 3, and Jour. Geol. Soc., Lond., December 1873), then it would follow that the rocks north-westward of the ridge must be newer than those of the Mari series, which is not the case.

Taking this north-westerly dip to be the prominent stratigraphic feature of the Mari ridge, associated, however, with other flexures of the beds, these will be found to bend over an anticlinal axis coinciding with the khud immediately south-east of the station, the first of a series of undulations, which becoming more open pass through all the hills to the southward on this side of the Jhilam valley.

The synclinal axes of these undulations seem to rise towards the eastward, steady low dips in the opposite direction being visible from Mari in the precipitous flanks of some of the distant hills on this side of the Jhilam, as in that supporting the plateau of Narh and others.

About Mari itself the rocks possess but little interest in detail; they contain only, so far as is known, obscure vegetable impressions; and there is not even evidence to prove whether they are of marine or freshwater origin. Close to the station, however, in the khud between it and the limestone hills opposite, about Clifden, on the connecting ridge of Kúldana and along the upper road to Abbottabad, the local geology becomes much more attractive and important, although obscure and difficult to work out owing to the crushed and fractured state of the rocks.

The lofty masses which fill the front of the mountain-landscape northwards from Mari, strike the eye at once as being of different rocks from those of the Mari ridge; their naked or, for the most part, unwooded slopes permitting the gray limestone of which they are so largely composed to appear and influence their colour. This contrast is very strongly marked where the red Dewal portion of the Mari ridge forms one side of a deep khud, from which the gray ridges and spurs rise abruptly towards the peak of Chambi and the high summit of Murchpuri (9,229 feet).

The change in the geological structure of the ground is well seen by following the new or upper military road to Abbottabad from Mari station. Proceeding along this towards Sunny Bank Hotel, the reddish and gray sandstones and purplish red clays or shales of the Mari series, with south-easterly dips, appear in the road cuttings, one thin band of grayish-olive shale occurring among the reddish rocks below Titighar, and a little débris of a greenish color near to Sunny Bank. Just at the latter place nummulitic shales and limestone are nearly horizontal in the Kúldana road, more of the limestone and red débris being seen on a spur below it. The red beds are again to be found from this to the Kúldana cross-roads, just before reaching which

Section along the Upper Abbottabad road.

Sunny Bank.

there is a small exposure of impure limestone, probably part of a lenticular mass, inclined towards the Mari hill. It contains number of small *Nummulites* little *Bivalve* shell casts, and rarely fragments of *Crustaceans*.

Kúldana cross-roads.

A few paces further, on the Kúldana side of the turn in the road, are bright purple and reddish friable clays breaking down into small splinters. Some compact earthy calcareous beds like lithographic limestone underlie these, and clays as before (except the purple parts being dark, almost to blackness) are then met with. In these latter are a few sandy bands marking stratification, vertical and highly inclined southwards. A little further, an anticlinal flexure occurs, and limestones among the red clays containing sometimes small *Nummulites* in quantities dip in the opposite direction. Certain differences in these limy bands from those left behind render it doubtful that this arch in the beds repeats those on each side. Here the rocks are for a short distance concealed by débris from the hill, some of which is cemented into calcareous breccia, and all largely consists of limestone. The next rock seen, *in situ*, is a strong 600-feet band of dark blue or black compact limestone, alternating with gray and black shales, and dipping east-south-east at 60°. This limestone has in places black filmy patches, some of the beds are lumpy, the nodules being partially enclosed by shale, and it contains small fragmentary spiral shells, fragments of *Echinoid* spines, and in some layers numerous *Nummulites*, *Rotalinæ*, or other small *Foraminiferous* organisms.

This strong limestone band crosses the Kúldana hill in a north-easterly direction, striking into the Dewal Khud, where it is lost to view, but on the other side it may be traced all along the slope of the Mari ridge, passing by Sunny Bank, Clifden, and Ghoragali, on the Ráwal Pindi road, to beyond Trét. At the last three places there is on the Mari side of it a more or less strongly developed band of gypsum, associated with red and greenish clays, close to the reddish or gray sandstones and reddish purple clays of the Mari ridge. At many places along this zone and in its neighbourhood south-easterly dips may be observed in all the rocks. The gypsum band is not seen in its place on the Kúldana road, but may be represented by a few strings and needles of this mineral in the red clays.

From the Kúldana limestone rib on to the commencement of the ascent to Khairagali, a distance of about two miles and a half, the road section exposes numerous alternations of bright red and purplish shales or clays, and limestones with strong gray sandstones, the latter predominating in the first mile; amongst these towards the end of the 3rd mile from Mari and commencement of the 4th are five exposures of gray, greenish, brownish, and olive shales, sometimes let into their places by faults, sometimes regularly interstratified with the red clays and gray sandstones, the whole dipping at high angles in a south-easterly direction. From about three and a half miles to where the road passes through a small gap, to overlook the Dewal Khud, the gray sandstones are no longer conspicuous, and many beds of limestone, generally thin and earthy, arrange themselves in three groups alternating with deep red and greenish and lavender coloured shaly clays, which are nearly vertical or slope generally as before. Some of the calcareous layers abound with *Nummulites* and some appear quite unfossiliferous.

3rd Mile.

Gap at junction of Back road.

In the gap abovementioned the same clays are found, then contorted limestones with few and obscure organisms, then alternations of limestones and shales, then again red, lavender, brownish, and purplish clays with calcareous layers, much crushed and contorted, are seen close to the foot of the incline. The most of the dips towards the end of this Kúldana portion of the section underlie towards northerly directions, particularly near the few huts at Deriágali. The whole of the road section from Kúldana, lower-Martello tower, to the foot of the Khairagalí ascent, exhibits numerous

Deriágali.

slips or dislocations of the strata, and it is difficult to say how far these may repeat the beds. The rocks at both ends of this part of the section are so much alike that repetition would seem probable, but certainly not of the whole mass, for at the northern end the bulk of the red clays and calcareous bands is very much greater than to the southward. Many of the strong gray sandstones are exactly such as occur above on the Mari hill, but there is some slight difference in the clays, which here are redder and more inclined to break down into chips like nails; however, this sandstone portion of the section, if not a repetition of some of the Mari beds, would seem to possess a character as nearly identical as any two stages of one lithological formation or group need be. The gray and olive shales have no representatives among the bulk of the Mari beds, and the whole of the Kúldana rocks seem closely allied to Mr. Medlicott's "Subathu group," but the question remains whether to limit the distinction to the Kúldana rocks only, or to include under the same name of "Subathu" the whole of the Mari series? Just along this road to Abbottabad there is nothing to prove concordance or discordance between these "Subathu" and the "Mari beds," but their complete conformity being established by other sections towards the low country, they are looked upon as stratigraphically inseparable, the only grounds for dividing them being the evidence they contain of nummulitic age, which does not, however, preclude the possibility of the Mari beds belonging to a later portion of the same period. Altogether the Mari beds seem to correspond closely with the Dagshai zone of the Subathu section.

These Kúldana rocks, too, have somewhat the aspect of a transition or intermediate group between the Mari series and the hill nummulitic beds to the north, for among them beds will be found bearing considerable similarity to the limestones and shales upon one side, and also some, as above stated, much resembling the rocks of the Mari group on the other; indeed, if the succession was regular, clear, and unbroken, such beds as these of Kúldana might well form the passage from the calcareous rocks below to the mass of arenaceous and argillaceous ones above.

Deriágali, place of abnormal contact.

Just at the foot of the Khairagali ascent, the series now described is interrupted by a line of contact, the discordance on each side of which is not there very prominent, but which is nevertheless one of the most strongly marked structural features of the geology of the whole country, including adjacent portions of Kashmir. The lower tertiary rocks to which the Kuldana series belongs are everywhere brought into junction with the 'hill limestones' such as occupy the KhairaGali slopes, by a line of junction as definite and marked by sudden discontinuity as is any known line of dislocation.*

A few yards beyond the huts at Deria Gali the purple and variegated series of Kuldana, dips at 30° to the northwards directly at a mass of crushed and broken nummulitic limestone and shale dipping in the same direction. A moment's consideration, however, will show that if this dip had occurred in otherwise undisturbed strata, a large portion of the Kuldana series ought to overlie the variegated rocks; instead of which, limestone of a different aspect occupies their place, proving the discordance just mentioned. These dark, solid, compact and lumpy limestones, interstratified with dull gray and brownish shales, broken, twisted and contorted, occupy the ascent for nearly a mile and a half beyond the huts at Deria Gali. They contain here and there ample evidence of their nummulitic age in the small *Foraminifera*, *Nummulites*, and *Rotalina* which they contain (though these at times require search to find), and the strong outcrops of the limestone band may be seen projecting from the hillside towards the Mari Khud, increasing the appearance of discordance.

* See Records Geological Survey, Vol. VI, part 3.

At the distance above-mentioned and about half-way up the Khaira Gali incline, where the road bends westward into a steep ravine, it crosses a mass of red clays and greenish gray sandstones occupying a space of about 100 yards in width, and bearing traces of much crushing and displacement. Such dips as are seen bending towards the south-east at high angles and nearly vertical. The junction with the nummulitic limestones, &c., on either side is concealed by débris, the dip of the shales and limestones to the north-west being quite discordant, while those on the opposite side, though in the same general direction, are too distant to argue conformity therefrom.

5½ miles.

This narrow band of sandstones and red clays strongly resembles, if it is not absolutely identical with, some of the Kuldana series: it may be traced from a spur close beneath KhairaGali, cutting through the limestone hills and khuds in a south-westerly direction along the flanks of the KhairaGali and Bhumkot spur to a place called Liran opposite to Clifden, where it disappears. Here, at Liran, it is overlaid by or associated with a considerable mass of stratified rock-gypsum of pinkish white colour, dipping, as the red zone generally does, in a south-easterly direction. Throughout its course it seems to be cut off by a fault from the limestones to the north-west, while its south-eastern boundary may very probably be another fault. The only fossils which have been observed are plant remains in the sandstones similar to those of the Mari and Kuldana rocks. The situation of this remarkable band apparently foreign to the local series, plunging into the lateral ravines and rising over the intervening spurs, marking a deep line of fault cutting through the limestone and shale series, bears testimony to the dislocation of the locality and may also be considered corroborative evidence of the nearly parallel line of abnormal junction between the limestones of the hills and the lower part of the outer tertiary series, coinciding with an extended region of faulted dislocation.

Beyond the place where the upper Abbottábád road crosses this red band, and thence to the crest of the spur at Bareán Gali (where there is another cluster of huts and bunnias' shops), black, compact, and lumpy nummulitic limestones and shales, varying up to several yards in thickness, may be observed. Their stratification exhibits as much forcible disturbance as before, and the prevalent dips are northerly at steep angles.

Bareán Gali.

Having here arrived at the crest of the first spur or ridge north-westwards from Mari, the situation overlooks on one side the profound Deval Khud, and on the other, deep ravines leading tributaries of the Haro river down from Chambi Peak. From a neighbouring eminence upon the ridge a view may also be obtained towards Mari, the deep khud beneath it and the col, or connecting spurs, at Ghora Gali uniting the Mari ridge with the limestone chain opposite, in the same way as the ridge and hill of Kuldana does. Down in the valley between these two connecting ridges may be seen the old road to Abbottábád descending the slopes and spurs from Mari beneath Nandkot and Clifden. This old road, like the new one, exposes a section in the cuttings, crossing the extension of the Kuldana limestone rib, and beds which ought to occupy nearly the same horizon as those immediately to the north of it at Kuldana. These beds, however, on the lower road bear only a general resemblance to the former section; red clays predominate, the sandstones differ both in quantity and kind, sometimes containing layers crowded with *Nummulites*. And the thick masses of greenish olive or gray shale of the Kuldana section are not seen. The ground seems to be much slipped and faulted; and down towards the bottom of the khud on the Mari side, this old road crosses several alternations of strong limestone and crushed red and variegated clays or shales, difficult to identify, except in a general way, with those at the northern end of the Kuldana ridge. Contortion, slippage, and local development might, however, easily account for the differences between the

Old road to Abbottábád, Clifden, &c.

two sections. The bottom of the khud, and for several hundred feet above it on the Mari side, as well as the whole of the opposite side (except at Liran previously mentioned) is of nummulitic limestone and shale, and the general dip of the section like that at Kuldana is to the south-east.

Bareán Gali.

Returning to Bareán Gali, the nummulitic limestone of the spur from KhairaGali into the Deval Khud may be seen passing downwards for hundreds of feet with a steep dip to the northwards, which, changing to vertical, turns in the side of the Masote glen so as to dip at a high angle to the southward. Far down in this glen the rocks contain nummulitic *Foraminifera*, but it is very probable that they are not all nummulitic, for southward of the continuation of the red zone cutting through this spur high up near KhairaGali, a band of hard sandstone was found, which may suggest that the limestones beneath it belong to some of the lower groups. One great inverted synclinal fold in the limestones far below this sandstone band is also visible in the side of this spur opposite to the steepest part of the ascending road from Deria Gali to Bareán Gali.

KhairaGali.

From this latter place up to KhairaGali the road runs on the western side of the crest of the ridge; the same dark, compact and lumpy nummulitic limestones and shales being seen the whole way. The beds are much contorted, but near the barracks dip generally south-westerly, and further on close to the bazaar are inclined the opposite way at 60° to 70°. Just here another narrow red band, consisting entirely of clay sloping entirely in the same direction, passes through the bazaar and down into the khud to the westward; its relations are, however, very obscure.

KhairaGali to Changli Gali.

From Khaira Gali to Changli Gali there are two roads; of these the main one ascends on the west side of Chumbi Peak, and the other, or back road, generally in a dangerous state, only passable for men, takes the eastern side. A sketch section along part of it, with remarks thereon, will be found in Dr. Waagen's paper in Geological Survey Records, Vol. 5, p. 15. Following the main road upwards rocks of different age from those previously mentioned will be found, though some of the limestones are sufficiently like the nummulitic ones to escape anything but close scrutiny, and sometimes even this leaves them doubtful. The observation has been made that the nummulitic limestones may be detected by their bituminous smell; this is frequently, though not always, the case; but a better test seems to occur in the lumpy character, seldom long absent from the nummulitic beds.

These limestones and other rocks seen at intervals along the road have been referred from their frequently obscure fossils to the triassic and jurassic formations (see Dr. Waagen's paper just mentioned).

State of the rocks.

Something of the confusion among the rocks here may be gathered from the observation that within the short distance of about two miles from KhairaGali to Changla Gali by the main road, the jurassic beds re-appear seven times, the triassic four times, and the nummulitic three times; their places of contact being for the most part lines of fault or slip, of which fourteen or fifteen have been noted. The rocks are generally inclined at high angles from north-east and south-west axial lines; but even these are themselves inclined. and in places nearly vertical; the positions of the beds affording no help towards restoring the original arrangement of the curves or the relations between the different groups.

Jurassic.

For a short distance from KhairaGali nummulitic limestones and shales occur, their north-by-westerly dip rising from about 35° to vertical, steady in the limestones, but crumpled, crushed, and contorted in the shales; just beyond the vertical beds of limestone and separated from them by a slip or fault are some black shales much overrun by débris. They are probably a portion of the Spiti shales (jurassic) coming through from the other side of the hill.

The road turns round a small shoulder of the hill here, and a few paces beyond are some shaly limestones with a five-feet band of shales, underlying about 150 feet of hard dark-coloured ferruginous sandstones, shaly in their upper part. These dip at 70° north-west, and have been referred to the "Gieumal Sandstone," Upper Jura of Dr. Stoliczka, (see Memoirs, Geological Survey, Vol. 5, pt. 1).

Trias.

The road turns sharply here to the right, entering an open khud, and the next rocks seen are black and gray, strongly and thinly-bedded, limestones with some clay or rotten shale bands. The beds are steep, vertical, and bent over a nearly vertical axis. These limestones extend about 150 yards from the sharp turn mentioned, at which distance they have a strongly oolitic texture, overlying a thin-bedded zone. They contain a few fossils of triassic aspect. Although they appear to overlie the Gieumal sandstone and a few beds of the latter, with 5 feet of black shale both inclined towards the limestone, occur immediately beyond it, the junctions seem to be on lines of fracture and the limestone does not resemble the description of the cretaceous beds resting on the Gieumal sandstone series of Dr. Stoliczka.

Along with the small exposure of this sandstone and shale just mentioned are 100 feet or so of dark-coloured vertical limestone apparently belonging to the jurassic sandstone series, for a few beds of the latter, also vertical, are next seen, and a little further on, thin-bedded, black and gray shaly limestones are also nearly vertical or dipping at a high angle, north-west, indicating an apparent alternation of limestones in the sandstone series.

Here another fault brings into the section contorted and vertical, dark gray and gray, thick and thinly-bedded limestones, seen for 250 yards. They are occasionally interstratified with shaly layers, and are at the further end of the exposure oolitic. In these beds traces of fossils are not numerous, but the rocks appear to be triassic.

Jura.

Next seen is a mass of about 80 feet of vertical solid blue gray ferruginous sandstone calcareous in places and resembling that referred to the Gieumal series. It contains traces of fossils, which, however, could neither be extracted nor made out, and it seems to be enclosed between two lines of fault.

Trias.

Beyond this the road passes through vertical or highly inclined black and gray limestones, for 200 yards. They are partly thin-bedded alternating with shales, some are oolitic, and some largely composed of fragments of shells, among which are small oysters (one *O. Haidingerii ?*), casts of a large smooth *Bivalve* and of strongly ribbed shells, apparently *Trigoniæ*, also small *Rhynchonellæ* and some *Gastropods*. These are perhaps the most typical triassic rocks of the whole section.

Apparently brought into junction with these limestones by a reverse slip or fault, is a small quantity of vertical Gieumal sandstone, with some layers of black shale.

9th Mile.

Débris overshoots the bank for a short way, and at the 9th mile post, are gray sandy micaceous shales with limestone layers probably triassic, dipping to the eastward at 65° and other angles.

A few paces onward the dip changes, coinciding with a break in the rocks, and thin-bedded gray compact limestone which weather light yellow dip at 45° north by west for 100 yards. They contain beds full of small *Oysters*, and are believed to be triassic.

A very sharp turn in the road occurs here for another hundred yards, beyond which, gray, flaggy, and thin-bedded shales are seen, bent into bold curves, weathered of a light yellowish gray colour, and overlying some gray limestone occupying an arch in the beds. No fossils were found here, so that the position of the shales is doubtful. Débris then conceals the rock for a few paces, protruding from which are some black rusty and gray pisolitic shales.

Nummulitic.

Just beyond the last named beds, nearly vertical nummulitic limestone and shales occur, the former having sometimes black filmy carbonaceous patches. These beds continue for 500 yards crossing the road with high northerly dips when not visibly curved. They contain pretty generally distributed—*Rotalinæ*, little spines, small *Nummulites*, *Corals*, and *Orbitoides ?*

Belemnites.

Near the upper end of this exposure of nummulitic limestone superficial débris occurs again, allowing, however, some thick, bedded oolitic limestone to appear, in contact with which some brownish gray shales highly inclined to the northward contain numbers of canaliculate slender *Belemnites*. From the arrangement of the rocks here, it is probable that the mass of nummulitic limestone is included between faults on each side. Close to this place, but further up the hill, are dark thin-bedded limestones succeeded by calcareous sandstone, over which is a thick mass of shales, in parts very black and concretionary, resembling the Spiti shale of Dr. Waagen's paper, except that no trace of fossils could be discovered in them. They are overlaid by a few feet of the dark rusty Gieumal sandstone, and are cut off by a fault from about 150 feet of blackish and gray flaggy impure limestone, with carbonaceous films and shaly layers, dipping to the west by north at 70°. These beds contain a group 10 to 12 feet thick, in which shale fragments are closely compacted together. They are possibly of jurassic age. The upper portion of these limestones is very earthy and flaggy, and just at a spring beside the road, they are separated by a band of very black sulphurous shale, from nummulitic limestones inclined as before at steep angles to the northward of west. At 9 feet upwards in these nummulitic beds another black shale band, about 3 feet 6 inches thick, occurs, but less pyriteous than the lower one which may mark the base of the group. Between the spring mentioned (used as watering place for the Khairagali mules) and Changligali, the shales and limestones of the hill nummulitic group only are to be seen; they present much contortion as usual, and contain in the way of fossils small *Rotalinæ* and little *Corals* of different kinds, as well as a large *Gastropod* in bad preservation.

Nummulitic.

Changligali.

From Changligali onwards by this road to Dúngágali the nummulitic rocks predominate, but there are masses of unfossiliferous limestone believed to be triassic, and in two places nearer than Darwaza-kuss, the jurassic beds of sandstone, limestone, and "Spiti shale" are seen, the largest exposure of them being for several yards on each side of the 16th mile slab at a place called Kondragali.

Here the Spiti shales contain *Ammonites* and *Inoceramus*, *Belemnites*, *Pectens*, &c., and apparently uncanaliculate *Belemnite* casts with casts of *Bivalves* (perhaps *Trigoniæ*) occur in sandy beds nearer to a Mule dâk chowki. Besides these there are distributed through the rocks hereabout obscure shells, bands of corals and beds largely made up of shell fragments in the limestones.

Dúngágali.

Nummulitic rocks recur in force for a mile south of Dúngágali, again on top of Murchpuri mountain, and all along the road from Dúngágali to Kálábág, about half a mile beyond which place, these rocks are seen almost in junction with the Attock slates, stretching from Mianjáni mountain, (the highest in this country, attaining nearly 10,000 feet) away towards the south-west.

Down in the bottom of the khud between Dúngágali and Kálábág, and also isolated at a much higher level under the last named post, there are some peculiar red beds the relations of which have not as yet been worked out. They consist of bright red and purple clays, harder red earthy beds, hard blue and red-striped sandstones, variegated greenish and blackish purple earthy beds, and a mass of liver-colored and greenish clay or shale alternating with bands of white and gray finely crystalline gypsum and limestone. They extend for more than a mile down the valley of the Haro river, and at first sight seem allied to the gypseous rocks of the Subathu group, but it is difficult to understand how these could have come into such a position except by enormous faulting. It is perhaps possible that these rocks may belong to some of those "*below the Trias*" of Sir Ban mountain near Abbottabad (see Memoirs of Geological Survey, Vol. IX, p. 335), but until a closer acquaintance with the structure of the ground has been obtained, it is hardly safe to assign them to any particular stage. Their beds exhibit at least one anticlinal curve, and if normally placed, considering the undulating character of the rocks along the Abbottabad road high above, they ought to occupy a position very far down in the series. They are evidently the rocks referred to in Dr. Verchere's paper to the Asiatic Society of Bengal, Vol. XXXV, as "Geyserian." From the foregoing descriptions and Dr. Waagen's paper, it will be seen that the Chumbi peak over Khairagali and the Abbottabad road, expose beside the nummulitic rocks two of the secondary formations. Secondary rocks are also known to occur among the long spurs or ridges from this higher region, passing northwards of Rawul Pindi; hence the conclusion may be arrived at that a central mass of these rocks exists within the Murchpuri mountains. In none of the situations mentioned however are their exposures sufficiently simple to admit of strong assertions regarding their conformity or otherwise, but it is very probable from observations made in Hazara (Memoirs, Geological Survey, Vol. IX, art. 3) that the jurassic beds discordantly overlie the triassic series, while both of these and the nummulitic beds also are most likely quite unconformable to the Attock slates.

The chief interest connected with the rocks of the whole district is the identity of some of them and their fossils with the central Himalayan series examined by Dr. Stoliczka in Spiti, &c.; also the resemblance between certain of the limestones and those of the Krol group pointed out by Mr. Medlicott, (Memoirs, Geological Survey, India, Vol. V, part 1, and Vol. III, part 2) as well as the connexion between the outer tertiary rocks here and the Sub-Himalayan series of the latter author.

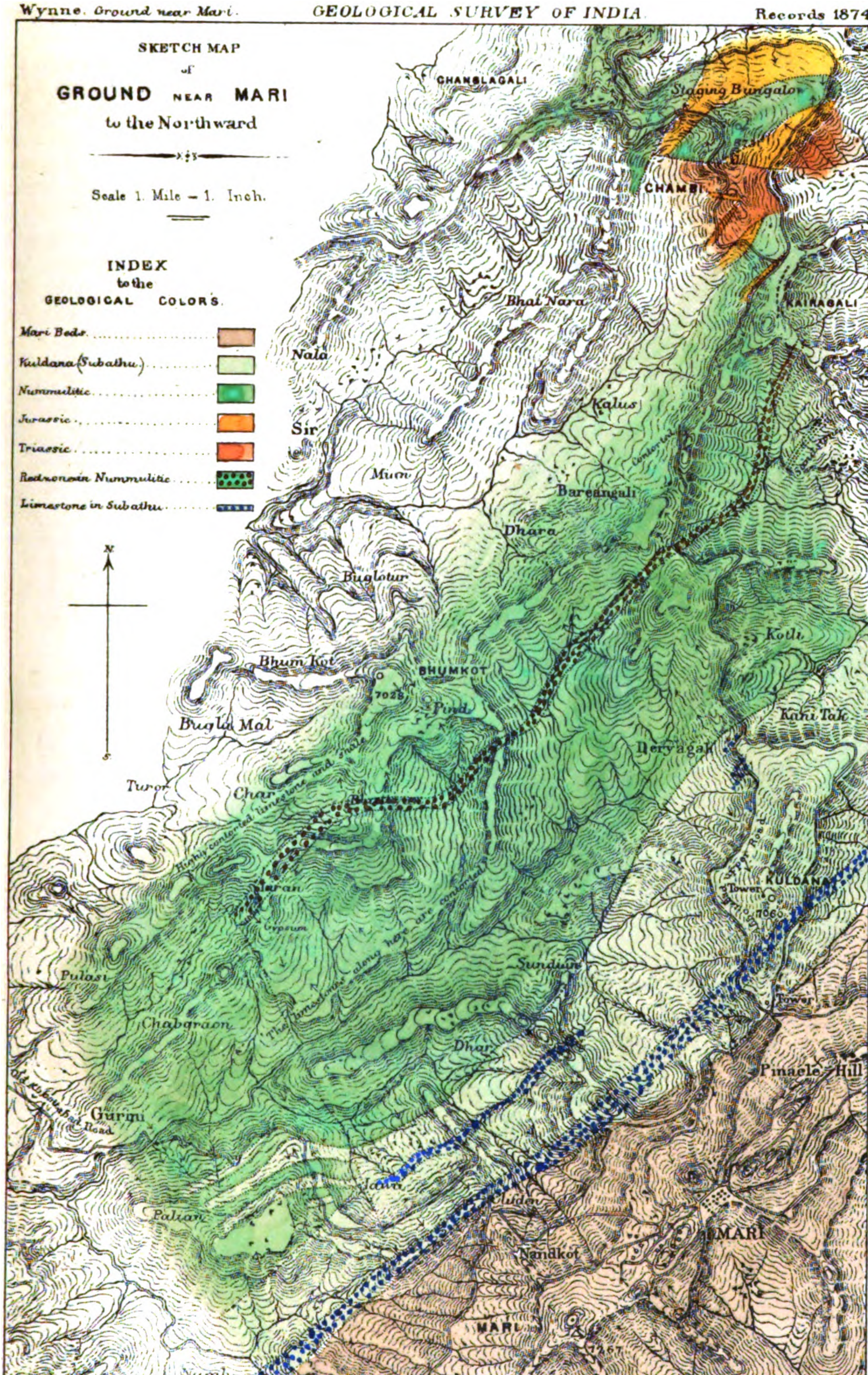
MURREE,
October 1873. } A. B. WYNNE.

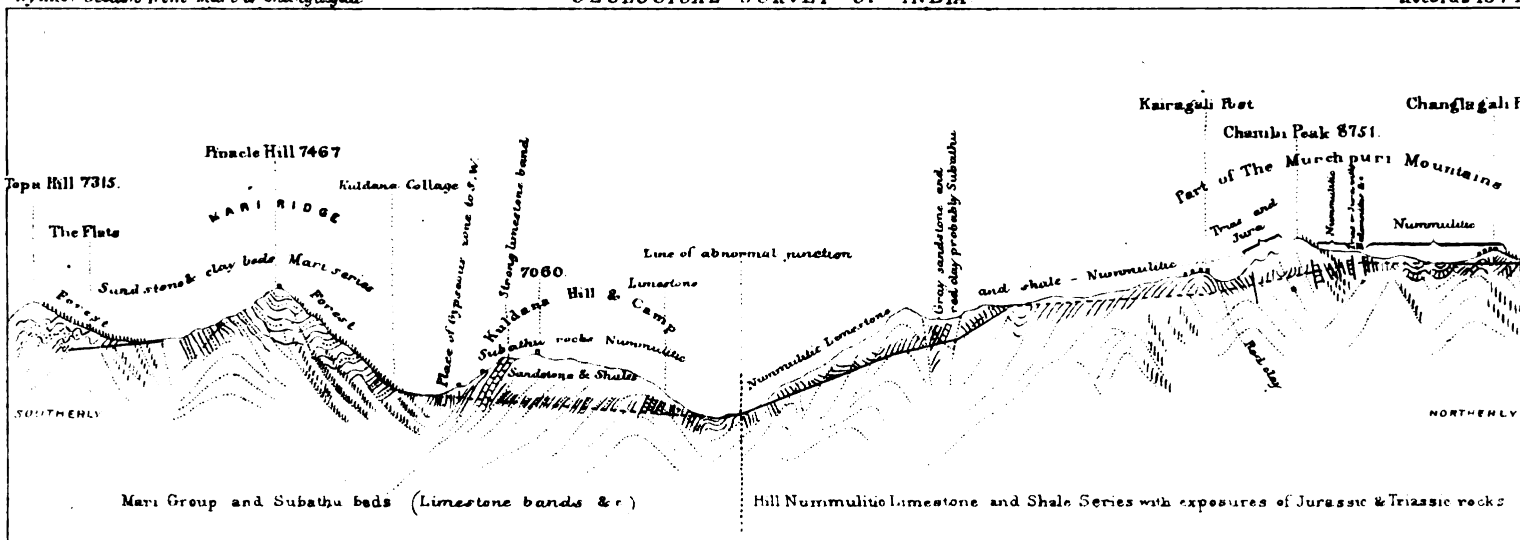
DONATIONS TO MUSEUM.

Six slabs of flexible sandstone.—COL. MCMAHON.

From the Portugese Commission at the Vienna Exhibition.

Galena	loc ?
Argentiferous galena	"
Antimony	Dist. Porto.
Tinstone	Bragancia.
Tin from ditto	"
Massive iron pyrites	San Domingo.
Natural asphalt in clay	loc ?
Lava	From one of the Colonial possessions.


SKETCH MAP
of
GROUND NEAR MARI
to the Northward
Scale 1. Mile = 1. Inch.
INDEX
to the
GEOLOGICAL COLORS.
Mari Beds
Kuldana (Subathu)
Nummulitic
Jurassic
Triassic
Nummulitic
Limestone in Subathu
N.
S.
CHANGLAGALI
Staging Bungalow
CHAMBI
Bhal Nara
KAIRAGALI
Nala
Kalus
Sir
Mura
Bareangali
Dhara
Buglotur
Kotli
Bhum Kot
BHUMKOT
7025
Pind
Bugla Mal
Kahi Tak
Deryagali
Turor
Char
KULDANA
Tower
Gypsum
Sundian
Pulasi
Tower
Chabgraon
Dhar
Pinacle Hill
Gurni
Road
Paliari
MARI
Nandkot
MARI
7257



SKETCH SECTION FROM MARI TO CHANGLAGALI

Scale of 1 Inch to a Mile horizontal exaggerated vertically.

The dotted lines show the chief khuds and spurs. The line of section is not straight but follows the high ground and the Abbottabad Military Road, shown by a hard line, broken where the road passes behind hills.

From the Australian Commission at the Vienna Exhibition.

Coal	Barnett river, Queensland.
"	Darling Downs, "
"	Victoria.
Coke	"
Chromic iron	Brisbane.
Manganese and iron-ore	Gladstone, Queensland.
Carbonate of copper, (malachite) ...	Cloncurry.
Antimony, (grey sulphuret)	loc,
Iron pyrites (mispickel)	loc?

Purchased.

Malachite	Russia.

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April 9th, 1874.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1874. [August.

GEOLOGICAL OBSERVATIONS MADE ON A VISIT TO THE CHADERKUL, THIAN SHAN RANGE, *by* DR. F. STOLICZKA, *Naturalist attached to the Yarkand Embassy.*

After a stay of nearly a month in our embassy quarters at Yangishar, near Kashgar, the diplomacy of our envoy secured us the Amir's permission for a trip to the Chaderkul, a lake situated close on the Russian frontier, about 112 miles north by west of Kashgar, among the southern branches of the Thian Shan range. Under the leadership of Colonel Gordon, we—Captain Trotter and myself—left Yangishar about noon on the last day of 1873, receiving the greeting of the new year in one of the villages of the Artush valley, some 25 miles north-west from our last quarters. On the 1st of January 1874 we marched up the Toyan river for about 20 miles to a small encampment of the Kirghiz, called Chung-terek; and following the Toyan, and passing the forts Murza-terek and Chakmák, we camped on the fifth day at Turug-at-bela, about 11 miles south of the Turug pass, beyond which, five miles further on, lies the Chaderkul. On the sixth we visited the lake, and on the day following retraced our steps, by the same route we came, towards Kashgar, which we reached on the 11th January.

Having had a shooting day at Turug-at-bela, and one day's halt with the King's obliging officers at the Chakmák fort, we were actually only nine days on the march, during which we accomplished a distance of about 224 miles. It will be readily understood, that while thus marching, there was not much time to search for favorable sections in out-of-the way places; but merely to note what was at hand on the road. I can, therefore, only introduce my geological observations as passing remarks.

Leaving the extensive löss-deposits of the valley of the Kashgar Daria, the plain rises very gradually towards a low ridge, of which I shall speak as the Artush range. It is remarkably uniform in its elevation, averaging about 400 feet, somewhat increasing in height towards the west and diminishing towards the east, which direction is its general strike. This range separates the Kashgar plain from the valley of the Artush river, which cuts through the ridge about eight miles nearly due north of the city. Viewed from this, the entire ridge appears very regularly furrowed and weather-worn on its slope, indicating the softness of the material of which it is composed. One would have, however, hardly fancied, that it merely consists of bedded clay and sand, mostly yellowish white, occasionally reddish, and sometimes with interstratified layers of greater consistency, hardened by a calcareous or siliçious cement. On the left bank, in the passage of the river through the ridge, the beds appear in dome-shape, gently dipping towards the Kashgar plain on one side, and with a considerably higher angle into the Artush valley on the other. On the right bank at the gap all the exposed beds dip southward, those on the reverse of the anticlinal having been washed away by the Artush river up to the longitudinal axis, and thus exposing almost vertical faces. These remarkably homogeneous, clayey and sandy beds may appropriately be called *Artush beds*, and although I could nowhere find a trace of a fossil in them, it seems to me very probable that they are of marine origin and of neogene age.

The southern slopes of the ridge are on their basal half entirely covered with gravel, which in places even extends to the top, assuming here a thickness of from 10 to 15 feet. Locally the gravel beds are separated from the main range by a shallow depression, forming a low ridge which runs along the base of the higher one, and from which it is, even in the distance, clearly discernible by its dark tint. The pebbles in the gravel are mostly of small size and well river-worn; they are derived to a very large extent from grey or greenish sandstones and shales, black or white limestone, more rarely of trap, basalt, and of gneiss. With the exception of the last-named rock, all the others had been met with *in situ* in the upper Toyan valley. The pieces of gneiss belong to a group of metamorphic rock which is usually called *Protogine*. It is mainly composed of quartz and white or reddish orthoclase, with a comparatively small proportion of a green chloritic substance. The white felspar variety generally contains as an accessory mineral schorl, in short, rather thick, crystals. I shall subsequently allude to the probable source from which the protogine pebbles might have been derived.

From Artush we marched, as already stated, northwards, up the Toyan river, and for the next 22 miles one was surprised to find nothing but the same Artush—and gravel—deposits, the former constantly dipping at a high angle to north by west, and the latter resting on them in slightly inclined or horizontal strata; while among the recent river deposits in the bed of the valley itself the order of things appeared reversed. The gravels, having first yielded to denudation, were here underlying the clays derived from the Artush beds, thus preparing an arable ground for the agriculturist, whenever a favorable opportunity offered itself. A few miles south of Chungterek the laminated Artush beds entirely disappeared under the gravel, which from its greater consistency assumed here the form of a rather tough, coarse conglomerate. In the bend of the river the latter have a thickness of fully 200 feet, and are eroded by lateral rivulets into remarkably regular Gothic pillars and turrets. It is rare to meet with a more perfect imitation of nature by human art. The general surface of the gravel deposits is comparatively low, from 400 to 500 feet above the level of the river, and much denuded and intersected by minor streams and old water-courses.

At a couple of miles north of Chungterek the Koktan range begins with rather abrupt limestone cliffs, rising to about 3,000 feet above the level of the Toyan. Nearly in the middle of it are situated the forts Murzaterek and Chakmák, some ten miles distant from each other. The southern portion of this range consists at its base of undulating layers of greenish or purplish shales, overlain by dark coloured, mostly black, limestone in thick and thin strata, the latter being generally earthy. The limestone occupies all the higher elevations, and, as is generally the case, greatly adds to the ruggedness of the mountains. About five miles north of Chungterek, I found in a thick bed of limestone an abundance of *Megalodus triqueter*, a large *Pinna*, a *Spiriferina* of the type of *S. Stracheyi*, blocks full of *Lithodendron* corals, and numerous sections of various small *Gastropods*. Thinner layers of the same limestone were full of fragments of *crinoid stems*, and of a branching *Ceriopora*, the rock itself bearing a strong resemblance to the typical St. Cassian beds. In this place the shales, underlying the limestone, were partly interstratified with it, in layers of from 5 to 10 feet; and from this fact it seems to me probable that they also are of triassic age, representing a lower series of the same formation.

Proceeding in a north-westerly direction, the *Megalodus*-limestones are last seen near Murzaterek. From this place the greenish shales continue for a few miles further on, much disturbed and contorted; and at last disappear under a variety of dark coloured shales, slates, and sandstones, with occasional interstratified layers of black, earthy limestone. The strike of the beds is from east by north to west by south, and the dip either very high to north or vertical. At Chakmák the river has cut a very narrow passage through these almost vertical strata, which rise precipitously to about 3,000 feet, and to the south of the fort appear to be overlain by a lighter coloured rock. It is very difficult to say what the age of these slaty beds may be, as they seem entirely unfossiliferous, and we can at present only regard them as representing, in all probability, one of the palæozoic formations.

About five miles north-west of Chakmák a sensible decrease in the height of the range takes place, and with it a change in the geological formation. The palæozoic beds, although still crossing the valley in almost vertical strata, become very much contorted; while, unconformably on them, rest reddish and white sandstones and conglomerates, regularly bedded, and dipping to north-west with a steady slope of about 40 degrees. The rocks, though evidently belonging to a comparatively recent (kainozoic) epoch, appear to be much altered by heat, some layers having been changed into a coarse grit, in which the cement has almost entirely disappeared. I have not, however, observed any kind of organic remains in them. A little distance further on they several times alternate with successive, conformably bedded, doleritic trap. The rock is either hard and compact, being an intimate, rather fine grained mixture of felspar and augite in small thin crystals, or it decomposes into masses of various greenish and purplish hues, like some of the basic greenstones.

After leaving the junction of the Suyok and Toyan (or Chakmák) rivers, and turning northwards into the valley of the latter, the panorama is really magnificent. Shades of white, red, purple and black compete with each other in distinctness and brilliancy, until the whole series of formations appears in the distance capped by a dark bedded rock.

Although, judging from the greater frequency of basaltic boulders, we already knew that this rock must be found further north, we hardly realised the pleasant sight which awaited us on the march of the 4th January, after having left our camp at Kulja, or Bokum-bashi. The doleritic beds increased step by step in thickness, and after a few miles we passed through what appears to be the centre of an extensive volcanic eruption. Along the banks of the river columnar and massive basalt was noticed several times, with occasional small heaps of slags and scoriæ, among a few outcrops of very much altered and disturbed strata of red or white sandstone, thus adding to the remarkable contrast of the scene. In front of us, and to the right, stretched in a semicircle a regular old Somma; the almost perpendicular walls rising to about 1,500 feet above the river, and clearly exposing the stratification of the basaltic flows, which were successively dipping to north-east, east, and south-east. On our left, as well as in an almost due western direction, portions of a similar Somma were visible above the sedimentary rocks, all dipping in the opposite way from those ahead of us. The cone itself has in reality entirely disappeared by subsidence, and the cavity was filled with the rubbish of the neighbouring rocks.

Passing further north we crossed a comparatively low country, studded with small rounded hills and intercepted by short ridges with easy slopes; the average height was between 12,000 and 13,000 feet. This undulating high plateau proved to be one of the head-quarters of the *Kulja* (*Ovis Polii*), chiefly on account of the very rich grass vegetation which exists here. For this the character of the soil fully accounts. The entire ground was shown to consist of limestone gravel and pebbles of rather easily decomposing rocks, mixed with the ashes and detritus, evidently derived from the proximity of the volcanic eruption. Only rarely was an isolated basaltic dyke seen, or the tertiary sandstone cropping out from under the more recent deposits.

Viewing the country from an elevated position near our camp at Turug-at-bela, the conglomerate and gravel beds, well clad with grass vegetation, were seen to stretch far away eastwards, and in a north-easterly direction across the Turug pass; while on the south they were bounded by a continuation of the somewhat higher basaltic hills. Towards the west I traced them for about seven miles, across a low pass at which a tributary of the Toyan rises in two branches; while on the other side two similar streams flow west by south to join the Suyok river. To the north the proximity of a rather precipitously rising range shut the rest of the world out of view. For this ridge the name Terek-tagh of Humboldt's map may be retained; its average height ranges between about 16,000 and 17,000 feet. In its western extension it runs almost due east-west, composed at base of a tough limestone conglomerate of younger tertiary origin, followed by white dolomitic limestone, and then by a succession of slaty and dark limestone rocks, the former occasionally showing distinct signs of metamorphism, and changing into schist. All the beds are nearly vertical or very highly inclined, dipping to north by west, the older apparently resting on the younger ones. North of Turug-at-bela the range makes a sudden bend in an almost northerly direction, and continues to the Chaderkul, where it forms the southern boundary of the lake-plateau. By this time the white dolomitic, and afterwards the slaty beds, had entirely disappeared, and with them the height has also diminished. A comparatively low and narrow branch of the range which we visited consists here entirely of dark limestone, which in single fragments is not distinguishable from the Trias limestone of the Koktan mountains, but here it does not contain any fossils. The ridge itself, after a short stretch in a north-east-by-north direction, gradually disappears under the much younger conglomeratic beds.

Across the Chaderkul plain the true Thian Shan range was visible, a regular forest of peaks seemingly of moderate and tolerably uniform elevation. The rocks all exhibited dark tints, but most of them, as well as the hills to the west of the Chaderkul, near the sources of the Arpa, were clad in snow. The lake itself was frozen, and the surrounding plain covered with a white sheet of saline efflorescence.

Brief sketch of the geological history of the hill ranges traversed.—In order that the preceding remarks may be more easily understood, I add a few words regarding the changes which appear to have taken place at the close of the kainozoic epoch within the southern offshoots of the Thian Shan which we visited.

Short as our sojourn in the mountains was, it proved to be very interesting and equally instructive. Humboldt's account of the volcanicity of the Thian Shan, chiefly taken from Chinese sources, receives great support; but we must not speculate further beyond confiding in the expectation that both meso- and kaino-zoic rocks will be found amply represented in it.

As far as our present researches in the physical aspect of the country extend, we may speak of three geologically different ranges: the *Terek range*, which is the northernmost, the *Koktan* in the middle, followed by the *Artush range*, below which begins the Kashgar plain. All three decrease in the same order in their absolute height, the last very much more so than the middle one. The first consists of old sedimentary rocks, the second of similar rocks in its southern parts, while younger tertiary and basaltic rocks occupy the northern portions, the third is entirely composed of young tertiary deposits. The general direction of all the ranges is from west to east, or nearly so; this direction evidently dating from the time when the whole of the Thian Shan chain was elevated. The undulating high plateau between the Terek and the Koktan is, near Turug-at-bela, about eight miles wide, the distance between the two ranges diminishing westward, while in the opposite direction it must soon more than double. Judging from the arrangement of the pebbles, which, as already noticed, are half derived from limestone, the direction of the old drainage must have been from west to east, and must have formed the headwaters of the Aksai river, which on the maps is recorded as rising a short distance east of the Chaderkul. Similarly, the gravel valley between the Koktan and Artush ranges indicates a west to east drainage, and its width appears to have approximately averaged 20 miles. About three miles north of Chungterek a secondary old valley exists, also extending from west to east, and is diametrically cut across by the Toyan river. In this valley, which was formerly tributary to the one lying more southward, the gravel beds accumulated to a thickness of fully 100 feet. As the Artush range did not offer a sufficiently high barrier, masses of the gravel passed locally over it or through its gaps into the Kashgar plain, which itself at that time formed a third large broad valley.

Thus, at the close of the volcanic eruptions in the hills north of Chakmák, we find three river systems all flowing eastward, and made more or less independent of each other by mountain ranges, about which it would, however, not be fair to theorize (in the present state of our knowledge) on the causes of their assumed relative position. It must have been at that time that the pebbles of protogine were brought down from some portion of the hills lying to the west; and it would be interesting to ascertain whether or not this rock is anywhere in that direction to be met with *in situ*. When the turbulent times of Vulcan's reign became exhausted and tranquillity was restored, the whole country south of the axis of the Thian Shan must have greatly subsided, and the wider the valleys have been, the more effectively was the extent of subsidence felt. To support this idea by an observation, I may notice that north of Chungterek, at the base of the Koktan range, the Artush beds have entirely disappeared in the depth, and the gravel beds overlaying them dip partially under the Trias limestone, a state of things which cannot be explained by denudation, but only by subsidence and consequent overturning of the older beds above the younger ones. A similar state of things is to be observed on the Terek range, where the young tertiary limestone conglomerate is in some places of contact overlain by the much older dolomite. Now, if the broad valley of the Kashgar plain sank first, and gradually lowest, as it in all probability did, we find a more ready explanation of the large quantities of loose gravel pouring into it and accumulating at the base of the Artush range.

The sinking in of the volcanic centre north-west of Chakmák first appears to have drained off the former head of the Aksai river, making it the head of the Toyan instead; and to the north of the Terek ridge it was most probably the cause of the origin of the Chaderkul. The subsidence of the country followed in the south, making it possible for the united Suyok and Toyan rivers to force their passage right across the Koktan range, strengthen the Artush river, cut with facility through the Artush range, and join the Kashgar-daria. While thus indicating the course of the comparatively recent geological history of the ground, it must be, however, kept in mind, that this change in the system of drainage had no essential effect upon the direction of the hill ranges. This, dating from much older times, was mainly an east-westerly one, following the strike of the rocks which compose the whole mountain system.

KASHGAR,
16*th January* 1874.

NOTE.—Since the foregoing paper was in type, the calamitous news of Dr. Stoliczka's death has been received. This opportunity is therefore taken of publishing a few last geological notes communicated in a private letter. The following is from a letter dated Kila Panj, Wakhan, 14th April 1874:—

"We crossed from Yangihissar to Sirikul in ten days; and after two days' halt at that place, crossed Pamir Khurd in twelve days. The last few marches on this side were about the worst we had. The road is very bad, and the daily snow-storms so heavy, that on one day we were not able to make more than five miles. Wakhan itself is a miserably poor country; and it is a question whether we shall be able to get enough supplies to take us back, if we do not get something sent up from Fyzabad. Our ponies will require at least twelve days to recover from the fatigue they had on the little Pamir. Whether by that time the road by Pamir Kalan will be open is very questionable.

"I ought to tell you something of the geology, but it is in very few words. There are no younger rocks the whole way than trias limestone. The Pamir Khurd proper is all gneiss and metamorphic schist. Do not imagine that the 'roof of the world' is an elevated plain; nay, it is a mere valley, well supplied with gneiss and boortsee, and from two to three miles in width. From the hills to the south, glaciers come down almost into the valley; while the hills on both sides were deeply clad in snow; so much so, that for several miles not even a few square feet of bare rock was visible. If we go back by the Pamir, I shall try to make a halt of two days before reaching Sirikul, and examine the triassic limestone. The old slates give no hope of yielding any trilobites."—EDITOR.

ON THE FORMER EXTENSION OF GLACIERS WITHIN THE KANGRA DISTRICT, *by* W. THEOBALD, *Geological Survey of India.*

Preliminary remarks.

The subject of the former extension of glaciers along the southern slopes of the Himalayan chain to far greater distances than they now reach to, might at first seem of necessity to involve, for the due treatment of so comprehensive a question, the examination of a far wider area than I am about to review in my present remarks, and this to a certain extent is true, for the phenomena in question undoubtedly form but a portion of a very grand and widely spread display of glacial conditions extended over an area which, from the insufficiency of our data, it were at present premature even to endeavour in the most general way to indicate by limits; nevertheless, as it is hardly possible for the more enduring results of long continued glacial conditions to be better studied or more characteristicly displayed than in the Kángra district, and as the subject, moreover, is one which has been rather neglected by previous writers, I conceive that a few remarks thereon, even confining myself to the limited area indicated, will not be altogether without interest and value as a basis whence future observations may be extended both in an eastern and western direction.

Moraines, the most striking no less than the most enduring of the products of glaciation, form so conspicuous a feature of the surface of so large a portion of the Kángra district, that the attention of the least observant traveller is rivetted by them, and I had hardly set foot in the district before I was questioned as to the origin of those trains of loose stones so common near the hills, and whose general aspect was so different from the ordinary accumulations of débris usually swept down by streams in such situations, and the magnitude of so many of the boulders in question rendering it obviously difficult to refer their transport to the agency of hill streams and suggesting rather the intervention of some mysterious or cataclysmal debâcle.

Medlicott in Memoirs, Geological Survey.

Mr. H. B. Medlicott, in his paper on Himalayan Geology dated January 1864 in Vol. III of the Memoirs of the Geological Survey of India, page 155, was the first to draw attention to the presence of 'erratic' blocks along the "base of the Dháoladhár" and to record their occurrence in this region "at so inconsiderable an elevation as 3,000 feet," but no attempt is made to define the precise limits within which these erratics occur, or to map their course. In fixing their lowest limit too at 3,000 feet, Mr. Medlicott has somewhat erred on what may be termed the safe side, since the fort of Kángra, which is the midst of them, is no more than 2,419 feet above the sea, while 2,000 feet may in round numbers be taken as the mean elevation of the isothermal line, coincident with the limits of the terminal moraines. The statement, too, that erratics first appear on the "east about Haurbágh" is likely to convey an erroneous impression as I shall hereafter show, since though undoubtedly there is a very sudden development, as it were, of these 'erratics' from Haurbágh westwards, yet their absence eastwards from this point, is due to denudational causes, and not to a sudden or local development of glacial phenomena continued along the flanks of the Dháoladhár range, west from Haurbágh merely, but of this more in the sequel.

Dr. Verchére. Notice of erratics and floating-ice.

Dr. Verchère, in his account of the Geology of Kashmir, the Western Himalaya, and Afghan Mountains, in the Journal of the Asiatic Society of Bengal for 1867, Vol. XXXVI, Part II, page 113, describes erratic blocks north of the Salt Range, in Latitude 33°N. and refers them to the agency of floating-ice; but there does not seem anything in his description incompatible with the idea of these blocks being the disintegrated remnants of old moraines, rather than due to the transporting powers of floating-ice; and it is, I think, rather more probable than otherwise, that they will prove to be strictly connected with the erratics of Kángra, and of cotemporary origin, during the glacial period to which my present observations refer. Speculation on this point is, however, premature, and must wait the result of observations over the intermediate area, which have yet to be recorded.

Constitution of moraines.

The task of tracing out the course of the moraines which descending from the Dháoladhár range pushed boldly across the Kángra district, is rendered unusually easy from the great contrast which exists between the rock of which the great majority of erratic and moraine blocks consist and the tertiary clays and sandstones whereon they lie. Near the boundary of the tertiary groups, the erratic blocks almost wholly consist of an easily recognised granitoidal gneiss, usually highly porphyritic, forming the central mass of the Dháoladhár range, and which rock, only towards the eastern extremity of the district, assumes a distinctly schistose or fissile habit, which proclaims its relation to the gneissose or metamorphic group of rocks, rather than to an intrusive rock or granite proper. After traversing, however, for some distance the area occupied by tertiary rocks, the moraines are found to consist, in addition to the gneiss of the Dháoladhár, of an ever increasing admixture of well rounded and water-worn boulders, from 4 inches up to 9 feet or more in girth, of the harder schistose and silicious rocks, derived from the coarse boulder conglomerates constituting the uppermost beds of the Náhun, or miocene tertiary, group through which the old glaciers ploughed their way. In proportion, too, with the decrease in number of the Dháoladhár erratics, compared with the other materials of the moraine, a diminution in size may be remarked, till eventually only an occasional small boulder, to be detected only here and there if carefully looked for, remains of the Dháoladhár gneiss, to indicate by its tell-tale presence the former extension of the glacier on which it had travelled so far; and it can therefore be readily understood how, in some cases, the actual extent of a glacier may have been greater than that assigned to it, from the difficulty, in the absence of the familiar Dháoladhár rock, of discriminating between materials properly belonging to an old moraine and the precisely similar materials where the moraine has either ceased or become wasted and enveloped in deposits due to atmospheric and fluvial agency as opposed to glacial, the more so as the moraines themselves have, since the period of their final arrest, been everywhere subjected to the energetic operation of the former forces. The actual limits, however, within which it is doubtful if glaciers formerly extended or not, from the disintegration and rounding off by subsequent atmospheric action of their terminal moraines, are extremely narrow; but the vast power of denudation in particular places, and under favorable conditions of surface, and the ability of the existing rivers to remove every trace of former moraines, is in many places well illustrated in the area under review.

Power of denudation to obliterate moraines regulated by conditions of surface.

From general considerations there can be little or no doubt, that the valley of the Biás afforded passage to a noble glacier, to a point at least as low down as Nadáon, which would give a course of 120 miles in length from the snow-fields at the sources of the river; but the present main channel of the river has since that period been so deeply and sharply excavated that not a trace (or such at least as a cursory examination would enable one to detect) exists of a moraine, such as we know must have resulted from and marked the course of so extensive a glacier. At Sujánpúr the moraine of the Sujánpúr glacier is seen pushed right across the present channel of the Biás, at a much higher level than that of the present stream, which has made a clean and deep cut through it; yet, though the erratic blocks scattered round the Traveller's Bungalow at Sujánpur, and all over the truncated end of the moraine on the opposite side of the river, are of a large size, not a trace of one can be seen in the river bed beneath. This fact conclusively shows the power of the existing rivers (where from their narrowed channel, as at Sujánpúr, their effective force is largely increased) to utterly remove all traces of such deposits as these old moraines even where they contain massive boulders of 12 feet in girth and upwards; or what is rather more likely than any actual transport of such blocks is, that when once fairly sucked into the waterway, they are pounded to pieces by the incessant impact against them of the hard silicious boulders driven forcibly against them during floods. No one who has listened to the ceaseless thunder and muffled rattle of a swollen Himalayan stream can doubt the full power of such an agent to effect in time the above result.

Sujánpúr (glacier). Moraine breached by the Biás.

Again, between Mandi and the bridge over the Biás, below that town, undoubted traces are met with of the old trunk moraine of the Biás valley, where the present valley is rather open; but just above and for a long way below the bridge, the river gorge is swept perfectly clean, as with a besom, of all traces of a moraine, such as may be noticed a little higher up; and this would seem to be generally the case where the valley narrows, or is unusually precipitous, either in the main channel of the Biás, or in the channels of its tributaries, the power of moraines to withstand the erosive action of rain and rivers depending far more on the physical character of the gorges they occupy, and the slopes whereon they repose, than on either their bulk and dimensions or the magnitude and character of the materials of which they are composed.

Trunk glacier of Biás.

The Ul (Ool) river which enters the Biás above Mandi takes its rise in the continuation of that line of snowy peaks whence the glaciers of the Kángra district descended, and no one who has examined the district, or has a tolerable map to consult, can entertain the shadow of a doubt that an enormous glacier must have once traversed the valley of the Ul, debouching into the Biás valley and uniting with the great trunk glacier of that river above Mandi. But no trace of any moraine could be detected in that portion of the Ul valley near Jatingri

Valley of the Ul.

Absence on it of moraines, due to its physical configuration.

examined by me, and a perfectly adequate explanation of this circumstance is, I think afforded by the very steep character of the hill sides bounding the valley. The Ûl valley is not only very straight, but remarkably steep, the sides in many places forming an angle of not less than 60,° so that any one who will reflect what sort of a slope in nature an angle of 60° represents, will easily understand how impossible it would be for such incoherent materials, as moraines are made of, to effect a lodgment in such a situation, and resist for ages the combined effects of floods in summer and avalanches or snow slips in spring, to sweep them *en masse* into the yawning gulph below.

Map of the district and enumeration of glaciers.

A reference to the accompanying map will give a clearer idea of the general course, arrangement and relations to each other of the glaciers which formerly traversed the Kángra district, than any mere verbal description; but neither the scale of the map nor the time I was enabled to devote to the subject suffice for any attempt at details as regards the various subordinate features and minor surface changes referable to the glacial period in question, though the sketch embraces all the essential points of the case.

Between Mandi on the east and Nurpúr on the west (being the area to which my remarks are mainly confined) seven principal glaciers descended into the valley of the Biás, which was then of course filled by a superb trunk glacier to which the above served as lateral feeders, and which taken in order from east to west may be thus described.

1.—The Dailu Glacier.

The Dailu glacier.

The most easterly feeders of this glacier passed down through the village and thannah of Haurbágh in Mandi, and after being joined by several equally large or larger glaciers from either side of the village of Dailu, the united glacier descended the narrow valley of the Rána river, which joins the Biás ten and half miles below Mandi. The most westerly feeder of this glacier was formed by the bifurcation of a huge glacier, which descending nearly opposite the village of Aiju, there split into two streams, one of which descended the Rána valley, whilst the other assumed an opposite course, and formed the most easterly feeder of the next glacier.

2.—The Baijnáth Glacier.

The Baijnáth glacier.

This glacier was formed by the union of several large glaciers, which united below Baijnáth and pursued a course down the valley of the Bimm river, which joins the Biás nearly midway between the mouth of the Rána above and the large town of Sujánpúr below. The most easterly branch of this glacier has been noticed above, as coming from near the village of Aiju, whilst the most westerly branch was similarly formed by the bifurcation of a vast glacier, which passing down a little to the east of the village of Banuri (Bunooree) was split into two streams against the cuneiform mass of hills some three miles south of that village.

3.—The Banuri (Bunooree) Glacier.

The Banuri glacier.

This glacier is the smallest, as far as the area covered by it, of any under notice, and might be regarded almost as a satellite of the next, with which it was probably intimately connected, but as some of its moraines reach the Biás by a separate course it is enumerated with the rest. It consisted mainly of the westerly feeders of the glacier above described as bifurcating south of Banuri, with some obscurely defined contributories, still more to the west, and joined the Biás some few miles above Sujánpúr.

4.—The Sujánpúr Glacier.

The Sujánpúr glacier.

This very large glacier was composed of several parallel and inosculating streams, all running with a comparatively straight course past Burwárneh to the Biás at Sujánpúr, the main stream having evidently descended along the course of the Negál river.

5.—The Haripúr Glacier.

The Haripúr glacier.

This was the largest and most interesting glacier under notice. The most easterly feeders of it passed close under Dhár bungalow past Puthiár, and thence with a grand curve south of Nagroteh; whilst the most westerly feeders descended close to Bághsu cantonments. Between these limits a number of glaciers descended from the lofty Dháoladhár range, pierced the outer range of schistose rocks, and coalescing below Kángra into one mighty stream ploughed their resistless way through the tortuous gorge of the Ban Ganga, past Haripúr, and through the village of Godeir (below which large erratics are scarce) as far as the village of Ghuriál (Ghooryal) or perhaps even farther.

6.—The Guj Glacier.

The Guj glacier.

This glacier might be appropriately named after the village of Nagroteh, near which it debouches into the plains, but as there is a better known village of that name, mentioned above, east of Kángra, it will obviate confusion if the name of the river down which it passed is substituted. The most easterly feeders of this glacier descended a little west of Bághsu, the most westerly ones, a little west of Rihlu (Rihloo).

7.—The Jawáli (Juwalee) Glacier.

The Jawáli glacier.

This glacier, the most westerly one in the Kángra district, was composed of two main branches, one from the east, flowing under Tiloknáth, whilst the other passed down close under Kotleh, below which place the two united, flowing from nearly opposite directions, and together passed down the gorge of the Darh river, debouching into the plains at Jawáli. Below Jawáli the moraine of this glacier, mainly, perhaps, through the action of subsequent atmospheric forces, spreads out into a fan-shaped talus (and the same is more or less observable in the case of the Guj glacier also), so that its precise termination is not clearly marked, but it not improbably extended to the Biás either independently or after uniting with the last.

Existing glaciers of this region.

In speaking of the glaciers enumerated above I have used the past tense, as I am uncertain if at the present day even so much as a permanent remnant remains of some of them; though to the eastward of the region they originate in, towards the head of the Ul valley, snow-fields and glaciers are represented on the map. Whether or not shrunken remnants of any of them still remain pent within the deeper vallies among the peaks of the Dháoladhár range, is of little moment, since the precise course pursued by them is no less plainly marked by the Cyclopean trains of boulders they have left behind them, than if they were still present to our eyes on their original proportions.

Moraines in Kángra.

The moraines within the Kángra district present everywhere such similar features that a description of one of them will *mutatis mutandis* stand for all the rest, the differences between them being confined to their relative size, and the secondary characters impressed on them by atmospheric action, and the extent to which they have been cut into and abraded by existing streams. Descending from the central peaks of the Dháoladhár range, in the form of sinuous streams of boulders, rugged, angular, and massive, many of which attain over 50 feet in their greatest diameter, they traverse by narrow gorges the range of hills composed of schistose rocks, intervening between the Dháoladhár range and the plains of the Kángra district, on reaching which they expand, inosculating and coalescing in the open ground to such an extent as to cover the greater portion not occupied and defended against invasion by hills. In fact so complete was the union of these glaciers that the whole of the area shown in the map to have been traversed by them must have presented the appearance of one huge ice-field, if we can rely on the evidence of the perfect mantle of moraine material which now covers the ground.

Former appearance of Kángra district.

The size of some of the gneiss blocks which have travelled well out into the plains is surprising, till the mind fully realises the quasi-omnipotent power of the agency involved in their transport. Near Busnur south of Rihlu, I measured one block embedded in a field by the roadside, 125 feet in girth, and in this and other cases the present dimensions are probably much under the original size of the block, from the desquamation of the surface under the action of frost, sun, and rain, and in some situations by the friction of stones swept against them by streams. Again, between Bághsu and Dárh, four blocks in the immediate neighbourhood of the road measured in girth, respectively, 100, 125, 134, and 140 feet. Blocks of this size occur, of course, but seldom, but those from 70 to 100 feet somewhat more commonly, whilst blocks approaching 50 feet in girth are too numerous to reckon. So great is the abundance of the rocky fragments brought down by these glaciers, that the entire country just outside the narrow schistose range, which skirts the district to the north, is so covered with them as to leave no other rock visible; and but for the fact that none of these blocks can be seen *in situ*, and for the section occasionally revealed in a deeply cut river bed, the casual traveller might very naturally consider the whole area he was traversing to be granite or gneiss.

Size of erratics.

The process by which this condition has been brought about is a very simple one, but at the same time bears striking proof of the magnitude of the forces at work, and the duration of the period during which they were displayed. On quitting the narrow gorges in the hills wherein they had hitherto remained forcibly pent up between rocky walls, the glaciers at once expanded, partly through the natural tendency of a piled up mass, possessing the known plastic character of glacier ice, to spread out on a level surface, under the simple operation of gravity, and partly to the lateral displacement which later glacial accessions descending such gorges would receive from the accumulated moraines of earlier years, heaped up in their direct path, either during periodical meltings or during the secular retrocession, probably not a continuously uniform process, of the isothermal line of the terminal moraines of the whole group of glaciers in question. Exception will doubtless be taken by some to the idea of expansion through plasticity having had any appreciable influence in producing any lateral diversion of the moraine when they enter the plains, and I am prepared to admit the subordinate operation of this cause to the second one I have mentioned, but that it was a *vera causa* to a certain extent will, I think, be admitted, if due weight is given to the probable dimensions vertically of the glaciers in question. If, as has been conclusively established, a *shallow* glacier can quadruple its thickness when compressed between narrow limits, it cannot be theoretically denied the power of reassuming a shallower, that is, a more *expanded* form, when, on issuing from the hills, it becomes relieved from all pressure having a tendency to counteract the ordinary effects of gravity on a plastic body, heavily weighted by the pressure of the enormous moraines supported by it, which can hardly be so insignificant as with time to produce no appreciable result. Thirty or 40 feet is no uncommon thickness for one of these Kángra moraines, and I greatly doubt if in some cases a hundred feet

Fan-shaped expansion of glaciers on quitting the hills.

would not be an under estimate. If then we make allowance for the intermingled ice and snow, which must have cemented this prodigious mass together, we shall not greatly err if we calculate the pressure it must have exerted on the glacier, whereon it rested as equal to a stratum of solid granite of one-half that thickness, a force amply sufficient, when applied to such a thick stratum of plastic* glacier ice, as we must suppose to have been associated with such giant moraines, to have produced a very sensible lateral expansion of the ice river, initiative, if no more, of that expansion or lateral deviation, a tendency to which all the moraines, more or less, at present display on debouching from the hills.

Deviation of glaciers.

That later glaciers have thrust past earlier ones, and intersected their moraines, seems scarcely to admit of a doubt, thereby producing an irregularity and confusion in the arrangment of the erratics and materials of moraines spread over the country, at first suggestive of the less regular or sporadic agency of floating-ice rather than of glaciers, whose frequent inosculation has been the real cause of the irregularity in the network of resulting moraines.

Kángra to Bághsu.

Along the course of the road from Kángra to Bághsu numerous illustrations of the conditions sketched above present themselves. Long lines of moraines are seen to stop abruptly and sink out of sight beneath the soil; sometimes indicative of the arrest, either temporary or final, of the parent glacier, at others of the disruption and truncation of a moraine by a glacier of later date pursuing a nearly coincident course. Near Bogli, after passing the temple and tank of Gangabarabi, the road skirts a low ridge, with a well-marked moraine on the right—a long string of erratics, whose course is sharply defined; but on turning the end of the ridge, and looking towards the village of Ich-hi, the country is seen freely overspread with blocks in which no regular order can be made out.

Floating-ice—no conclusive evidence of.

The suggestion of Mr. Medlicott, as to the possible intervention of the agency of floating-ice, in distributing erratics in Kángra, here occurred to me, but I was eventually led to reject the idea, from the fact that, as far as my observation goes, these erratics never ascend beyond a certain relative height, which being no greater than that within which the traces of glaciers are found, goes far to disprove the intervention of any other agency for the distribution of the blocks in question. It is of course obvious that floating-ice and glaciers could not have cotemporaneously occurred over the same area, and the fact that no erratic blocks are known in Kángra, beyond the general limits attained by glaciers as fixed by their continuous moraines, is hence almost conclusive disproof of the agency of floating-ice within the district. The erratic blocks are so marked in character that they could scarcely escape detection, if they occurred beyond the limits above assigned to them, and this, for a negative argument, must be allowed unusual weight. If then the above conclusion is correct, the more perfect and lineal moraines are the youngest, and (trivial atmospheric denudation apart) exhibit the precise appearance they did on the waning of the glacial conditions in which they originated, whilst the more scattered and dissociated blocks must be regarded as the fragmentary remnants of more ancient moraines, whose continuity has been long since destroyed by surface changes wrought by the altered course and direction of glaciers of a later period.

Disproof of its former existence in Kángra.

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* Prof. Tyndall very justly combats the idea of ice being regarded as a 'viscous' body, properly so-called, and would seem to touch the root of the matter, by limiting this so-called viscous quality of ice to a capacity of yielding to *pressure*, not *tension*. With this cardinal fact established, it is unfortunate that the term 'plastic' was not always used in place of 'viscous,' as the essential idea of adhesiveness involved in the word 'viscid' or 'viscous,' in addition to the mere property of 'plasticity,' was not really necessary to the theories of hose who used the term.

All the Kángra moraines have a very arched or 'hog-backed' outline, and are always separated by a more or less strongly marked valley or ravine from the hills round which they pass. In the case of the larger moraines, the resulting effect on the landscape is rather curious: hills viewed across one of these moraines have a peculiar sunken or 'hull-down' appearance, from the crest of the moraine intercepting all view of their base, as the marine horizon does of a vessel's hull at a certain distance, and trees and villages situated on the opposite slope of one of these moraines from the observer are from the extreme curvature of its surface similarly concealed from view.

Another feature of the surface, occasionally very prominently displayed, is the rapid slope of a moraine across the valley wherein it debouches. This is well seen in the moraine west of Dailu bungalow, in the rapid slope of that portion which passes from Aiju down the course of the Rána river. The river running past the village of Dailu brings down no erratics above that village, but Dailu itself stands on the verge of an easterly branch of the same glacier which joins it lower down.

Physical features in Kángra resulting from glacial conditions.

I will now describe certain physical peculiarities of surface in the Kángra district directly connected with the glacial conditions which formerly prevailed there.

The Kángra district may be ideally divided into three vertical areas or zones.

1st, preglacial area.

Firstly, a preglacial area embracing the whole country which contributed, from peak to plain, towards the genesis and development of the glaciers under consideration; speaking roughly and without any measured data to check the estimate, the above zone or area embraces all ground higher than from 250 to 300 feet above the mean level of the present streams.

2nd, glacial area, proper.

Secondly, a glacial area, proper, embracing the entire area either occupied or excavated by the glaciers, which may be approximately fixed as commencing at the bottom of the above division and terminating below at a level of about 150 feet more or less above the mean level of the present streams.

3rd, postglacial area.

Thirdly, a postglacial area embracing the whole of the ground below the basal limit of the last division, and the rësult of aërial denudation subsequent to the cessation of glacial conditions.

The first division calls for little remark save that it is the area within which we should most naturally expect to meet with erratics, deposited from floating-ice anteriorly to the formation of the moraines of the lower ground, had any such agency been in operation; but I am unacquainted with any such, and therefore, no less than from the physical difficulties such a supposition would involve, have rejected it for the simpler one of glaciers, whose former prodigious development is so stamped on the country. By floating-ice, I of course understand ice floating at or near the sea level, since the assumption of floating-ice in some elevated inland sea, of sufficient height to bring its waters within reach, or nearly so, of the ordinary glacial isothermal of its latitude, is perfectly unwarranted by evidence, certainly at least in the Kángra district; the only fine clayey deposit, the result of a tranquil mode of deposition, which could possibly be referred to such conditions, being a red clay of clearly postglacial age, which in some parts attains considerable development, and which may be referred to a postglacial period of lacustrine deposition coincident with a general subsidence of the whole Himalayan region and the gradual approximation of the general climate to that which at present obtains. This red clay covered at one time enormous areas in Kángra, and may not improbably mark a period of true lake formation, when along the southern slopes of the Himalaya lakes existed more extensively than existing indications would lead us to suppose; but denudation has to a large extent removed all traces of this finer deposit, though still to be found here and there if sought for, as, for example, south of Nadáon and between Jawáli and Nurpúr.

The second division is emphatically the area of glacial display, and to it are restricted all the moraines and erratics, which are approximately in the position where they became fixed on the waning of glacial conditions, and nowhere can the relations of this to the other divisions be better seen than near the town of Kángra.

Kángra.

Approaching Kángra by the Jullunder road after passing the village of Dowlutpúr, the road commences the ascent of a steep ridge of hills at first composed of pebbly sandstones with a little red shale, which soon give place to thick beds of very coarse conglomerate, which throughout Kángra constitute the highest sub-division of the Nahun group of tertiaries, of presumedly miocene age. The crest of the ridge is pierced by a tunnel, shortly after passing through which, and commencing the descent towards Kángra, a fine view is obtained of the celebrated fort of that name, perched on a cliff, overhanging the boiling river below, the cliff as well as some scarped heights beyond and above the fort consisting of the same coarse boulder conglomerates as those constituting the ridge over which the road is carried. When about half way down the road or rather more, a few large boulders of 'Dháoladhár' gneiss may be detected lying about, or wedged into clefts and gullies worn by surface water in the coarse conglomerate, and into which situation they have rolled from above, as these gneiss boulders in question are not weathered out of the conglomerate, but are the familiar erratics from the Dháoladhár moraines. Continuing to descend, these boulders increase in number, till the stream (a branch of the Ban Ganga) is reached, when its bed is seen to be filled, and I may almost say, blocked, with enormous masses of the Dháoladhár gneiss, contrasting curiously in the eyes of a geologist with the beds of boulder conglomerates wherein the river gorge is excavated and wherein they are wholly wanting.

Contrast between gneiss boulders in stream and banks of conglomerate.

I should not omit to notice in this portion of the road opposite Kángra, the occurrence on the road side of a large boulder of red quartzitic sandstone, of nearly 15 feet in girth. This boulder is undoubtedly an erratic, but derived from the coarsest upper beds of the conglomerates so largely here developed, but which have nearly everywhere suffered so from denudation, that little, save huge boulders strewed about, indicates their former presence. This particular boulder is interesting from being the largest from these beds I have anywhere measured, and for a true water-worn * and rolled boulder it may be considered immense, the second to it in size being, however, close on 12 feet.

Immense boulder from the Nahun conglomerates.

Where the road crosses the stream the valley is narrow, but higher up it opens out more, and is seen terraced on different heights, most of such ground being under cultivation. Just below the fort stands the soldiers' church, and it would seem to mark nearly the lowest limit or level of glacial erosion proper, that is, the level of the bed of the old glaciers, or, perhaps, a trifle below it. The post office, on a slightly higher level, seems well within the vertical zone or valley of glacier erosion, and the mean between these two points may be taken as the approximate mean level hereabout of the base of the old glaciers. Passing on to the dâk bungalow scattered erratics are seen on the steep sides of the valley, becoming scarcer as we ascend

Level of the base of the glaciers about Kángra.

* This term of course applies to its original formation as a water-worn boulder in a coarse boulder conglomerate, not to its last vehicle of transport which I take to be 'glacial.'

to the immediate vicinity of the bungalow. Still, however, the dâk bungalow, or rather perhaps the still higher Mission church, may be regarded as marking the highest level of glacier action; and to the action at a very early epoch of a glacier descending the course of what is now a deep valley beneath the dâk bungalow to the north, I am inclined to refer the flat truncated outline of a hill which confronts the dâk bungalow at a nearly similar elevation in that direction.

The difficulty of always satisfactorily determining the upper limits to which glaciers have reached arises from the paucity of moraine débris, and erratics in such situations, especially where the ground has been steeply carved out as near Kángra; whilst the precise lower limits of glacier erosion are not uncommonly obscured by the subsidence in mass of the moraine, *pari passu* with the subsequent fluviatile and non-glacier erosion which has latterly supervened.

The third division, of postglacier erosion, calls for brief remark. Its area is freely covered by moraine débris and erratics, which, in the case of the large fragments, have simply subsided *pari passu* with that denudation which has removed the base whereon they rested. A very neat illustration of this process is seen in the bed of the stream beneath the road near the dâk bungalow. The river takes a sharp bend round a sort of promontory sharply cut out of the old plateau in which the present river has excavated its bed, and above which the old glaciers passed at a higher level. The true character of the linear trains of boulders here seen, and the fact that they are moraines subsided *in situ*, are clearly shown. These lines of boulders evidently stretched down, quite irrespective of the present river, over ground, now represented merely by the narrow spit left by the river. On this spit the boulders are seen to rest, and if it might be possible for the stream to have imparted the linear arrangement to these trains of huge boulders, it is obviously beyond the power of water to have washed them up against the face of the spit in the manner in which they occur.

Dr. Falconer on the absence of lakes south of the Himalayas.

A few words may not here be out of place touching the views held by Dr. Falconer on the causes which have acted towards the conservation of lakes in the Alps, and the probable reason of the non-existence of any lakes of similar magnitude along the vastly more colossal Himalayan range, where their presence might not unnaturally be looked for on a scale of even greater magnitude than in the neighbourhood of the Alps; since the glacial phenomena previously described by me go far to invalidate the conclusions which Dr. Falconer, in ignorance of the former existence of the phenomena in question, was led to draw. Dr. Falconer, writing on this subject, regards the Alpine lakes (Falc. Palæont. Memoirs, Vol. II, page 651) as great fissures with rivers running into them, which originated in the process of elevation of the whole chain. Precisely similar results in his opinion followed the elevation of the Himalayas, but in the Alps a glacial period supervened, which filling these 'fissures' or lake basins with ice, prevented their being choked up with detritus, as would have happened under milder climatal conditions. For India, on the other hand, "these lake basins were gradually silted up by enormous boulders and alluvium of every kind," since in these "tropical regions the ice never descended from the highest summits down into the plains."

Views of Dr. Falconer untenable.

Now, the condition of the Kángra district clearly renders the above view of Dr. Falconer untenable, since it is abundantly clear that glaciers descended well into that outer region, wherein we might expect lakes to occur, and it is clear that no material difference existed between the Himalayas and the Alps, *quoad* climate and the former prevalence of glacial conditions over both areas. Whether at any period lakes existed within the Himalayan area, comparable with those bordering the Alps, may be allowed to remain an open question, which, I am not disinclined to think, will hereafter be answered affirmatively; but whether they once existed or no, we have in the excessive erosion of the river channels traversing the drainage basins, wherein any such lakes must have stood, a cause fully adequate to account for their subsequent disappearance. In the open ground of the Kángra district I have estimated the amount of erosion of the river beds since the termination of the glacial period as upwards of 100 feet, and there seems to me no fixed limit which we are called on to assign in the case of those larger rivers which descend from the main Himalayan chain, so that even had large lakes occupied positions along the main river vallies subsequent to the glacial period in question, we can still understand, from what is seen in the Kángra district, how such lakes may have emptied by the ordinary operation of those forces which are now and ever have been perpetually at work deepening every Himalayan gorge. I content myself, however, with throwing out the hint, as the subject is too large a one to be discussed in a paper like the present.

Period of glacial conditions in Kángra.

It remains only to add a few words on the period during which glacial conditions prevailed in Kángra, and this is capable of being fixed with tolerable exactness with regard to the tertiary deposits of the region.

'Nahun group.'

The great bulk of the tertiary deposits of the Kángra district belongs to the 'Nahun' division of Mr. Medlicott, approximating in age to the miocene of European geology. This group contains in addition to numerous Pachyderms and Ruminants (a correct and discriminative list of which is a most urgent desideratum), the remarkable Chelonian *Colossochelys Atlas*, Fal.. This group of an enormous, but unascertained thickness, not less certainly than 10,000 feet, was tilted up and involved in the great disturbance its beds display, and moulded to the main orographical features of the district prior to the development of the glacial conditions in question.

Sivalik group.

The Nahun group is followed by a series of deposits of very inferior thickness, but not less rich in remains of a varied fauna. Within the Kángra district no direct evidence exists, from contact, of the relative age of the glacier deposits and the Sivalik group; but the evidence afforded by the fauna of that group is wholly in favor of its being postglacial, and of the fauna being associated with conditions of climate analogous to those now existing. Without entering into greater detail, it is sufficient to mention in support of this view the occurrence of two living crocodiles in the Sivalik beds, and several species of land and fresh-water shells still living, and the same association of extinct types with the precursors of numerous species of living mammalia, as is seen in the pliocene deposits of the Narbada valley.

Glacial phenomena east of Kángra.

With regard to the occurrence of glacial phenomena along the Sub-Himalayan region east of the Kángra district, I think that future observations specially directed to the subject will reveal an unexpected amount of evidence, which, if not so obvious, will be found no less conclusive than that displayed in Kángra. The scope of my own observations only permits my saying that remnants of moraines occur in the Sutlej valley as low down as Bilaspúr, and erratic blocks, not now directly connected with any moraine, but probably transported to their present position by a prodigious trunk glacier which descended the Sutlej valley without much reference to its present configuration, as low down as the mouth of the Gumber river and probably lower. The blocks I refer to a moraine at Bilaspúr consist of the harsh Krol limestone forming the ridge which near that town is cleft by the valley or gorge of the Ullay river, down which a glacier passed into the trough of the Sutlej. Anything, however, like a connected moraine of this Sutlej glacier no longer remains; but to its disintegration and removal is no doubt largely due the enormous sheets of recent con-

Moraines at Bilaspúr.

Erratics in the Gumber.

glomerate, which literally choke the Sutlej valley, and which may be well seen, among other spots, at Dihur (at the ferry on the Mandi and Biláspur road), at Biláspur, and at Bubhor, where the Sutlej debouches into the Una dún.

Section of the Sutlej above Dihur.

Approaching the Sutlej from the direction of Mandi, when a little better than a mile from the ferry, the whole of the high ground behind the village of Kángra is found sheeted over with beds of sandy gravel evidently the upper beds of a thick deposit of either fluviatile or lacustrine origin, mantling round the hills of harsh Krol limestone bounding the valley, which to a great extent it must have originally filled. On descending towards the river these sandy beds give place to coarse gravels, which still lower down pass into the coarsest boulder shingle, mainly composed of a heterogeneous mixture of Himalayan rocks, among which the Krol limestone of the neighbouring hills is a prominent ingredient. Among the rest, scattered boulders of the porphyritic gniess of the Dháoladhár are seen, from their size of unquestionable glacier origin, and these may be traced as low as Dihur, of various dimensions up to 8 or 10 feet in girth, associated with numbers of boulders of nearly the same size of the hardest schistose and trappean rocks, from the region of the inner hills, and all at one time probably transported to the vicinity by glacier agency.

Erratics at Biláspur.

At Biláspur in the bed of the river beneath the Rajah's Garden, I remarked erratic blocks of hard schistose rocks from 12 to 15 feet in girth, but to what precise distance down below the Gumber mouth these can be traced I cannot say.

Reflections.

But what a vision of the past is not here raised by these simple boulders lying neglected in the river bank or used for the ignoble purpose of cleansing the clothes of man's emmet-like race. As there can be little doubt that the glacial conditions to which these blocks testify, were induced mainly by the simple elevation of the whole Himalayan area, so there can be equally little doubt that such elevation was effected without materially affecting the grander orographical features of the country, and hence it comes that we must picture to ourselves as the agent employed in their transport a mighty trunk glacier, debouching somewhere above Bubhor, after a course of some 350 miles, a spectacle unmatched for grandeur at the present day in the loftiest regions of either hemisphere.

Without pursuing farther all the arguments which might be adduced, it will suffice here to summarise the conclusions which may be drawn from the glacial phenomena of the Kángra district—

1st.—That prior to the deposition of the Sivalik group, the whole Himalayan area stood at an elevation not less than 12,000 feet and perhaps 15,000 feet, higher than at present.

2nd.—That in consequence of this superior elevation, the whole of the Sub-Himalayan region north of the Duns (which had then no existence) exceeding 1,500 feet elevation, was subject to the incursion of glaciers, which from the magnitude of the drainage area whence they descended were of the most colossal proportions.

3rd.—That the Sivalik period was marked by a subsidence of the whole Himalayan area, a corresponding retrocession of glacial conditions, and a return, during the reign of the Sivalik fauna, to conditions not very dissimilar to those now obtaining in the region.

NOTE.—There are many features in Mr. Theobald's paper very tempting for the critic; but they must be left to the intelligence of the readers. One omission he has made is fairly open to editorial comment; the more so, as it affords a most instructive illustration of what threatens to become a very serious stumbling-block in geology, involving, as it does, the ignoring, abandonment, or even the inversion of the fundamental principle of the science. The evil indicated is the blind adoption, or application, of the homotaxeous method in the classification and nomenclature of formations.

Glacial phenomena, and the 'glacial period,' having been lately very prominently under discussion, it will astonish many that in a paper treating specially of the former enormous extension of the Himalayan glaciers, no mention should be made of the possible connection of this fact with 'the glacial period'; the sole cause assigned for the case of the Himalaya being a supposed greater elevation of from 12,000 to 15,000 feet. The local time assigned by Mr. Theobald for the Himalayan glacial period may be correct: there is no doubt of its being posterior to the disturbance of the Náhan group, and to the excavation in it of the existing drainage system; and the reason given for its being anterior to the Sivalik group (as properly restricted by Mr. Theobald) is at least plausible. But here the fallacy steps in: the Sivalik formation is 'pliocene'; the 'glacial period' is 'post pliocene'; it is therefore needless to consider the relation of the latter with the prepliocene glacial period of the Himalaya, as well attempt to identify it with the Talchir (palæozoic) glacial period.

It is enough to state the case, to show the danger of it. Palæontologists are cutting themselves adrift in loosening their hold upon the chain of physical causation. Are they in a condition to say that even the Sivalik fauna (as restricted) *could* not be contemporaneous with the pliocene tertiaries of Europe, as is implied in the above argument?

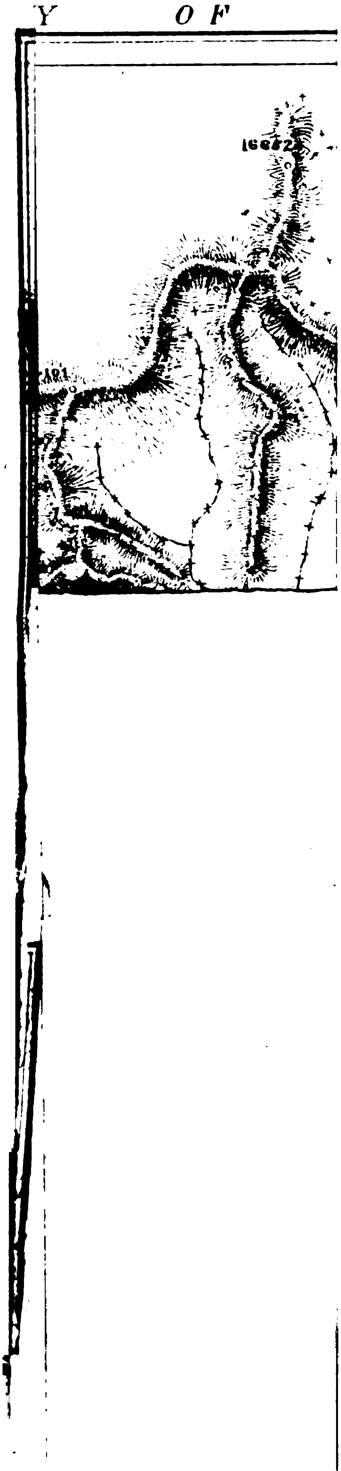
It is plain that the possible, not to say probable, connexion of the glacial periods here and in Europe offers an incomparable means of fixing the contemporaneity or correspondence of the extinct faunas of such distant regions. The importance of this possibility will not be lost sight of.—EDITOR.

ON THE BUILDING AND ORNAMENTAL STONES OF INDIA, *by* V. BALL, M. A., *Geological Survey of India.*

In the year 1871, when at home on leave, my friend Professor Hull, Director of the Geological Survey of Ireland, informed me of his intention of bringing out a work on BUILDING AND ORNAMENTAL STONES, and invited my assistance in reference to the portion of it treating of India. Fortunately my promise of assistance was made conditionally upon my having leisure sufficient to hunt up all available authorities on the subject, as since then up to the present time (April 1874), I have been almost constantly on the move, and during the short periods I have spent in Calcutta my time has been taken up by other more pressing occupations, so that I have found it utterly impossible to attempt to do anything like justice to the subject.

Professor Hull's book having been published in 1872, the present notes are printed in the Records as an instalment of what may hereafter be written. In a country covering so large an area as India, and where, in spite of the comparatively little use made of stone in modern British buildings, building stones have been employed for a long period of time by the natives, ample material exists for a very much more extensive account than the present. My chief difficulty has been to compress the principal facts within the limits available for the purpose.

By giving full references to the principal authorities on the subject, the reader is placed in possession of a means of acquiring fuller details than there is room for in the present account.


Y O F

Throughout the Gangetic valley the public buildings which have been erected under the auspices of the British have until quite recently been built almost exclusively of bricks. In many cases the difficulty of obtaining a building stone within an easy distance of the towns situated in the alluvial valley, and in all the consideration of primary economy, have led to the employment of perishable bricks instead of lasting stone in the construction of our officers' courts, private residences, &c.

Character of Anglo-Indian buildings.

Even in parts of the country where good building stones are to be obtained, bricks are often the only material regularly used.

It is no doubt this feature of Anglo-Indian architecture which in part gave rise to the saying that if the English left India, in a century after their departure no sign of their occupation, save that afforded by a few empty beer bottles, would remain.

Unfortunately the use of bricks cannot be justified even by the appropriate or ornamental character of the results. If durability is sacrificed, we are justified in asking if not for ornamental structures at least for buildings calculated to make this trying climate somewhat more endurable. But what do we find? To quote the words of Major (now Colonel) Medley: "Who does not know the scene of desolation that comes over one at first sight of some of our Indian cantonments: the straight and dusty roads, the rows of glaring white rectangular barracks, the barn-like church differing only from a barrack in the presence of a square tower and classical! portico, the Roman Catholic Chapel ditto, only smaller and with bright green doors all round"? and again: "It must, I think, be allowed that the true principles of architectural construction for buildings in the east, which are to be used by men habituated to an entirely different climate, have not as yet been discovered; a mosque, for instance, has a pleasant temperature both in winter and summer, while a Gothic church in India is, as a rule, either very hot or very cold. I do not say that Gothic churches are unsuitable to India, but only that they are so as we now build them."*

Architectural results from the use of bricks.

Temples and houses built in the native style, though often somewhat close and ill ventilated, are generally considerably cooler than any European buildings. This is particularly true of the massive stone structures of the north-west.

Native buildings suited to the climate.

In new countries, such as Australia and America, the engineer or architect often experiences a difficulty in determining the durability of materials which he may wish to employ. Even in England this difficulty is not unknown, as is evidenced by the failure of the stone used in the construction of the houses of Parliament; but in India, in the civilized parts, wherever building material occurs, ancient temples or other native buildings are almost sure to be found. These furnish all the information which can be required as to the durability of the stone when exposed to the atmosphere.

Evidence of durability of material afforded by native buildings.

The other qualities in building stones—strength, appearance, and susceptibility for ornamental treatment—can all be determined by simple and readily applied tests; but there is no known speedy test of durability.

Other qualities admit of speedy tests.

The presence or absence of certain minerals, or some peculiarity in the structure, are causes sufficient to determine the decomposition, which may be more or less protracted, but which must eventuate in the disintegration of the stone and the consequent disfigurement, if not total destruction, of the building in which it has been employed.

Causes of disintegration.

* Prof. Papers on Indian Engineering, Vol. I, pp. 201-2.

With examples of stone work which range in age from before the Christian era up to modern times, the engineers and architects of India have an immense advantage over those of newer countries.

Care requisite in selection of material.

It should be scarcely requisite to observe that the proof of a certain formation affording good building stone is not sufficent to justify the conclusion that all the stone of that formation is equally durable. Yet the passing of individual blocks of stone is under these circumstances, there is reason to believe, often performed in an imperfect manner. Cases might be quoted where ill-chosen stones have not proved equal to the work which might justly be expected from the material had a little care been used in the selection, and thus, too often, a material has received a bad name and evil reputation where in truth its qualities have not been put to a fair trial.

Skilled stone-workers more numerous formerly.

Although locally, in the construction of bridges and other works where stone has been employed, vast numbers of coolies have been trained so as to become very fair stone-cutters, still the number of highly *skilled* artizans is probably less than it was in former times, when the inhabitants of almost every district in India into which Aryans penetrated erected their temples of stone. In many cases these temples, to the present day, exhibit admirable workmanship in the most difficult materials.

The building stone resources of India undeveloped.

To show how little has been done towards developing and rendering these resources of India available, it is only necessary to refer to the grim advertisements which daily meet our eyes in the newspapers, of tombstones of Aberdeen granite and Italian marble.

In further illustration of this, I may mention that at Ránigani, 120 miles inland from Calcutta, I have seen at the potteries enormous granite mill-stones for crushing quartz which had travelled probably 15,000 miles to their present destination, while within a radius of 20 miles several places could be indicated where stone suited to the purpose could be obtained were quarries only opened up.

Prospect of future development.

With increased facilities for carriage, by rail and canal, and with some modification of the traditions in favor of Public Works Department bricks, we may yet look forward to a time when the splendid building materials existing in India* will be brought into more general use for our public and private buildings. And we may thus yet hope to see structures of an ornamental and lasting character worthy of our position in this country.

The order in which the several classes of materials are arranged in this paper is that followed by Professor Hull—

I.—GRANITIC AND GNEISSOSE ROCKS.
II.—BASALT AND TRAPS.
III.—SERPENTINE, POTSTONES, AND SOAPSTONE.
IV.—MARBLE.
V.—GYPSUM AND ALABASTER.
VI.—ORNAMENTAL STONES.
VII.—LIMESTONES, KUNKUR.
VIII.—SANDSTONES, QUARTZITES.
IX.—LATERITE.
X.—SLATES.

* Some trials of indigenous limestones from the Vindhyans and from Karnúl for lithographic purposes appeared to give promising results; but the large quantity of stones which are used in the Presidency towns are still, I believe, exclusively imported from Europe.

I.—GRANITE AND GNEISS.

Most of the so-called granite of India is a granitoid gneiss, a resultant of the excessive metamorphism of sedimentary rocks. To what extent true eruptive, igneous granite occurs in the peninsula is quite unknown. Granite, which from its physical relations one may venture to conclude is of truly igneous and eruptive character, is not however absent. But, as a rule, the physical relations accompanying exposures of perfectly unfoliated granites in the metamorphic areas of India are not of a sufficiently definite character to enable one to assert with confidence the nature of the origin of those granites. There is no crucial test which can be applied to determine this question. Even microscopical examination of the minerals is not now considered to afford in all cases an infallible guide. But even if it be, it is not of easy application, and cannot be made use of in the field.

These remarks seem a necessary preface to the following account, as travellers and antiquarians, who have described buildings, have not often attempted to characterise, more than by some very general term, such as granite or sandstone, the materials of which those buildings have been constructed.

The metamorphic rocks occupy a very considerable area in India.

East of a line drawn from Rotásgarh on the Són through Umarkántak to Goa, the greater part of the country consists of metamorphic rocks. The younger rocks which do occur in that area are for the most part limited to comparatively inconsiderable basins. Metamorphic rocks, not to mention small exposures within the limits of the great basaltic flows of Western India, also occur in Bandelkand, Kach, the Gáro and Kásia Hills, and in the Himalayas. Whether these all belong to the same age or not is a question of much difficulty and uncertainty. The probability is that they do not. Lithologically there is sufficient general resemblance to justify their being all classed together in this account.

The varieties of materials suited to building purposes are of course very numerous. There are those caused by structure and those due to composition. By the former character they are divisible into foliated and non-foliated. The simplest form of the latter is a binary compound of quartz and felspar, or pegmatite, sometimes appearing as graphic granite. Then there are the ternary compounds, consisting of the two minerals just mentioned, with the addition of mica, hornblende, or talc, which are known respectively as granite, syenite, and protogine. Various modifications of these four varieties are produced by the presence of foreign minerals, such as, oligoclase, schorl, garnet, epidote, magnetic iron, &c.

As building stones the dense crystalline unfoliated varieties are the most durable. The presence of garnets or magnetic iron is likely to be detrimental, as these minerals under the influence of the atmosphere are apt to disintegrate, and so mar the appearance, if they do not ultimately endanger the stability, of the edifices in which stone containing them is employed.

I shall now endeavour to give some enumeration of the principal localities where these rocks have been used for the supply of building stones, and point out the features of the principal examples.

In the alluvial tracts of Bengal ancient buildings of stone are of most uncommon occurrence. Towards the west, however, in the rocky districts and on their borders, evidence is not wanting that the art of working in stone was practised whenever the material was available. In the Ganges close to Colgong there are several small hills which form islands in the present bed of the river. These hills consist of piled masses of a very compact grey granite, which in olden times used apparently to be resorted to for material for the construction of temples. The old holes for the wedges are still to be seen, and one enormous slab, which was partially split off, was never removed, and still clings to its place.

In Behár many temples are to be found in the construction of which granite was employed. At Gya some of the Buddhistical rails and the floorings of temples, &c., are of granite.

At Barábar Hill occur, so far as I know, the only instances of artificial caves excavated in these hard rocks. In sandstones and trap, as we shall see hereafter, not a few instances can be quoted.

Throughout the Chutia Nágpur Division sandstones are generally more or less accessible, so that temples built of granite are of by no means common occurrence. But as we proceed southwards along the eastern coasts from Midnapore through Orissa, the use of granite seems to be more and more common.

At Neeltigur Hill, in Pergunnah Ultee, in Orissa, Hindu temples and deities are of garnetiferous gneiss, as are also some large figures in the Black Pagoda at Pori.

On Mahendragiri Hill, in the district of Ganjam, I observed an example of what I have since been informed was not uncommonly the practice with regard to the construction of these temples. On the top of the hill is an unfinished temple built of huge blocks of porphyritic gneiss, which on their exposed faces are rough and uncut. The practice appears to have been, not to have attempted any ornamental work until all the stones of the building were in position and then to have pared them, so to speak, into shape. One of the stones which I measured in this temple had the following dimensions, 9′ × 3′ 9″ × 3′, which would indicate a weight of about 8 tons.

The natives get over the difficulty of accounting for such megalithic structures by asserting them to be supernatural, or by saying that "there were giants in those days."

In his report on the Nilghiri Hills, Mr. H. Blanford pointed out several places where excellent building stones could be obtained from the crystalline rocks. But not much use has hitherto been made of them. In Mysore a variety is obtained, which is split into posts 20′ long, which are used for the support of the electric telegraph wire. As readily accessible examples of the useful and ornamental purposes to which the gneisses of Southern India have been put, Mr. King instances the following:—

A polished slab of quartzo-felspathic gneiss in the Durbar hall in the Rajah's palace at Tanjore, which measures 18′ × 16′ × 2′ 1½″.

A small temple in the north-west corner of the Pagoda Court at Tanjore, which is "a perfect gem of carved stone-work," the elaborate patterns on which are as sharp as when they left the sculptor's hands.

Other beautiful examples of carving are to be seen at the Rock Pagoda of Trichínopoli, at Volcandapuram, and at the Chellumbrum Pagoda. "Even at Trivalur near Negapatam, at the eastern extremity of the great delta of the Cauvery, nearly sixty miles from the nearest gneiss quarries, the great pagoda and tank are surrounded by walls of massive gneiss."

"As an instance of the peculiar susceptibility of gneiss to fine carvings, the rings appended to the drooping corners of some pagoda buildings may be mentioned. These rings, the links within which are moveable, and the projecting corners, are carved out of single blocks of gneiss, such as may be seen at the Strimustrum Pagoda."

Mr. King also mentions the use of blocks of gneiss in the construction of walls, *bands* of tanks, beach groynes at Tranquebar, culverts, bridges, &c.

The ancient Druid-like remains called Karumbar rings which are found in various parts of Trichinopoli generally consist of rough blocks of gneiss. In parts of Chutia Nágpur old settlements of the Kols made use of gneiss in the erection of *Menhers* and *Dolmens.* But, at the present day, the Kols who erect such memorials for the most part dwell in a part of the country where flags of schist and slate are readily accessible, and they therefore do not use gneiss.

In Madras Mr. Foote says that the beds of very hornblendic gneiss which occur "at Palaveram, Cuddapary Choultry, and Puttandulum are largely quarried for the manufacture of articles of domestic use as well as for building purposes."

Other varieties in different localities in Madras are mentioned; some of these have been quarried to a considerable extent.

Except for purely local purposes, the construction of bridges, &c., where, upon economical grounds, the rock nearest to hand has been made use of, the varieties of granite, gneiss, &c., on account of their hardness, have not commended themselves as building materials to English engineers. So far as I know, there are, throughout the country, no British buildings of importance, in the construction of which these materials have been used.

References.

	Orissa ...	... Mem. Geol. Surv., India,		I, p. 277.
Blanford,	Nilghiris ...	... „	„	p. 244.
King,	Trichinopoli ...	... „	„	IV, p. 367.
Foote,	Madras ...	... „	„	X, p. 131.
Balfour's Cyclopœdia, Art. Granite.				

II.—Basalt.

Trap.—Any one who has paid attention to the subject is aware that the greater part of Western India, the Dekan, and the Central Provinces is occupied by a vast accumulation of eruptive rocks which are generally spoken of as Dekan trap. From north to south these rocks extend from a point 100 miles south of Gwalior to the vicinity of Goa, and from west to east from Bombay to Umerkántak, thus covering an area of about 1-6th of the peninsula, south of the Ganges. Roughly estimated, we may put down the area in which these rocks prevail at 200,000 square miles.

On the eastern side of the peninsula too, rocks, which, without going into details of the mineral constituents, may be conveniently spoken of generically as trap, occupy a by no means inconsiderable area, as in the Rajmehal Hills.

From the evidence afforded by the sedimentary beds with which these rocks occur interbedded, those in the west appear to be referable to the close of the cretaceous epoch, while those of the east (Rajmehal) belong probably to the jurassic.

The whole of the trap rocks which are used for building purposes are not, however, exclusively derived from the two above-mentioned sources. In many other of the recognised formations in India the trappean rocks occur as dykes; sometimes these are basaltic, but, in the older formations, diorites prevail.

In the Dekan and Rajmehal areas, other rocks are not altogether absent, as there are not only the sedimentary, interstratified rocks above mentioned, but also, on the outskirts, the deeper valleys occasionally disclose rocks of older formations.

The former, however, are not generally suited for building purposes,* and are therefore less used than trap, which, though sometimes difficult to cut, is, if well chosen, a most durable material, and is moreover susceptible of much delicate and artistic treatment.

As might be anticipated in the Dekan area, from the enormous thickness of these rocks which occur, the lithological varieties are numerous. These varieties are due both to differences in mineral composition and degrees of compactness.

With regard to the relative adaptability to building purposes of the various kinds of rock which are most commonly met with, Mr. Blanford remarks: "None of the beds containing zeolites, interspersed in irregular strings and veins throughout the mass, are good. They are too soft, brittle, and liable to decompose. None of the ash beds are equal in strength, toughness, or resistance to the atmosphere to the solid basalts, and no rock of a red colour should ever be taken for building purposes. It is almost always decomposed. Amongst the very best beds are the porphyritic basalts, such as those which form so large a proportion of the rocks on the Thull Ghât."

Mr. Bell says:—"The best I should consider to be the bluish-green basalt, which is very hard and heavy, having a specific gravity about 3·0, and which rings like a metal on being struck."

Probably the first use to which the trap rock was put in India was in the manufacture of stone implements or celts, of which specimens are occasionally found, in some cases far removed from the places where the rocks occur.

To a very early period must be referred that form of architecture which consisted in hollowing out and sculpturing the rock *in situ* into temples and dwelling places, of which we have magnificent examples in the caves of Adjanta, Ellora, and Elephanta. These caves contain sculptures and inscriptions indicative of their Buddhistical or early Brahminical origin. Several of these caves are assigned to a period from 200 to 150 years B. C.

At Gya, according to General Cunningham, some of the Buddhistical *rails* are made of basalt, others being of granite and sandstone.

Coming down to a more recent period, we find on the eastern side of India trap from the Rajmehal Hills made use of for lintels and door posts in Hindu temples, and not unfrequently for the images contained inside. Trap used in this partial manner may be seen in many of the old buildings in the vicinity of Rajmehal and the ruined city of Gaur: occasionally, too, in temples in the Burdwan District. The black marble of many writers is probably only this material. When covered by the native offerings of *ghee*, it is often, without doing what in the sight of the people would be regarded as desecration, impossible to make out the material of which the images are made.

In the famous Black Pagoda at Pori trap is said to have been much used. This material was probably derived from dykes in the metamorphic rocks.

In the Dekan and surrounding trap country this material has been used in the construction of forts and native buildings of various kinds.

One of the most magnificent works in trap is stated by Dr. Balfour to be an unfinished tomb of one of the Gwalior princes at Poona.

Recently it has been extensively used in the construction of bridges and stations on the lines of railroad which traverse the trap country, but I understand that from causes for which the stone is not altogether in fault, but rather the lime and workmanship, the work has not given complete satisfaction.

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* An exception will be found noted on a following page.

In the city of Bombay trap has been used to some extent, but chiefly in rubble masonry. All the finer buildings in Bombay are constructed of a very different material, as will be mentioned in its proper place.

The principal use to which the trap rocks of the Rajmehal Hills are at present put is for the supply of Calcutta with road metal.

References.

Building materials, Bombay Island, Carter's Geology of Western India, Bombay, 1857, p. 161.

Building stone in Western India, Merewether, Prof. Papers of Ind. Eng., Roorkee, Vol. VI, 1869, p. 130.

Geology of Bombay Island, Wynne, Mem. Geol. Surv., Ind., V, 1864, p. 173.

Geology of Western India, Blanford, Mem. Geol. Surv., Ind., VI, 1869, p. 379.

Masonry in a trap country, H. Bell, Prof. Papers of Ind. Eng., Roorkee, Vol. I, 2nd Series, 1871, p. 162.

III.—SERPENTINE.

Serpentine in sufficient quantity to be deserving of mention in this enumeration is of rare occurrence in India. In the sub-metamorphic rocks of Western Bengal, I have occasionally met with it in small quantities. In the district of Singhbhum, south of the station of Chaibassa, it occurs in beds of a white limestone.

In the Madras presidency, in the eastern part of the Kadapa District, a beautiful serpentinous marble is said to occur, but it has not been much used hitherto.

Dykes of serpentine, possibly the result of alteration of some original igneous rock, occur most uncommonly in the tertiary sandstones of the Andaman and Nicobar Islands. Some of the purer varieties might, if obtainable in large blocks, be used for ornamental purposes. A black variety streaked with green, which occurs at the head of Port Blair, particularly attracted my attention. So far as I know, no attempt has been made to work it.

Serpentine is said to be found in parts of Upper Burma, where it is worked and exported to China.

Potstones.—Chloritic schists, passing, on the one hand, into talcose, and, on the other, into serpentinous rocks, occur not uncommonly in the sub-metamorphic and somewhat less frequently in the metamorphic series.

In buildings the varieties of this material have only been used on a small scale for ornamental purposes, for which some of them, as being tough and at the same time easily carved, are particularly suited. More extensively they are used in the manufacture of altars, idols, plates and bowls.

In the southern part of Mánbhum, on the frontiers of Singhbhum, there are numerous workings, which generally take the form of narrow mines which are deserted during the rains. From these mines a considerable quantity of stone is annually extracted; the blocks are roughly dressed to the shape required, be it for *Lingam*, plate or bowl. They are then fixed in a rude lathe and cut into form and given a smooth surface. When finished, they are carted off to Burdwan, where they are in great demand, and a portion are sent on to Calcutta for sale.

In the neighbourhood of Gya too, there are many large mines and quarries of this stone, which supply a considerable trade in idols and utensils.

One class of the varieties used stands fire well, while the other does not. The former is of course the most esteemed by the natives. The cracking of the latter is probably due to the water of combination in the more chloritic varieties, which becomes released on the application of heat.

In many of the ancient temples in Chutia Nágpur images made from this material are not uncommonly met with.

The beautifully sculptured doorways of the Black Pagoda near Pori are of this material, which was probably obtained from the Nilghiri Hills in Orissa.

In some of the more finished temples at Bobaneswar there are large well polished and highly sculptured slabs of potstone let into the walls. (Stirling).

In parts of Trichinopoli these rocks are applied to similar purposes.

Soap-stone.—The very beautiful steatitic material so much used for delicate carvings in Agra, though generically related to the rocks mentioned under the above head, seems deserving of separate notice in this enumeration.

This rock is obtained in the territories of the Raja of Jaipúr. In Agra it is chiefly used in the manufacture of small ornamental articles, but has not yet entered into use as a material for architectural decoration, although it is admirably suited to the purpose.

Reference.

Keene—On the Stone Industries of Agra.

IV.—MARBLE.

Marble in India is better known from its great beauty in the few places where it does occur and its successful employment in the ornamental architecture of some of the cities of North-Western India, Rajputana, Guzerat, and a few other places, than from being generally distributed throughout the country.

The Taj at Agra which was erected by the Emperor Jehangir, to the memory of his favorite wife Nur Jehan, is built of polished white marble, and is by many competent authorities considered to be one of the most beautiful and perfect structures in the world.

The material for this glorious monument, as well as for many others, was obtained in the Jaipúr territories.

But the special purpose to which the marble of Jaipúr has been put, and for which it is so admirably suited, is the manufacture of screens, the delicacy of the tracery on which can in many cases be only compared with lace. This work is known by the name *Jalee.* Besides marble, sandstone is sometimes, however, employed for this purpose, as the following description by Mr. Keene will show: "It is a fine filagree of marble or sandstone fretted into an almost endless net-work of geometrical combinations, such as can only be understood by seeing the carvings themselves or good photographs of them."

In the opinion of Mr. Fergusson, the *Jalee* work of Ahmedabad in Guzerat is still finer; but the style of the two is quite different.

According to Mr. Keene, the finest example of this form of work to be met with in Northern India is the following; he says: "But all the marble-work of this region is surpassed by the monument which Akber erected over the remains of his friend and spiritual counsellor Shekh Suleem Chistee at Fatipúr Sikri (1581 A. D.). In the north-western angle of a vast courtyard 433 feet by 366 feet is a pavilion externally of white marble, surrounded by a deep projecting dripstone, of white marble also, supported by marble shafts crowned by most fantastic brackets shaped like the letter S. The outer screens are so minutely pierced that they actually look like lace at a little distance, and illuminate the mortuary chamber within with a solemn half-light which resembles nothing else that I have seen. The whole of this elaborate work, including the strange but most pleasing design of the brackets, appears to have been produced by the resident stone-cutters of the place—uneducated men earning probably an average wage of about a penny a day. I believe that no instance of such pure patient workmanship, so dignified, yet so various, is to be found in the world." In a very beautifully illustrated Work on the Architecture of Ahmedabad by Mr. T. C. Hope, B. C. S., with architectural notes by James Fergusson, photographs illustrative of this work and of buildings in sandstone will be found; many of these buildings are comparatively modern, and some are quite recent. It would appear that the art of working in these materials has been more fully conserved in Guzerat than in any other part of India. But it has been by no means lost or even discontinued, though it is not extensively practised now in the northern cities.

I am informed by my friend Mr. Hacket that at Rialo in Jaipúr the *Jalee* is still made, and that the traceries in it are as delicate as any which are to be seen in the Taj. Other quarries near Jaipúr are also in operation. In the "Hand Book of the economic products of the Punjab," by Mr. Baden H. Powell, there is a list of marbles of which the following are the principal: (1) an inferior marble which, however, takes a good polish from Narnul, in the Pattiala territory; (2) grey marble from Bhunsi; (3) black marble from Kashmir; (4) white and veined marble from Sardi in Jhelum; (5) yellow marble from Manairi, Yusufzai.

In the Narbada valley, the marble rocks, justly famous for the excessive beauty of the deep gorge cut through them by the river, consist of a tolerably pure white saccharine limestone. This is the strongest local development of the calcareous element which occurs with the schists in the Bijour series of rocks.

The marble, except locally in some of the temples, has not been used for building purposes. It is much jointed on the surface, and has been a good deal crushed by tilting into the present vertical position of its beds and by the trap dykes which traverse it. But it seems probable that large blocks might be extracted, and it is possible that portions might be obtained of sufficiently fine quality for statuary purposes,* but I am not aware of any attempt having been made to use it in this way.

I must add, however, that according to Dr. Balfour's Cyclopœdia, a block sent to the Paris exhibition of 1855 (?) was pronounced to be equal to Italian marble for statuary purposes.

Several localities in Bengal might be mentioned, where more or less pure crystalline limestones occur, but these are not of much economic importance. Silica, tremolite, and serpentine are the chief foreign minerals which occur in these crystalline calcareous rocks.

In his work on building stones, Mr. Hull mentions among other localities Syepore, Gya, and Durha in Bengal as localities where marble occurs in India. The name Syepore (whence the mineral called Syeporite) has its origin in a clerical error, and the names should stand as Jaipore or Jaipúr, as it is now spelt, and Jaipúrite. I am not aware of any marble being found at or near Gya, though the black basalt used in the temples there may very possibly have been so called by some visitor or antiquarian. As for Durha I am quite unable to trace any place bearing the name in Bengal proper. Possibly it may be Dura, near Bhurtpúr, in the Agra district of the North-Western Provinces. If so, the marble in use there probably comes from Jaipúr.

In the Khasia Hills it is said that much of the nummulitic limestone would produce most durable and occasionally very handsomely veined marble. It would answer well for ordinary purposes, chimney-pieces, slabs for tables, garden seats, and for flooring tiles.

In Southern India there are several well known localities where more or less ornamental and durable marbles are obtained; samples of these have been from time to time collected,

* Some parts are obviously too silicious to be so employed.

polished and exhibited both in Madras and Europe; favorable reports have been published, and there the matter has been allowed to rest.*

In the Palnad, according to Mr. King, there are some particularly well colored marbles. There are also breccia beds of various colors "in the western scarps of the Jummulmudgoos and the bottom of the slates in the Chey-air field." Dr. Balfour describes the marbles of the Kadapa District as being of various shades of green.

At Coimbatore, according to Mr. H. Blanford, there are crystalline limestones "susceptible of a high polish, and very transparent, which would afford a very beautiful material for internal decorations, the effect of which would be enhanced by the judicious selection of slabs of various tints. Pink and grey, occasionally approaching white, are the prevailing colors of the stone."

In Burma, for statuary purposes, marble is largely employed. The material for the well known sitting and recumbent figures of Gaudama is said to be obtained chiefly from the Tsygen Hills near the village of Mowe in the district of Madeya.

References.

Medlicott, J.—Nerbudda	... Mem. Geol. Surv., India,		II, p. 135.
Oldham, T.—Khasia Hills	... „	„	I, p. 185.
Blanford.—Coimbatore	... „	„	I, p. 247.
King, W.—Trichinopoli and Kadapa	„	„	IV, p. 370, & VIII, 282.
Keene.—Agra—Stone Industries of Agra.			
Powell, B. H.—Punjab—Punjab Products.			
Balfour.—Madras, &c., Art. Marble—Cyclopœdia.			

V.—Gypsum.

As a building stone gypsum has been very little used in India. To some small extent it is manufactured locally, where it occurs, into ornaments, and is occasionally employed for mixing with lime to produce a hard and shining surface on chunam work. The manufacture of plaster of Paris from calcined gypsum appears to be unpractised by and unknown to the natives.

Gypsum in quantities of importance and deserving of notice is found only, so far as I know, in the Salt Range in the Punjab, parts of the Lower Himalayas, Spiti, Kach, and Madras.

Its manner of occurrence at these various localities varies much.

In the Salt Range, according to Dr. Fleming,† gypsum occurs scattered in irregular beds and huge mass throughout the marl in which rock-salt also occurs. It is "for the most part of a light grey color, with a shade of blue and translucent on the edges. It has a saccharine appearance, but masses in which a coarse crystalline structure prevails are by no means uncommon. Red varieties also occur, and beds of a dark grey earthy gypsum are generally associated with the saccharine kind."

It is said to be very abundant at Pind Dadun Khan. It also occurs at Mari, Kalabagh, and Surdi, where it contains quartz-crystals of various colours, which are known as Mari diamonds, and are much used by the natives for necklaces, &c. The marl on Mount Kuringil is also said to contain abundance of gypsum.

Dr. Fleming suggested the gypsum of Pind Dadun Khan being made use of by the Public Works Department for building purposes.

The marl in which this gypsum occurs is considered to be of silurian age.

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* According to Mr. Balfour's Cyclopœdia: "Specimens sent to the great exhibition in 1851 were favorably reported upon as indicative of a valuable material, adapted to sculptural and ornamental purposes.

† Jour. As. Soc., Bengal, XXII, p. 260.

In Mr. Medlicott's account of the Sub-Himalayan rocks of North-Western India* he states that gypsum occurs in several parts of the district; it is found in lumps in the ferruginous clays of the Subathu group, and at Sahansadhara, below Masuri, it occurs in small irregular veins through limestone.

Mr. Mallet has described the deposits of gypsum in the Spiti valley. He believes them to be derived from thermal springs, as the masses occur at all levels unstratified and amorphous, and what is more to the point, the thermal springs are at present depositing gypsum with the carbonate of lime. The origin is traced to chemical reaction between† iron pyrites and carbonate of lime, the former abounding in the underlying black slates.

Mr. Mallet concludes his observations thus: "The compact unaltered portions of the gypsum are of a snowy whiteness, and would form a beautiful material for ornamental purposes. All of it, from its apparent purity and freedom from iron, &c., might be manufactured into very superior plaster of Paris. One fatal bar, however, exists to its economic employment, namely, the mountain carriage across the entire breadth of the Himalayas."

In Kach Mr. Wynne‡ reports the existence of gypseous shales below the regular nummulitic beds; but the deposit of gypsum appears to be inconsiderable there.

In Madras gypsum occurs in several places. "It is most abundant in the Ootatoor beds (cretaceous), especially in the belemnite clays to the east of Ootatoor and in the unfossiliferous clay to the north-east of Muravuttoor.§

It might be obtained in any quantity for ordinary purposes, such as moulds; but for casts it is generally too impure; however, selected portions, chiefly in the form of transparent plates of selenite, would answer for a small demand for the latter purpose.

Dr. Balfour, in his Cyclopœdia, besides the above, also enumerates the following localities. The Chingleput District, Sadras, Ennore, the Red Hills, Nellore, Masulipatam, and Bangalore.

Gypsum is used by the natives medicinally, and can be obtained in most bazars in small quantities.

VI.—Ornamental Stones.

The use of ornamental stones in buildings in India, either in the way of mosaic or on a larger scale, has not been much practised latterly.

Probably the finest extant example is afforded by the inlaid work in the Taj at Agra. The following is a list of the stones used there as ascertained by Dr. Voysey:—

Name.	*Locality.*
Lapis Lazuli	Ceylon and Thibet.
Jasper	Basaltic trap of Hindustan.
Heliotrope	Basaltic trap of Hindustan.
Chalcedon Agate	Basaltic trap of Hindustan; also from Sone and Narbada.
Chalcedony	Basaltic trap of Hindustan; also from Sone and Narbada.
Cornelian	Basaltic trap of Hindustan; also from Sone and Narbada.
Sarde	Basaltic trap of Hindustan; also from Sone and Narbada.
Plasma, or Quartz and Chlorite	Basalt of Dekan.
Yellow and striped marble	Guzerat.
Clay slate	?
Nephrite or Jade	?

* Mem. Geol. Surv., India, Vol. III, p. 177.
† " " " V, p. 157.
‡ " " " IX, p. 266.
§ " " " IV, p. 214.

The following passage will give some idea of the elaborate character of these mosaics: "A single flower in the screen around the tombs, or Sarcophagi, contains a hundred stones, each cut to the exact shape necessary, and highly polished; and in the interior alone of the building, there are several hundred flowers, each containing a like number of stones."

In various parts of the basaltic areas of India varieties of agates and jasper occur in considerable abundance, and are collected and sold to lapidaries, who cut them into useful and ornamental articles; but they are not much used for mural decoration or mosaics at the present day. In the valley of the Narbada and Sone such pebbles are found somewhat abundantly. I believe there is no case of the original matrix, the basalt, being worked for them, but the gravelly beds of some of the tertiary rocks, which consist mainly of débris from the basalt, are mined in several places. In Western India the mines at Ruttunpur, east of Broach, are the principal. The stones found there are sold to the lapidaries of Cambay and Jabalpúr.

In the Rajmehal Hills very beautiful agates, common opal, and other varieties of silica are abundant, but are not, so far as I know, sought after or collected.

At Vellum, in Trichinopoli, some tertiary grits contain pebbles of rock crystal, smoky quartz, cairngorm and amethyst, which are cut by the local lapidaries.

References.

Voysey, Asiatic Researches, Vol. XV, p. 429.
Blanford, Mem. Geol. Surv., India, Vol. VI, p. 219.
King, Mem. Geol. Surv., India, Vol. IV, p. 370.
Keene on the Stone Industries of Agra, 1873.

VII.—LIMESTONE.

Under the head of MARBLE I have separately described those varieties of limestone which, from their crystalline structure and ornamental appearance, are entitled to be so dignified. In the present section I shall confine myself to an account of the chiefly, but not exclusively non-crystalline varieties which are used or are available for use as building materials or for the manufacture of lime.

By far the most important deposits of rock limestone in the northern portion of the peninsula of India are those which occur in the Vindhyan series. In the lower Vindhyans occurs a group of thin-bedded limestones which in the places where they are best exposed have a total of several hundred feet in thickness. At Rotásgarh it is chiefly quarried for burning. It is brought down the Sone in boats and into the Ganges, by which means it is distributed over a considerable area of country. When the Sone canal is opened this trade will probably become more regular, and it is possible that Calcutta may be supplied from this source, a contingency much to be desired in view of the great expense of Sylhet lime, which is that which is principally used at present.

Attention has been drawn to this limestone too as being, within a reasonable distance, the only source of a material of steady, known composition capable of affording a suitable flux for employment in the proposed iron-works in the Rániganj country.

It should be mentioned, however, that the steady composition can only be depended on in individual layers, as the proportion of associated argillaceous matter varies in successive layers.

This rock has been traced as far west as the neighbourhood of Katni on the Jabalpúr line; at Múrwára, &c., quarries have been opened where the Jabalpúr railway crosses the outcrop.

Higher in the Vindhyan series the Bandér group includes a limestone which is not only used as a source of lime, but as a building stone in the Dumoh district, where it is preferred to the lower sandstone; the same is said to be the case in the vicinity of Nimach.

Some of this stone was reported on favorably for lithographic purposes, but it has never come into use.

In several parts of Bengal occupied by the metamorphic rocks limestones occur, but they are in general too much impregnated with foreign minerals to be of use either as building stones or as sources of lime.

In the neighbourhood of the Khási Hills the so-called Sylhet limestone is extensively manufactured into lime for the Calcutta market. The principal factories are at Chátak and Sonamganj, and along the banks of the river Súrma between these two villages. The quarries are "near the village of Tungwai or Tingye, from which the stone is brought to the neighbourhood of Pondua and to Chátak. Other very large quarries are in the vicinity of the great orange groves between Teria-ghât and Lacát, from which also the stone is conveyed to Chátak for burning." This limestone is of nummulitic age.

Under the head of marble will be found a notice of the portions of it which come under that denomination. How far it has been used as a building stone, locally, I have no information, but there is no reason to doubt that good building stone could be obtained.

In Western India limestones occur in the metamorphic and the Bijour series; they are, however, usually too silicious to be employed in the manufacture of lime, and I can find no notice of their being employed as building stones; but some of the highly calcareous Bágh beds and the nummulitic limestones of Guzerat are used to a certain extent. Regarding the latter, Mr. W. T. Blanford says: "It is difficult to obtain it in large masses, or to trim it neatly. It is employed by the natives for bowries, temples, &c., other compact calcareous beds being used for the same purpose."

In the north-west of India the limestones of the Lower Himalayas are, some of them, applicable to building purposes, and "some fit for ornamental or monumental purposes might be found among the thick-bedded, hard limestones of the Krol group."

The lime in this area is chiefly made from a porous tufa, which occurs along the flanks of the limestone ridges.

In Southern India limestones of at least three distinct geological periods are used as building stones. The oldest of these are the crystalline limestones of the metamorphic series. At Coimbatore there is a limestone belonging to this series which has attracted some attention, as it would make a good building stone as well as being a source of lime; while portions are highly ornamental, as is mentioned under the head of marble. This limestone is described by Mr. Blanford in the Memoirs of the Geological Survey, and at greater length in the Madras Journal of Science. Mr. King also, in his Geology of Trichinopoli, mentions this rock and gives some additional localities. He states that it has been used as a building stone in connection with the Madras and Beypúr railway, and has given complete satisfaction.

The two series of metamorphosed rocks occurring in Southern India, and which are known by the names Kadapa and Karnúl, each contain limestones. For building purposes those of the latter seem to be the most important. The Karnúl series belongs, it is considered, to the same general age as the Vindhyan of the northern parts of India. Mr. King remarks in reference to these rocks. "The limestones, where they are at hand, have been largely used by the people of the country, the larger villages in the Khoond-air valley having their better houses built of well-selected and dressed Nergee beds, while the wells of the Kadapa and this valley are all lined with this stone." Mr. King anticipates that the railway and canals will tend to develope the use of these building materials.

There are still to be mentioned the limestones of cretaceous age which occur in Southern India. These are of two kinds, one being purely sedimentary, the other derived from coral reefs. As building stones they are somewhat extensively used by the natives, but, according to Mr. H. Blanford, "are ill qualified for exposed exteriors, where they rapidly yield to the heavy tropical rains."

References.

Mallet ...	On the Vindhyan series, Mem. Geol. Surv., India, VII, p. 113.
Oldham ...	Khási Hills, Mem. Geol. Surv., India, I, p. 181.
Medlicott ...	Lower Himalaya, Mem. Geol. Surv., India, III, p. 176.
Blanford, W. T. ...	Western India, Mem. Geol. Surv., India, VI, p. 380.
Blanford, H. ...	Southern India, Nilghiri Hills, Mem. Geol. Surv., India, IV, p. 204, and I, p. 246.
King, W. ...	Trichinopoli and Karnúl, Mem. Geol. Surv., India, IV, p. 370, and VIII, p. 282.

PORBUNDER STONE OR MILIOLITE.

The name miliolite was given by Dr. Carter to a rock which is found in the neighbourhood of Porebunder in Guzerat. Though somewhat oolitic in structure, it is not of oolitic age, and therefore the above name was given to distinguish it.

It is considered to be of newer tertiary, probably pliocene age. In Guzerat its greatest development is in the Gir Hills, where, as also in some of the valleys, it rests upon an arenaceous clay. It is a wide spread deposit, and is said to occur on parts of the coast of Arabia and in Kach.*

As it appears in Guzerat it is a somewhat coarse calcareous grit, abounding in foraminifera towards the west, but containing fewer organisms, and being more argillaceous towards the east. As a building stone it is admirably suited to many purposes, but is said to be incapable of sustaining great pressure. It is largely quarried about twelve miles from Porebunder, from whence it is shipped to Bombay and other places.

In Bombay it has been largely used for building purposes, more particularly in the construction of the recently erected Government buildings.

References.

Carter ...	... Geology of Western India.
Theobald ...	... " Guzerat, M. S.
Wynne ...	... Kach, Mem. Geol. Surv., India, IX, p. 81.
Balfour ...	... Cyclopædia.
Merewether ...	... Building stone in Western India, P. P. of I. E., VI, 1869, p. 137.

KUNKUR OR GUTIN.

The calcareous concretions which occur in the alluvial clays, and which are known under one or other of the above names, occupy a very important position as a building material, being in very many parts of the country the only source of lime. In addition to this, some of the more massive varieties are used as building stones in parts of India as in the Central Doab.

In the bridges on the Ganges Canal between Rúrki and the Nanún Fork block kunkur has been largely employed, except for the archwork. In the case of the Kasimpúr bridge the external faces of the arches themselves have, however, been made of this material.

In the vicinity of this section of the canal the block kunkur is readily procurable.

Block kunkur was also much used in the bridges on the Fatehgarh and Koel branches of the Ganges Canal. It is thus described by Colonel Sir Proby T. Cautley: "In extremes, the stone may be described, in its most perfect state, as a gray semi-crystalline rock, tough,

* The Kach rock, which has been supposed to represent the miliolite, is, according to Mr. Wynne, devoid of organisms.

with occasional amygdaloidal or irregularly shaped hollows, dispersed through its mass, the hollows being filled with earth. In its most imperfect state (I allude simply to the block kunkur which is available for building purposes) these hollows are more numerous, and they give to the rock a honeycombed appearance to which I have before adverted. It is found in extensive tabular masses or strata (generally accompanied by sand), the upper and lower sides of which are slaty and apparently imperfectly indurated; the induration, in fact, increases towards the centre, where it is frequently of the hardest description of the newest lime rocks, and of a crystalline character."

Owing to the honeycombed surface of the stone, it was found necessary to protect it by stucco from the direct action of the water and of the atmosphere. This rock has also been used, where readily obtainable, in the construction of buildings connected with the railroad.

Block kunkur, similar to the above, is obtained in parts of the Jamna below the ordinary water level. Its more common form is in nodules, and in this form its occurrence is so general throughout alluvial soils in India wherever they exist that it were useless to attempt to indicate its geographical distribution in detail.

The better qualities of kunkur contain 70 per cent. of carbonate of lime; from this downwards the proportion constantly varies with the amount of clay or sand which is taken up.

Besides its usual employment for mortar, it is, when burnt and powdered without slaking, an excellent material for hydraulic cement. To this purpose of course only certain varieties are applicable.

VIII.—SANDSTONES.

Several of the recognised formations in India afford sandstones admirably suited for building, and some of them have from very early times been largely drawn upon for the supply of materials for this purpose.

Among these formations the great Vindhyan series stands pre-eminent. The difficulty in writing of the uses to which these rocks have been put is not in finding examples, but in selecting from the numerous ancient and modern buildings which crowd the cities of the North-Western Provinces and the Gangetic valley generally, and in which the stone-cutter's art often appears in its highest perfection.

The Lower Vindhyans,* consisting for the most part of shales and more or less flaggy limestones, and from the inaccessible position of the rocks in some of the principal places where they occur, as in the Sôn valley and Bandelkand, have not been worked to any great extent.

The Kaimúrs, however, have been worked extensively at Chunár, Mirzapúr, and Purtábpúr, as well as at minor intermediate points. The sandstones are in general fine-grained and of reddish-yellow or greyish-white colors. They occur in beds which are said to vary in thickness—at Purtábpúr and similarly elsewhere, from 6 inches to 8 feet. These beds often spread for long distances without any joints or fissures to break the continuity, in consequence of which very large blocks can and have been extracted for various purposes.

In the Riwa group, overlying the Kaimúrs, the sandstones are not so much used for building purposes.

"This is due partly to the beds being frequently coarse and harsh, and greatly subject to false bedding; partly to the fact that the Riwas do not occur much close to the Gangetic valley or to large cities. Some portions are, however, of superior quality, and supply all local wants."

Above the Riwas come the Lower Bandérs, which are described as being, for the most part, coarse, harsh, and gritty, and occurring only in thin beds.

* The following particulars are chiefly taken from Mr. Mallet's Memoir.

The Upper Bandérs, however, make up for the deficiencies of the underlying group by affording two varieties of excellent building stone, one dark-red, sometimes quite unspotted, sometimes streaked and dashed with yellowish-white spots.

The other is a yellowish-white, very fine grained rock, perfectly homogeneous both in texture and colour.

The latter is said to be, on the whole, the better building stone on account of its more uniform coloring and its being not so liable to disintegration from the effects of long continued exposure.

Probably the earliest use to which any of the rocks of the Vindhyan formation were put to was in the manufacture of stone implements, many of which, formed of the denser indurated varieties of sandstone, have been found in India.

So far as I have been able to ascertain there are no cave temples, or at least none of much note in the Vindhyan sandstones. But there are memorials of a very different class, many of which date from a period before which the idea of using stone in the construction of houses had not been entertained. At any rate, there are no buildings or remains of buildings which can with safety be regarded as belonging to so remote a period.

These memorials are the great monoliths or *lâts*, many of which bear the edicts of Asoka, the protector of the earliest Buddhists, and who reigned about 250 B. C. Besides these pillars he is said to have erected 84,000 Buddhist sanctuaries called stupas or topes.*

Some of these monoliths are of great size, and are generally polished throughout the portion intended to be exposed. They were surmounted by carved and ornamented capitals, upon which figures of lions or elephants were placed.

The polished portion of the shaft tapered uniformly from base to summit, and in every way these remarkable monuments testify to considerable skill in the stone-cutter's art. Still it would appear that this art was not made use of in the erection of buildings, and when the first stone temples† were excavated and adorned a century later, the stone architecture, as pointed out and described by Mr. Fergusson, was a "mere transcript of wooden forms," showing that at that time the art of using stone for these purposes was only being then first adopted, and that though the material was changed, the workmen continued to use the designs suited to wood. It was only gradually through several succeeding centuries that the forms and designs became suitable to the material.‡

It is considered by the best authorities that the palaces, temples, and buildings generally of those early times were mainly constructed of wood, as they are for the most part in Burma and Siam at the present day.

The resemblance between these monoliths and those of Egypt, some of which have been taken away into Europe, cannot fail to strike the attention. The connection is believed to be more than a mere apparent one, the discussion of which, however, belongs to the province of the Antiquary.

As these *lâts* afford the most striking evidence which can be given of the size of the stones which are obtainable from the Vindhyan sandstones and the durability of the material, I append the following enumeration of the principal of them which are known. The details are chiefly from General Cunningham's Archæological reports:—

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* Balfour's Cyclopædia, Article Asoka.

† Stone monuments, Fergusson, 1872, p. 456.

‡ It is right to add that this deduction of Mr. Fergusson is contested by Babu Rajendra Lal Mitter. See Jour. As. Soc., Bengal.

List of remarkable Monoliths in India.

Name.	Position.	Material.	Length. Observed.	Length. Estimated total.	Diameter. Upper.	Diameter. Lower.	Weight (estimated).	Age or period.
Bakra or Bhim Sen-ka lât ...	Beshrah, 27 miles east of Patna...	Polished sandstone ...	32′	36′-37′	38″·7	49″·8	50 tons ...	Unknown.
Navandgarh	Lauria, 15 miles north of Bettia...	„	32′ 9½″	...	26″·2	35″·5	18 tons (polished portion).	Asoka } About 250 to 200 B. C.
Ara Raj		„	36′ 6″	...	37″·6	41″·8	34-40 tons ...	„
Firuz Shah's Pillar * ...	Delhi	„	...	42′ 7″	25″·3	38″·8	27 tons ...	„
„ No. 2 † ...		......	32′ 8″	...	29″·5	35″·82	...	„
Bhim Sen-ka gada ...	Kosam, on the Jumna	......	28′	36′-40′	29″·5	...	...	? „
Allahabad	... ...	......	...	42′	...	...	...	„
Kahaon	46 miles south-east of Goruckpúr	Coarse grey sandstone	24′ 3″	27′	...	...	...	84 A. D., or 219 A. D.
Bhutari	Between Benares and Ghazipúr ...	Reddish sandstone ...	15′ 5″	...	28″·85	...	...	? 100 A. D.

* Removed by Firuz Shah from its original site in district of Salora near Khizrabad, on the Jamna.

† Said to have been brought from Meerut.

Mr. Mallet mentions two large blocks which are found "about a mile south-east of Rupas near the quarry from which they were cut:" the dimensions of these suggest a near connection with those enumerated above. Not improbably they belong to the Asoka period. One is a circular column 34′ 6″ long, with upper and lower diameters of 2′ 8″ and 3′ 3″. The other is a parallelopiped 42′ 6″ long by 5′ 3″ × 3′ 8″ and 5′ 9″ × 4′ 1″, with an estimated weight of nearly 60 tons. The neighbouring villagers appear to know nothing of their history.

The quarries at Dehri on the Són are the most eastern of all those which have been opened in the Vindhyan rocks. At present they are largely worked in connection with the Són irrigation and canal projects. The stone is a compact whitish sandstone susceptible of artistic treatment, and, what is of more importance for the present purpose to which it is put, strong and durable.

The next point of importance where there are quarries is Chunár. The vicinity of the Ganges has, during a period of at least 2,000 years, afforded a ready means of transport for the excellent building stones which are obtained from the Kaimúr rocks at Chunár.

The East Indian Railway now affords an additional means of transport, but is, however, I believe, not very much used for the purpose, water carriage being so very much cheaper.

Benares, and other cities and towns of less note, both in ancient and modern times, have largely used Chunár sandstone. The ghâts at Benares, the palaces, the walls, the minarets, and many of the temples are built of this material. To Calcutta a certain quantity is brought for paving and tombstones, &c. The only stone church in Calcutta is St. John's, which is built of Chunár stone.

It has also been used to some extent in other buildings in Calcutta, but for paving purposes, as has elsewhere been shown, the so-called Burdwan stone has also been employed.

The next quarries to be mentioned are those of Mirzapúr, which, with those of Purtábpúr and Seorájpúr, have supplied Mirzapúr and Allahabad with material for the construction of their buildings, both ancient and modern. The stone for the Jamna bridge was, according to Mr. Mallet, obtained from some quarries a few miles up the river, whence it was brought down in boats.

From this the limits of the Vindhyan rocks sweep southwards in a great bay, and the next place where they have been worked to any large extent is in the neighbourhood of Gwalior, where they have been used in the construction of forts, temples, &c. It may be mentioned too that in the exposed faces of sandstone there are carved some figures of Titanic dimensions.

Although, as was remarked, the sandstones of the Riwa group are not generally used, still "in the neighbourhood of Hosungabad and also in the Sípri and Gwalior districts some thin red flags from ⅛ to 1 inch thick are much used for roofing."

Perhaps the most important quarries in India are those in the upper Bandérs to the south of Bartpúr, at Fatipūr Sikri, and Rupás, which have furnished building materials since before the commencement of the Christian era to the cities of the adjoining plains. Portions of the Taj at Agra, Akber's palace at Fatipūr Sikri, the Jamma musjid at Delhi, and generally the grandest and the meanest buildings in Agra, Delhi, and Mutra (Mathura) have drawn upon these quarries for their materials.

To quote Mr. Mallet again: "The palace of the Rajah of Bartpúr at Deeg, which is regarded as one of the most beautiful edifices in India, testifies at once to the excellence of the stone employed and the skill attained by the stone-cutters of that district. Cupolas resting on slender shafts of 2 and 3 inches diameter, arches supported on strong, yet graceful pillars, windows formed of single slabs of stone perforated into the most elaborate tracing, meet one at every turn."

In conclusion, it may be mentioned that the sandstones both here and at Chunár have been largely used for telegraph posts; the facility with which some of the varieties split renders it possible to obtain posts 16′ long of material which will resist white ants and the action of the weather.

Thus the ancient pillars of Vindhyan sandstone have been instrumental in annihilating time by preserving in an imperishable record fragments of the history of upwards of two thousand years ago, while the posts of to-day have been subservient to the destruction of space, for it may be said that the telegraph which bears our messages from Calcutta to Peshawur over a distance of 1,500 miles in a few seconds of time practically overcomes space.

The preceding remarks refer only to the Vindhyan rocks, as exhibited in the great Vindhyan and associated ranges on the south of the Gangetic valley. In order to complete this notice, it will be necessary to allude to the occurrence of rocks believed to belong to the same geological period in other parts of the peninsula.

Between Sambalpúr and Raipúr in the valley of the Máhánadi, a series of sandstones, shales and limestones, considered to be contemporaneous with some of the Vindhyan series, occupy a considerable area. But in that wild part of the country there has as yet been no local demand for building stones.

Again, rocks referable to the Vindhyan series occur in the country to the south of Nágpúr, in the region about the confluence of the Weinganga and Warda rivers.

In the Karnúl district south of the Kistna there is another series of limestones, shales and quartzites which is considered to be referable to the Vindhyans.

Mr. King, in his description of these rocks and the underlying Kadapa formation, says: "There is no lack of good and easily wrought stone all over the district; but these can only become of value as they are locally required or as the means of communication are opened out over tbe district."*

For further examples of the uses to which these sandstones have been put in ancient times reference should be made to General Cunningham's Archæological Survey Reports.

Among the sandstones of the Dámúda series (the representative of the carboniferous period in India) there are several varieties which are suited for building purposes and which have already to a small extent been made use of.

Throughout the Dámúda valley where these rocks occur, they have been used in the construction of temples, some of which are of considerable antiquity. Among the finest examples three Jain temples at Barákar are deserving of particular notice, as exhibiting some rather elaborate carving which has stood well.

But still more ancient work in this material is to be seen in the caves of Sirguja and Cháng Bokhár, which bear inscriptions in the old *Pali* character, testifying to their extreme antiquity.

In recent times the sandstones at Barákar have been quarried largely for local use in the construction of the Barákar bridge and for various purposes in connection with the East Indian Railway. A considerable portion of the new High Court in Calcutta is also built of this material. Being readily accessible at the terminus of the Barákar branch of the railway, this rock will probably always be more or less used for purposes to which brick is not suited.

In Hazáribágh and Ránchi some of the sandstones of this series have been used to a small extent, and the flaggy beds of the underlying Tálchírs to a somewhat larger extent for paving the European barracks, &c.

References to these sandstones will be found in the numerous reports on coal-fields in the Memoirs and Records of the Geological Survey.

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* *References.*

Voysey, on the building stones and Mosaic of Akberabad or Agra, Asiatic Researches, XV, 1825, p. 429.
Owen, Purtabpúr stone quarries, P. P. on I. E., II, 1865, p. 81.
Blanford, W. T., Western India, Mem. Geol. Surv., India, VI, 218.
Mallet, Vindhyan series, Mem. Geol. Surv., India, VII, p. 116.
King, Kadapa and Karnúl formations, Mem. Geol. Surv., India, VIII, p. 281.

The sandstones of the various groups included in the Máhádévá series have been largely used; the members of the lower groups are, however, in many cases either too friable or contain too much iron to be lasting when exposed to the atmosphere.

In the Bágra group, a sub-division of the Máhádévás, there are sandstones applicable to building purposes, and which have been used to some extent locally. The Tawa viaduct is built of these sandstones.

Some of the beds of sandstone in the Jabalpúr group yield an useful building material. A very dense indurated variety, which occurs in the station of Jabalpúr, has been quarried to a considerable extent for local purposes.* The viaduct over the Narbada below Jabalpúr furnishes the most important example of the applicability of the sandstones of this group to building purposes.

Close to Katák (Cuttack) there are some sandstones which Mr. Blanford considers to be younger than the Máhádévás, but the exact age of which is, from the absence of fossil remains, still uncertain. These sandstones were used in the construction of temples at Bobaneswar, and to some extent for various building purposes in Katák; but laterite and gneiss seem to have been more largely employed. Some ancient caves at Kundageree have been excavated in these rocks.†

The intertrappean rocks of the Rajmehal series, whose contained fossil plants present a markedly jurassic facies, consist of sandstones, flag beds, and shales. The two former are occasionally employed for local building purposes, but cannot be considered to be of much importance.

The compact sandstones of this series at Conjeveram and several other places offer, according to Mr. Foote, a very easily dressed and moderately durable building stone.

In reference to the jurassic rocks of Kach, Mr. Wynne says: "The finer grained slightly calcareous yellow sandstones of the lower jurassic group form tolerable building stone; and some of the close, hard silicious grit bands, though difficult to trim or dress fine, would afford a very lasting material for rough work."

Several other sandstones are locally used. Mr. Wynne gives a list of the different building stones used in Bhúj, as furnished to him by His Highness the Rao of Kach.

Rocks of this age are found in the Rajmehal Hills, Utatúr (Ootatoor), and at various places on the east coast between Trichinopoli and the Godáveri and in Kach.‡

The Bágh beds, which belong, it is considered, to the cretaceous period, contain some good sandstones suited to building purposes. Mr. Blanford, in his report on Western India, says: "The massive sandstone of the Déva and those which occur throughout the country to the south of Allirájpúr and Bágh would furnish excellent material. The gritty calcareous bed at the top, where it is not too cherty, would be well adapted for construction and could be easily worked.§

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* Medlicott, Records, Geological Survey, V, p. 77.

† *References.*

Building materials of the district of Cuttack, Jour. As. Soc., Bengal, XI, p. 836.
Memoirs, Geological Survey, I, pp. 250 and 277.
Records, Geological Survey, V, p. 59.

‡ *References.*

Oldham, Jour. As. Soc., Bengal, and Pal. Ind.
Foote, on the Geology of Madras, Mem. Geol. Surv., India, Vol. X, p. 132.
Wynne, Geology of Kach, Mem. Geol. Surv., India, Vol. IX, p. 93.

§ Blanford, Western India, Mem. Geol. Surv., India, VI, p. 380.

The rocks of the Sivâlik and Náhan groups which represent the upper and middle tertiary period of Europe are generally too unconsolidated to form durable building stones. These rocks, as is well known, form the outer ranges of the Himalayas at various places from west to east.

Mr. Medlicott remarks: "Those stations, as Dagshai, Kasaoli, Subathu, Dhurmsala, which are built on the eocene groups of the Sub-Himalayan series, have an unfailing supply of good building material in the massive sandstone rocks. Among the older rocks there is no stone fit for anything but that for which rough rubble may be used. There are several examples of native architecture along the border of the plains for which an excellent building stone was obtained from rocks of the Sivâlik group, but it must have been found in detached blocks and discontinuous bands, the mass of the rock being quite unfit for the purpose. Stone fit for ornamental or monumental purposes might be found among the thick-bedded, hard limestones of the Krol group."*

QUARTZITES.

The gradation from the loosest and most granular sandstone to the most intensely vitrified quartzite is so complete that it is impossible to draw a sharp line of demarcation between them. I therefore place the quartzites with the sandstones in this enumeration. Were the arrangement a purely geological one, a large portion of them would have to be classed with the schistose or gneissic rocks.

If we except those varieties of the Vindhyan and Karnúl sandstones which are sometimes called quartzites, the use of rocks coming under this denomination has been very inconsiderable. Indeed the only instance known of a quartzite being regularly quarried is in the Susinia Hill in Mánbhúm. The works there were carried on for some years by the Burdwan Paving Stone Company, and large quantities of the stone have been used in Calcutta for pavings, copings, and other similar purposes. There are several varieties of this material found; in some there is a large proportion of felspar, when it should be called granulit rather than quartzite.

Although these rocks have been so little used, the Bijaur or submetamorphic series, in many parts of the country, afford quartzites suitable for building purposes; wherever these occur in the vicinity of Vindhyan sandstones, the latter will naturally be preferred, as they are in most instances much more easily worked. The vitreous fracture of many quartzites is in fact a bar to their employment where much finish is required.

IX.—LATERITE.

The term laterite has been applied generically to a group of rocks which play an important part in the superficial geology of India. The common character which persists throughout all the varieties of laterite is the possession of a ferruginous element which is in the form of brown hydrated peroxide on the surface, sometimes as the black magnetic ore inside. The reddish-brown appearance, due to the presence of the peroxide, explains the origin of the name (*later*, a brick) which was, I believe, first conferred upon it by Dr. Buchanan.

The various forms in which laterite occurs are due to differences of composition and differences of structure. The combinations of these two qualities produce almost infinite varieties. The principal structural varieties are either nodular or cellular, the former being the younger, and it is supposed, in a measure, derived from the latter. The varieties in composition vary much in the quantity of the peroxide which they contain and in the character of the other materials. Both classes pass off into mere detrital laterite, to the ferruginous element in which they have no doubt mainly contributed.

* Medlicott, Mem. Geol. Surv., India, III, p. 175.

This is not the place for going into details or enumerating the various theories which have been suggested to account for the origin of this most singular deposit. It may be mentioned, however, that no theory accounts satisfactorily for the sources whence the large amount of iron can have been derived.

The distribution of laterite in India is widespread throughout the Peninsula, Ceylon, and in Burma. It occurs not only as a costal deposit underneath the Eastern and Western Ghâts, but also in many parts of the interior, not unfrequently capping lofty hills and plateaus to a depth of several hundred feet, often producing the dead level surfaces which constitute a striking feature in Indian scenery. Although perhaps it shows its finest development on or in the vicinity of trappean rocks, it occurs resting on rocks of all periods, occasionally far removed from any exposure of trap. It has not been observed, I believe, in any part of the Himalayas.

As a building stone, though it can hardly be called ornamental, it possesses some qualities which render it acceptable in the eyes of the natives; it is easily worked, hardens on exposure, and wears well. In the costal districts many temples, some of considerable antiquity, are built of laterite and appear to have stood well. In the Rajmehal Hills there is a small fort built of neatly cut blocks of laterite without mortar. These blocks have retained their original sharp edges.

In Midnapúr and Orissa slabs of from 4 to 5 feet long are extracted by cutting a groove round the slab above and another underneath, a few wedges are then driven into the latter, and the slab splits off. This or a nearly similar process is used for the extraction of blocks of laterite in all parts of the country where it is worked by natives.

Mr. King, in his Geology of Trichinopoli, says: "Where of poor quality, the laterite soon crumbles away when exposed to the influences of weather and moisture, as may be seen in the basement of many of the houses in the Fort of Tanjore. The laterite has there weathered away, leaving the walls perfectly honeycombed, and the layers of mortar, which are more durable, standing out as a regular net-work." In a note Mr. Foote adds: "The laterite in this case was in all probability badly selected, for in all my subsequent observations of this stone as a building material, it would appear that continued exposure to atmospheric influences, or wet, as in the case of tanks or bowries, only tends to improve the stone. Most of the religious edifices and tanks constructed of this stone show the lines and angles of the carvings as sharply as though fresh from the builder's hands."

Mr. H. Blanford also remarks: "At Andanapet I noticed some carved blocks forming part of an old and ruined pagoda the mouldings of which were as perfect as when first cut. Owing to its porous structure, however, laterite is but little fitted for fine sculpture."

Laterite has been largely used in the works in connection with the irrigation operations in Orissa. The anicut on the Kossai at Midnapúr has been altogether built of this material. The stone for these purposes has, I believe, given the engineers much satisfaction.

The Vellour anicut at Chetia-tope near Bhowagiri in the Trichinopoli district is partly built of laterite.

Dr. Balfour gives the Arcade Inquisition at Goa, St. Mary's Church, Madras, and the old fortress at Malacca, as examples of its use in the construction of buildings by Europeans.*

* *References.*

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X.—SLATES.

For building purposes, more particularly for roofing, slates have not been much used in India, except in some of the stations of the North-West Himalayas. This is probably due to two causes, the first and principal being that in the oriental style of flat-roofed architecture which is generally adopted for British buildings in India, slates could be only partially employed, and in the alluvial districts their place is amply filled by tiles.

Secondly, most of the slates known to occur in India, are either non-cleavable, or, if cleavable, retain also their laminated faces. The laminated slates are difficult to work into sufficiently thin layers, and are not much used, as an undue amount of timbering becomes requisite to support the weight of slates of this character.

At Dalhousie there are some large quarries in which there are slates and schists of various qualities. The best are said to be much more schistose than Welsh slates, still they are readily fissile, can be easily dressed, and can be obtained of considerable size. The fissile plains are in this instance parallel or nearly so to those of lamination.

The slates in use at Simla* are, according to Mr. Medlicott, distinctly laminated, and in every way inferior to those obtained along the flanks of the Dháoladhár, and which are used at Dalhousie and Dhurmsala.

Slates, the qualities of which are not so well known, are also obtained at Ferozpúr, Páli, Chimnawar, and Sonah, all in Gurgaon, and at Attock, Abbotabad, and Spiti.

At Chitéli, in Kumaon, occurs a slate which it was proposed to employ for roofing purposes at Ranikhet and other places. Mr. Hughes, comparing this slate with the Welsh standard, writes: "It differs from the latter in splitting along the lines of lamination instead of the planes of cleavage. It is coarser in texture, more silicious (sandy), heavier, and has a duller ring on being struck." The supply is ample for all possible requirements, and slabs of a foot square, ¼ of an inch thick, can be obtained easily.

In the submetamorphic rocks (Bijaur series) of Chota Nágpúr slates not uncommonly occur. In these the fissile planes are for the most part those of lamination. In Mánbhúm I met with a bed, however, which had most distinct cleavage structure, but there was also a tendency to split along the layers of lamination; thus, this rock breaks up into regular prisms at the surface, but it is not impossible that a good slate might be obtained, as the material is compact and dense.

In Chaibassa the school-boys have only to run down to the stream near the town to obtain a new slate for doing their sums on.

In the Karakpúr Hills, near Monghir, slates have been extracted.

The demand for slate is so small in Calcutta that I do not think it probable that these slates will ever be quarried to any large extent.

In the Champanir beds between Soorajpúr and Jumbooghora, north-east of Baroda, there are some slates which, as far as can be judged from their appearance at the surface, are considered promising by Mr. Blanford.

In the Bijaur series near Bágh there are also slates which are not so fine grained as the preceding, but some of which might perhaps answer for roofing purposes.

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* Some of the slates which have been used at Simla for roofing temples are said to have lasted for hundreds of years.

Clay-slates occur both in the Kadapa and Karnúl formations in Madras; but though thin slabs can be obtained, they are not suited for roofing purposes, and where harder and more durable stone is obtainable their employment for flagging is not recommended.

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SECOND NOTE ON THE MATERIALS FOR IRON MANUFACTURE IN THE RÁNIGANJ COAL-FIELD, *by* THEODORE W. H. HUGHES, A. R. S. M., F. G. S., *Geological Survey of India.*

In continuation of my former paper* on the raw materials for iron smelting in the Rániganj field, I have a few analyses of iron ore and kunkur to record which will afford a more complete series for computing their values than already exists.

Iron-ore.—The percentage of iron in several different samples of ore from various spots in the Rániganj field has been given in the Memoirs of the Geological Survey,† but the impurities were not separately estimated. In the following analyses the amount of alumina, lime, phosphoric acid, and insoluble residue, besides the iron, is indicated; and a useful comparison can be instituted between the Rániganj ores and those of other countries. All the samples are derived from the iron-stone measures, known geologically as the iron-stone shales group, and they were collected entirely in the western portion of the field:—

	Bagúnia No. 1.	Bagúnia No. 2.	Boldih.	Chalbalpúr.	Kúlti.	Malákolá.	Sibpúr.	REMARKS.
Insoluble	13·6	10·6	20·4	14·8	19·6	18·8	21·2	(a). A little magnesia and sulphuric acid occur in the Chalbalpúr, Chinákúri, and Malákolá ores. Being small, it was not quantitatively determined.
(Silica)	(11·6)	(8·6)	(16·8)	(12·1)	(16·4)	(16·2)	(17·)	
Sesquioxide of iron ...	65·44	53·2	52·28	66·45	60·4	62·92	43·82	
Protoxide of iron ...	...	13·48	1·08	...	...	...	8·92	
Alumina	6·25	4·07	5·89	4·7	5·8	3·91	5·17	
Lime...	·8	1·0	4·03	2·24	2·9	2·88	3·36	
Magnesia	·7	·85	1·8	a	·6	a	a	
Phosphoric acid... ...	·71	·57	1·43	2·05	2·2	2·57	2·3	
Sulphuric acid	...	·55	...	a	...	a	a	
Loss on ignition ...	13·5	16·0	13·2	9·6	9·2	10·2	14·4	
TOTAL ...	101·0	100·32	100·15	98·84	100·7	101·28	99·17	
Metallic iron ...	45·80	47·72	37·43	46·5	42·28	44·03	37·60	

* Records, Geological Survey of India, 1874, Vol. VII, Pt. I, p. 20.
† Memoirs, Geological Survey of India, 1860, Vol. III, Art. 1, p. 194.

Phosphorus.—An abstract of the phosphorus contained in these samples shows that the minimum quantity is ·23 per cent., while the maximum is 1·12 per cent. :—

Bagúnia	·23
"	·31
Boldih	·62
Chalbalpúr	·89
Kálti	·95
Sibpúr	1·04
Malákolá	1·12

These results indicate that much of the ironstone might be employed for the production of iron, but that some of them are bad.

It is possible that the quality of certain beds may be regular or nearly so, in respect to the amount of phosphorus they contain, and that by selection we may avoid the use of such bands as may be unsuitable. This feature must be determined before a final opinion can be expressed on the value of the ironstones.

Proportion of iron.—The proportion of iron is much larger than that contained in the bulk of ores employed in England; and some specimens are much richer than is indicated by the foregoing analyses.*

Kunkur.—These samples were examined by Mr. Tween, showing the amount of oxide of iron, alumina, insoluble residue, water and organic matter contained in them. The minimum quantity of carbonate of lime is 54 per cent.—

	Barmúrí.	Rámnagar.	Sánktoria.
Insoluble	40·6	30·4	27·2
(Silica)	(32·8)	(23·0)	(19·4)
Oxide of iron and alumina	2·7	1·9	2·0
Carbonate of lime...	54·0	65·4	66·3
Water and organic matter	2·7	2·3	4·5

Other samples of kunkur from the above localities gave of carbonate of lime—

Barmúrí	61·1	per cent.
Rámnagar	64·98	"
Sánktoria	66·12	"

The finest specimens were since furnished by Mr. Hynd, of Báséra. They contained as much as 79·5 per cent. A few analyses (in subjoined table) placed at my disposal by Mr. Dejoux show a range from 56·94 to 78·50 per cent. of carbonate of lime, giving an average result for the entire series of analyses of about 65 per cent. With this proportion of carbonate of lime, kunkur will be quite capable of acting as an efficient flux.

	Ránigánj.	Ránigánj.	Ránigánj.	Barrákar.	Bhiokúnd.
Carbonate of lime	72·0	56·94	66·50	66·20	78·50
Carbonate of magnesia	1·30	1·72	·20	1·50	2·00
Oxide of iron	·70	1·67	3·20	2·80	2·00
Clay	22·0	30·0	27·60	22·00	10·50
Sand (free)	2·0	9·67	2·50	7·50	7·00
TOTAL ...	100·00	100·00	100·00	100·00	100·00

* A sample from the Madápúr property of the Ránigánj Coal Association yielded as much as 52·45 per cent. of iron, and laterite from the same locality gave 25·38 per cent., which is above the average for that form of ore.

Limestone.—Besides kunkur there is some impure rock-limestone near the village of Páhárpúr at the base of Panchet Hill. It is a well known bed, and is marked on the revised map of the Ráníganj field. It contains 56·43 per cent. of carbonate of lime, and varies in thickness from 12 to 15 feet. A large quantity of stone might be obtained from it, but it possesses the disadvantage of dipping at a high angle.

Calcareous nodules.—There is, in addition to kunkur and rock-limestone, another source of flux, and that is the calcareous nodules in the clay beds of the Panchet series. The average proportion of carbonate of lime was found to be 66·8 per cent. The importance of this supply is quite subordinate to the kunkur, but it is well to bear it in mind.

Calcareous concretions also occur in the Tálchír series.

Limestone beyond the field.—In reference to limestone beyond the field, I have no additional information to record regarding the stone discovered by my colleague Mr. Mallet; but I have had an opportunity of inspecting a small quantity of limestone brought from the south side of the Damúdá near Ráníganj. It looks extremely pure, and if it occurs in anything like quantity, it would be of great value.* I scarcely anticipate, however, that it will be found in abundance, and the kunkur will, in the event of any attempt to establish large iron works, probably be the flux on which to rely.

Use of kunkur in Bírbhúm iron works, 1860.—Kunkur was successfully employed in the Bírbhúm iron works, and Mr. Blanford, when reporting upon them in 1860, records as a fact that Mr. Casperz, the manager, found it advantageous to partially burn the kunkur and then to slake it, in order to separate the more impure external parts.

This process could only be advantageously applied to the more regularly concretionary varieties of kunkur, showing centrical concentration, for the ordinary form of this rock is without any distinctive purer core.

Relative quantity of ore and kunkur.—I stated in my former paper that equal quantities of ore and kunkur would be required for the production of iron in a blast furnace. In the Bírbhúm works, a less proportion of kunkur was found to be sufficient, only 3 of kunkur to 7 of ore being necessary. Charcoal, however, was the fuel then employed, whereas in my experiments, coke containing as much as 30 and 40 per cent. of ash was used, and the ore was not quite so clean. With better coke, and an ore with an average of 42 per cent. of iron, the amount of kunkur requisite would be less. In estimates of the cost of manufacture, however, it is as well to be on the safe side, and equal quantities ought to be allowed for.

Malleable iron.—For the production of malleable iron, the direct process, which, I am indirectly informed, has been quite recently perfected by Dr. Siemens, greatly improves the prospect of the undertaking in India, for the impure as well as for the purer ores. One of the chief objections made to this process by iron-masters in England, that a greater proportion of the iron passes into the slag than occurs in the present method of manufacture, does not apply to the case in India, where a saving of materials is quite a secondary consideration to that of a saving in skilled labour.

The advantage claimed for this process, of not bringing the phosphorus into combination with the iron, removes one of the most serious impediments to the development of the great advantages for iron manufacture otherwise possessed by the Ráníganj coal-field.

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* Since writing the above, I have visited the locality whence the limestone was taken. It occurs as nearly pure calc-spar in small veins, striking N. and S., through a decomposed bed of gneiss. It will pay for extraction for special purposes, but cannot be looked to as a source of flux.

MANGANESE ORE IN THE WARDHA COAL-FIELD.

In connection with the question of iron-manufacture in India, it will be of interest to notice a discovery I made this year, within the limits of the Wardha coal-field, of a deposit of manganese ore, which is at present an ingredient of great service in the process for converting iron into steel, although its prime function in that process, and the presence of a certain proportion of manganese in the best steel, are questions still under discussion.

In 1869 I drew attention, in the manuscript report of my season's work, to the occurrence of manganiferous sandstone in the Kámthi series, but the proportion of manganese to the other constituents of the sandstone was altogether too small to render my discovery anything more than merely interesting. This year I was fortunate enough to meet with a much more available source of manganese, and it is this source which I wish to draw attention to.

The ore occurs in botryoidal masses in the red clays of the Kámthi series around Malágarh Hill. These concretionary lumps as usual contain much foreign matter, but the proportion of oxide of manganese is considerable. An analysis by Mr. Tween gave:

Manganese ore—

Loss on heating	8·5
Oxide of manganese	44·6
Iron and alumina	6·8
Sand and clay	40·1
TOTAL ...	100·0

The physical characters are those of psilomelane, which is a proto-peroxide of manganese; hard, having a bluish black colour, submetallic lustre, and a brownish black streak.

Of the ores of manganese this is about the most abundant. It is closely allied to pyrolusite, and by some mineralogists is considered to be only an impure variety of it.

I did not attempt to estimate the probable quantity procurable from the beds in which this ore occurs, as I wished before tracing it out closely to have its value determined analytically. I remember, however, being impressed with the idea that there was a large amount of it, of more and less purity than the sample I sent to our Museum.

None of our Indian iron-ores are known to contain more than a trace of manganese, and the independent ores of this metal seem to be somewhat scarce.

In the Panjáb it is said to come from Jammú, which may mean anywhere within the extensive Himalayan territory of the Máhárâj of Kashmír.

In Madras it is said to occur near Vizianágram, in Karnúl, Maisúr, and the Nilghiris.

In Barmá, it has been reported upon by our own officers and others.

In Bombay an earthy mixture of iron and manganese oxides, occurring as a dark brown powder in magnesian limestone, was found this year by my colleague Mr. Foote, at Bhimgarh in the Belgaum district. Its composition is—

Water and organic matter	14·6
Oxide of iron and a little alumina	22·0
Binoxide of manganese	20·0
Insoluble	44·8
	101·4

The consumption of manganese ore has hitherto been very unimportant in India; but if the extensive plans now under consideration for the conversion of the pure iron-ores of Lohárá be ever carried out, we may expect a considerable demand for manganese.

THEODORE W. H. HUGHES.

Calcutta, 1st July 1874.

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THE AURIFEROUS ROCKS OF THE DAMBAL HILLS, DHARWAR DISTRICT, *by* R. B. FOOTE, F. G. S., *Geological Survey of India.*

It had long been known that the sands of various streams taking their rise in the Dambal Hills contain gold; but the sources from which this stream-gold was derived were not positively determined, and it was with the object of settling this point that I was officially deputed to visit the hills in question at the close of last field-season.

The results of my examination of that region show that one source of the gold is to be found in at least one auriferous quartz reef, which will be described further on.

Stream-gold is known to occur also in several other places in Dharwar and Belgaum Districts, but, as far as I could ascertain, in very much smaller quantities. One locality in the Kuladgee District is doubtfully reported as auriferous. These occurrences will be again referred to.

Geographical position.

The Dambal Hills are situated in the Gudduck Talook, some miles south-south-east of the town of Gudduck, and are locally known as the Kappatgode, being so called after the temple sacred to Kappat Iswara, which stands on the western flank of the main hill, in long. 75° 45' east, and lat. 15° 13' north. They form the northern part of a belt of elevated ground extending in a single or double ridge north-north-west from Harpunhully, in Bellary District, across the Toongabadra to Bingud Kuttee, 3 miles west of Gudduck, where the ridge sinks into the great, black, regur-covered plain of Dharwar. The Kappatgode itself forms the highest part of the ridge, which there rises about 1,000 feet over the surrounding country in a bold, steep mass, whose flanks, though bare of jungle, are much obscured by débris, and during the rains well covered with long lemon-grass.

Rocks belong to the gneissic series.

The rocks which form this ridge and all the adjacent country for many miles around belong to the great gneiss formation of Southern India, and have here been subjected to immense disturbances, producing great contortions and fractures, and in parts a much greater degree of metamorphism than is usually met with, which adds greatly to the difficulty of unravelling the very obscure stratigraphical features of these hills. A complete solution of these stratigraphical obscurities will only be obtained by extending the survey both north and south of the auriferous tract, to which alone I confined my attention, as my time was limited and moreover much encroached upon by frequent heavy rain-storms. Immediately north of the Kappatgode Hills the continuity of the ridge is broken by a cross valley running nearly due east and west, and opening into the plains immediately west of Dambal. This valley is drained by the Dhoni nullah, which falls into the great Dambal tank, whence its waters eventually drain into the Toongabadra. On the south side of this valley the hills widen out considerably owing to the presence of a third ridge, but contract again to the south of the Kappatgode.

Geological structure of the ridge.

The ridge in its northern part, lying beyond the gold tract (where it is single and its structure quite simple) shows a double series of hæmatite schist beds intercalated between chloritic and other schists of great thickness, which to the east touches a broad band of highly silicious and often granitoid gneiss, on which stands the town of Gudduck. I found no section showing the exact relations of these two series; but it is most probable that the granitoid series, which may conveniently be called the Gudduck series, overlies the chloritic and ferruginous beds. On reference to the map accompanying these notes, it will be seen that further south a third hæmatite schist band appears at a still lower level, also accompanied by chloritic, hornblendic, and micaceous schists, and bends round on itself in a sharp curve immediately north of the Kappatgode, thus forming an anticlinal ellipsoid, which is crossed by the road running from Dambal to Soortoor. To this series I will give the name of the Dhoni series, from the village of Dhoni, which stands on it. This series is noteworthy, because containing several important beds of grey and greenish-grey crystalline limestone of considerable thickness, which would yield a building stone of great beauty and excellence, and far cheaper to work than any of the granitic rocks of the neighbourhood. If pure enough to yield good lime on burning, it would prove of great value in the event of the railway extension between Bellary and Hoobly being carried out, through a country otherwise poor in limestones. The principal beds lie in two groups, the one 2 miles north-west of Dhoni, the other 3 miles west-south-west of that village. Overlying this to the westward are other hæmatitic beds, the representatives doubtless of those before named, if not, indeed, the extensions of the same. As these beds form the mass of Kappatgode Hill, I will call them, and their more northern representatives, the Kappatgode series. The character of the associated schistose beds has changed, however, from chloritic to argillaceous, and the predominant color of the rocks from green to reddish buff or mottled whitish. Owing to the great development of cleavage, the true dip of these argillaceous schists is in many places perfectly obscured, and their relation to the rocks next following them to the westward very problematical. This next series consists of chloritic and hornblendic schists, intimately associated with a massive dioritic rock. This dioritic rock, though in parts strongly resembling some of the diorites forming the trap-dykes, which occur so frequently in the gneissic region, does not appear to be an irruptive rock, but rather a product of excessive metamorphism. The schistose rock appears to pass by imperceptible graduation into the highly crystalline mass. Nowhere did I find the two dissimilar rocks in close apposition, but everywhere some feet or yards in thickness of rock intervened, showing the graduation of the special characters. This series, which I will call the Soortoor series, after the large village of that name, at which the principal gold washing is carried out, occupies a band of country some 4 to 5 miles broad, which is bounded to the westward by a band of granitoid gneiss of undetermined breadth. The position of this granitoid band (which may be called the Moolgoond series) relatively to the Soortoor series is uncertain; but it is probable that the latter series is the younger of the two.

All the streams said by the natives to be auriferous rise within the limits of the tract occupied by the Soortoor series; and the upper course of the Soortoor nullah, the richest of all, lies entirely within the area occupied by the pseudo-diorite, and associated chloritic schists.

Quartz reefs in the Soortoor series.

Quartz reefs occur in all the rock series above enumerated, but those lying within the limits of the Soortoor series are the best defined, and, with a few exceptions, have the most promising lie, their direction being mostly north-by-west, south-by-east, or parallel to the strike of the bedding. The surface of the principal reefs has been much broken up, doubtlessly by gold-seekers.

The quartz reefs occurring in the other series are mostly well defined, and, with two or three exceptions. run in different directions. Many run in the lines of strike of the bedding, but many cut across it in various directions.

Auriferous reefs in the Kappatgode series, or Huttee-Kuttee reef.

The most remarkable quartz reef in the whole auriferous tract, and the only one from which I succeeded in obtaining gold, lies about a quarter of a mile east of the eastern boundary of the Soortoor series, on the eastern slope of a ridge lying north-west-by-north of Huttee-Kuttee, a small village on the road between Dambal and Soortoor. This reef, which runs north-by-west, south-by-east, lies in the line of bedding of a series of reddish ferrugino-argillaceous schists with chloritic bands, both containing numerous cubical crystals of pyrites now converted into limonite by pseudomorphosis. The reef is rather less than half a mile in its entire length, and only in a small part of this is it a well-marked vein. Both the southern and northern extremities are very irregular, thinning out to a mere thread, or a few parallel threads in places, and then swelling into bunches, to thin out again a few feet further on. The reef does not cross the valley of the Guleeguttee nullah to the north, but thins out and disappears on the side of the ridge. The quartz is the ordinary dirty white variety, and includes a few little scales of chlorite along the lines of jointing, together with occasional cubes of pyrites, which, like those in the schists, have been pseudomorphosed into limonite. Parts of the quartz are ferruginous, the impure oxide of iron occurring in strings and lumps. The specimen of gold I obtained here is imbedded in such a ferruginous string. Though very small, it is quite recognizable, and shows a great resemblance to various pieces of stream-gold obtained by washing. It is of a very rich color. The piece of quartz containing it lay among the débris, beside the top of the reef at its highest part, where it has been much broken up by gold-seekers, by whom irregular mining operations have been carried on along the course of the reef. Much of it has been completely broken up, and the hill side thickly strewn with fragments. Three rude sinkings hardly deep enough to deserve the name of pits, and a considerable length of shallow trenching along the course of the vein, remain still visible. Besides these, there is an old pit sunk on the east side of the wall-like part of the reef some little distance down the slope, probably with the object of ascertaining the continuity in depth of the reef. This seems to have been sunk by some one having more advanced ideas than the authors of the diggings on the back of the reef; but I could ascertain nothing certain or satisfactory as to whose work it had been. To the north-west of the reef a number of little short veins and bunches of quartz had been attacked in shallow trenches, and had had their surfaces knocked to pieces by the same people, who were, according to my guide (a coolie from the village of Dindoor), a company of native goldsmiths who lived in the now totally deserted village of Guleeguttee (Kubun Kutkuttee of the Revenue Survey Map). These works had been carried out at some period prior to any time within the memory of my informant. The patels of Dhoni and Soortoor and others, of whom I enquired concerning these diggings, either could not or would not give me any information about the people by whom they had been made. I am rather inclined to suspect that the pit last mentioned was sunk by the Manager of a Gold Company which was got up during the Bombay share mania, and which Company, under the guidance of a practical Australian miner, sunk a lakh and a half of rupees in the search for auriferous quartz, and obtained no returns but a few small nuggets of *Australian* gold, sent down from time to time by the judicious manager to allay the anxiety in the shareholders' minds till a convenient season came for him to disappear without having accounted for his expenditure. The only positive trace of his proceeding which I came upon or heard of was a pit about 15 feet deep, sunk on the south side of a quartz reef belonging to another series lying south of the village of Dhoni.

The Huttee-Kuttee reef is about 5 feet thick on the average, where well-defined and wall-like. The strike, as before-mentioned, is north-by-west, south-by-east, with an easterly dip of from 40° to 50°. Much of the reef has been broken down, but a length of about 35 yards remains like a cyclopian wall, and forms a very conspicuous landmark from the east.

Reefs in the Dhoni series.

The only other reefs deserving separate mention form a group lying about a mile to a mile and a half south of Dhoni village, on the north-east flank of the Kappatgode mass. Unlike the reefs already referred to, the reefs in this group consist, not of ordinary milk-white quartz, but of a distinctly bluish or deep grey diaphanous variety, with a varying amount of enclosed scales of white or pale mica. These reefs may, according to their courses, be assigned to two subordinate groups, of which the one was north-west by south-east, the other north-east-by-east, south-west-by-west. The members of the latter sub-group are much the best defined, and form dyke-like veins 5 to 6 feet wide and from 400 to 600 yards long. The other set, lying on the east side of the small stream, which flows from the north-east side of the Kappatgode into the Dhoni nullah, a little east of the village of Dhoni, are less well-defined veins, but of considerably greater length than the former.

None of the reefs in the Dhoni series run in the lines of bedding of the chloritic, hornblendic, and micaceous beds they traverse; but there are a very large number of bunchy strings of quartz of the ordinary milky white variety which run in the lines of both bedding and cleavage, but all of a size far too small to show on any but a very large-scaled map. These, as well as the diaphanous quartz reefs, contain remarkably little iron oxide; the superficial staining they show is due mainly to the decomposition of included portions on the surrounding rock.

The remaining quartz reefs noticed in the auriferous tract on the east flank of the Kappatgode, on the west flank of the ridge running north and north-west from the Kappatgode, and in the valley to the north-west of Dhoni village, are all of the ordinary variety of quartz running more or less in the strike of the bedding, and presenting no noteworthy peculiarity. As in all schistose rocks of the ordinary types, an immense quantity of free quartz occurs throughout their mass, in the form of laminæ, strings, bunches of all possible sizes. It is from these, rather than from the débris of larger veins in reefs, that the innumerable lumps of quartz covering the face of the country generally are derived. As the country is in most part utterly devoid of any vegetation except grass, all the larger occurrences of quartz are conspicuous objects in the landscape, need but little searching for, and are easily prospected.

Reefs in which a sulphide was found.

The almost invariable association of gold with the different sulphides of iron, lead, copper, &c., in quartz reefs, is well known; and hence in prospecting the reefs I have before referred to, I paid great attention to the indications of the presence or absence of sulphides, besides searching for metallic gold. In only three did I obtain positive evidence of the existence of a sulphide—the sulphide of iron—in the form of cubical pyrites. These three were the Huttee-Kuttee reef and the two parallel reefs to the east of Venkatapoor, but the number of inclosed crystals is in each case very small. It is largest in the Huttee-Kuttee reef. Much of the quartz in the different reefs is what the Australian miners technically call "mouse eaten;" that is, full of cavities formed by the weathering out of other mineral substances which had been enclosed. In the great majority of cases it was clear from the form of the cavities left that the enclosed minerals had been chlorite or hornblende. None of the cavities were cubical. In one reef in the Dhoni group I noticed some small and rhomboidal cavities, probably due to the removal of enclosed crystals of calcspar. Free gold is often found left behind in such cavities in really auriferous reefs in Australia and elsewhere; but none was met with here. All the reefs observed lie above the surface of the surrounding country, and have hence been far more exposed to weathering influences, which might account partially for the absence of sulphides in the reefs, but which will not account for the absence of the characteristic cavities they should have left behind.

From the great paucity of sulphides a proportionate paucity of gold is to be reasonably inferred in the reefs of the Kappatgode area. I must have broken off several hundred pieces of quartz while prospecting, but not one contained any visible gold; while that found loose at the Huttee-Kuttee reef contains but a very small quantity—a mere speck. A number of carefully selected samples was brought away from the most promising looking reefs, to ascertain whether they contain gold in so finely divided a state as to be invisible to the naked eye, which is frequently the case in Australian and Californian reefs. These were assayed at the Calcutta Mint through the kindness of Colonel Hyde, and in the Survey laboratory by Mr. Tween, but none of them yielded any gold.

Even if the reefs were moderately auriferous, the pioneers in mining operations would have many serious difficulties to contend against; the distance from the coast, and at present from any railway, would make the setting up of machinery very expensive. No timber or fuel of any kind is obtainable except at very great distances, and water would be very scarce except through the rainy season.

Alluvial Gold.

Gold-washers called Jalgars.

The washing for gold in the sands borne by the various streams flowing through the auriferous tract is carried out by a class of men called Jalgars, and they are now very few in number compared to what is reported about them in former years. I could only hear of three, two of whom were at Soortoor, and the third lived at Seerhuttee, in the Sangli Jaghir. I obtained the services of the two former, and made them wash for me in the Dhoni, Soortoor, Jilgerree, and other nullahs on the west flank of the Kappatgode. Of these nullahs, the Soortoor nullah was by them stated to be the richest, and this statement was fully borne out by the results obtained when washing there in my presence. Next in productiveness came the Dhoni stream, but the yield was greatly smaller, and hardly enough to remunerate them for their labour. In the Jilgerree nullah they got a yet smaller return; and in the other nullahs, including that at foot of the Kappat Iswara ravine, only a very few exceedingly minute spangles were obtained, just sufficient to show that gold was not entirely absent from the detrital matter.

Process of selecting wash-dirt.

The plan pursued by the Jalgars when I let them follow their own devices, was to take up the lower part of the latest flood deposit from the rocky or clayey bottom of the nullahs, not from the deepest part of the bed, but from the point at which a strong length of current slacked off, owing to a change in the direction of the stream. Another favorite sort of place from which to collect 'wash-dirt,' was the small alluvial terrace between the water at low flood level and the present high flood level. From this they collected the rain-washed surface, and in the case of the washings in the Soortoor and Jilgerree nullah, obtained much better results than from washing the material obtained in favorable positions from pockets in the beds of either nullah. In another washing in the Soortoor nullah, the wash-dirt selected was the kunkur crust deposited on the decomposing surface of a band of chloritic schist. This was altogether the richest washing made in my presence. Unfortunately the proceeds of this washing were, by inadvertence, mixed up with those of another, going on at the same time a little further down the nullah. The united results were said by the Jalgars to be a very good day's work. The second washing was made from a stuff collected at the base of the old alluvium bank, which there consisted of a bed of coarse shingle mixed with clay and fine ferruginous pisolitic gravel (a product of decomposition of iron pyrites), overlaid by black clay followed by a second but rather less coarse bed of shingle, on which rested the regur forming the soil of that part of the valley of the Soortoor nullah. The yield of this washing was rather less than that of the last mentioned. For the two washings I had four men at work for three hours at a place of their own selection—their favorite place according to their assertion; two men washed and other two dug and carried the material to the washing place. The quantity of wash-dirt put through the washing box, I estimated at 1½ cubic yards, from which the quantity of gold obtained weighs a trifle over 6½ grains, worth 9 annas in round numbers, at the rate of £3-17-6 for the ounce (troy) of gold.

Section of alluvium at Soortoor.

The method of washing adopted is simple, but might be made more effective at very little expense. The wash-dirt is scooped up with a small stout, broad hoe with a short handle, and carried in a basket or large wooden tray to the washing box, which has been fixed at the water's edge and propped up with stones to the required slope. The washer sits on a large stone in the water close to the side of the box, which is an oblong construction, made of light planks and open at one end. It is about 3 to 3½ feet long, 20 inches wide, and 9 inches deep, and strengthened with clamps. A stick of some elastic kind of wood is jammed against the sides and bottom at the lower and open end to form a catch. This done, the washer begins to ladle water on the wash-dirt, kneading it the meanwhile with the left hand and throwing out all the larger pebbles. The ladle or rather scoop used by the Jalgars was made of a long calabash, with one end cut off. It was held by the middle, an oblong hole having been cut into the incurved side, and a couple of small sticks tied across diagonally to the corners and fixed with strings passed through small holes. The elder man of the two, however, preferred to use a tin pot with cross handle, which had been given him by a former Collector of Dharwar. This goes on till a layer of sand has been formed in the box, so thick that the stick at the lower end is no longer a sufficient catch, and a second stick is jammed in and the washing process re-commences till the sand layer has risen almost level with the second stick; both sticks are then removed, the washer stirs up the layer of sand with a short, stout piece of wood and then sweeps everything into the large wooden tray held below the open end by the assistant. The washer then takes the tray, places it in the water, and performs the needful shaking and washing, technically called "panning off," till nothing remains at the bottom but fine sand, generally of black color. He then tilts the tray a little, and by judiciously dropping water out of his hand on the small layer of sand drives all the lighter particles forward and leaves the spangles of gold exposed. This small residue is then collected carefully by washing down into a half cocoanut shell, and taken home to be treated with mercury.

Process of washing.

From the shortness of the washing box and the very rude way of stopping the open end, and from the evidently careless style of manipulation, there must be considerable waste. Much better results would doubtless be obtained by using a box more like the Californian "Long Tom," which is generally 12 feet long, 20 inches wide at the top, and widening to 30 inches at the open end, besides being furnished with various ledges to catch any heavy material. The first man who wrote about the Kappatgode gold tract—that admirable observer, Captain Newbold, F. R. S., whose early death was so great a loss to the cause of science generally in India—was also of opinion that the washing was very carelessly and wastefully performed. My friend, Major Bartholomew, Superintendent of Police in Dharwar District, who with me watched the Jalgars at work in the Dhoni nullah, was, like myself, much struck by the rudeness of their appliances and the careless way in which they proceeded. I find it difficult, therefore, to understand the verdict of a Mr. J. Scholt, apparently a practical miner,

Process of washing susceptible of improvement.

who wrote in a letter to the *Times of India* (quoted in Balfour's Cyclopædia of India, article Gold), that he never in his whole experience met with such careful and effectual washing as that of the Kappatgode Jalgars, surpassing even the Chinese, who, in Australia, were considered perfection in that respect.

Small extent of workings.

The Jalgars ply their trade of gold washing only after heavy rains, and, as the Soortoor men informed me, for one month in the year, during which no agricultural operations are in progress. Their earnings are very various, and range from 5 to 50 rupees in a season apiece. They affected not to know of any gold *in situ*, and told me I was wasting my time in prospecting the quartz reefs. As it might be an idea of policy in their minds to keep to themselves as much of their knowledge as they fancied convenient, it would not be safe to attach too much evidence to their statements but that they were borne out by the statements of the patels of Dhoni and Soortoor, and numerous other villagers, whom I questioned through Major Bartholomew, who kindly acted as my interpreter to the Canarese people. The same information had been given me by the mamlatdar of Chikkodi, in Belgaum District, a shrewd Brahman, who had been for a considerable period the mahalkare of Moolgoond close to Soortoor. The mamlatdar of Gudduck also confirmed the information I had previously obtained.

Captain Newbold, in his resumé of information about gold tracts, published as No. 4 of his papers "On the Mineral Resources of Southern India," speaks of the banks of the auriferous nullahs being crowded with Jalgars after heavy rains—a very different state of things from what now prevails, and from which it may be inferred that the yield of gold has greatly diminished. It is very likely that such is the case; but another cause which has had great influence in diminishing the number of gold-washers may, I think, be found in the greatly increased prosperity prevailing in Dharwar District, since the American war created such a demand for cotton that immense wealth was poured into the district and gave a strong impetus to all sorts of other and more certain industries which have absorbed the great number of half idle men, who in former years devoted themselves to gold hunting in the rainy season.

Mr. Scholt's estimate of the alluvial gold.

Another writer on the Kappatgode gold tract—the Mr. Scholt, already quoted—formed a very low estimate of the alluvial gold return. According to the epitome of his letter to the *Times of India* given in Balfour's Cyclopædia, he confidently stated that the alluvial deposits would never pay, as the deposits in which the gold occurs are confined to a few insignificant nullahs and "blind water-courses" occupying the slopes and flats, the bed-rock in every case being exposed more or less, denoting a very scanty supply of wash-dirt, the native gold-washers (a very limited body) confining their operations to a stratum not exceeding 5 inches in depth. Twelve days' work at Soortoor yielded to Mr. Scholt from 2 to 3 rupees worth of gold (about a pennyweight).

I have already mentioned that the Jalgars did not try to get wash-dirt from deep pockets in the beds of the streams, the situations generally found most productive in the Australian and Californian gold washings. It was impossible to try the most promising places in the several nullahs at the time of my visit owing to the constant heavy rains. In the dry weather they might, however, be excavated by damming back the little streamlet that would alone remain then, and by simply baling out the hollows; but very little water would be then available for washing. The probability is that a little more gold would be found, but that as that operation has doubtless been carried out in former times by the natives themselves, no wonderfully rich pockets would be found to repay expenses; for it must be borne in mind that the inhabitants of the Kappatgode region are not ignorant savages like the Australians, who did not know the value of the precious metal.

Outturn of gold.

The annual outturn of wash gold from the Soortoor, Hurtee, and Dhoni nullahs, was estimated by Captain Newbold to be about 200 ounces after an average monsoon. What it may be at present, I did not succeed in ascertaining, but I think it may be safely set down at less than the tenth part of the former amount. The fact that so very few are attracted to the gold washings at present, appears to my mind very strong evidence of its not being a very profitable occupation. The poverty of the reefs is borne out by the very small yield of alluvial gold; and the inevitable conclusion appears to me to be that there are not sufficient prospects of success to justify any outlay of capital in mining works on a large scale.

Other metals found with the gold sand.

The stream-gold is found associated with a black sand consisting mainly of magnetic iron in minute octohedra, and a black residue not affected by the magnet. In the sand washed in the Dhoni nullah, I found several minute rounded grains of a grey metal, which on further examination proved to be metallic silver. A couple of little spangles of pale yellowish silvery hue were also obtained, which are doubtless electrum, the natural amalgam of gold and silver; beside these were a few minute grains of bronze colour, which on examination proved to be a mechanical mixture of metallic copper and oxide of tin. Newbold mentions having found a small fragment of metallic copper, grains of silver, and a few whitish metallic spangles which he took to be platinum; a supposition which does not seem, however, to have been substantiated. He also found gray silver ore in a fragment of quartz, but did not trace the source from which the quartz had come; nor was I more fortunate in that matter. In a green colored and very trap-like part on the pseudo-diorite, lying about a mile north-west-by-north of Soortoor, I found very numerous octohedra of magnetic iron of minute size, but very perfect, with numerous little lumps of copper pyrites and some iron pyrites. Iron pyrites of very white color, in minute parcels, is also widely dissemminated in an adjacent black variety of the pseudo-diorite.

Notes on previous observers.

Captain Newbold's notes on the geology of the gold tract are very brief, but, like all his observations, very correct. The Kappatgode gold region was subsequently visited and described by Lieutenant Aytoun, of the Bombay Artillery, but his description is unfortunately very meagre. He speaks of an exceedingly great development of iron pyrites in the gold region, and he observes that, "were it not that all the conditions on which the large development of the precious metals depends are here found in conjunction with the pyrites, it might be imagined that the small quantity of gold now found in the nullahs in this part of the country was derived from this source. Iron pyrites, as it is well known, often yield a small amount of gold." To my judgment the development of iron pyrites is small, except in the argillaceous schists near Huttee-Kuttee, in which the cubical crystals are found in moderate numbers. Lieutenant Aytoun does not appear to have traced the gold to its matrix, though he inferred correctly that it is found among the chlorite slate hills to the west. He mentions having obtained occasionally "small pepites of gold of a pear shape," but does not give the localities where they were found. His sections illustrating the geological structure of the hill group are correct in the succession of rocks shewn, but in various parts he seems to have taken the planes of slaty cleavage for planes of bedding.*

Dr. Carter, in his Summary of the Geology of India, in referring to Mr. Aytoun's paper, speaks of two hills, called the "Great" and "Little" Gold Mountains. These names seem to have gone out of use now, or to have no reference to the occurrence of the precious metal.

* Geological structure of the basin of the Jhalpurba in the Collectorate of Belgaum, including the Gold District, by Lieutenant Aytoun, of the Bombay Artillery. Transactions of the Bombay Geographical Society, Vol. XI, page 8; also reprinted in Carter's Geological Papers on Western India.

They were not mentioned by the Patel of Dhoni when pointing out all the different places seen from the summit of the Kappatgode.

Mr. Gilbert Elliott of the Bombay Civil Service, now Collector of Kuladgee, visited the gold tract in 1856; but I am unaware whether he wrote any report on it at that time. I think, however, that if he had re-visited the Kappatgode and the other gold localities with the practical knowledge of gold mining and prospecting he has since acquired in Australia, he would not lately have written so sanguinely about the prospects of gold mining in Western India.

My visit to the Kappatgode was greatly facilitated by the great assistance and personal kindness I received from Mr. Elphinstone Robertson, the Collector of Dharwar, and Major Bartholomew, Bo. S. C., the District Superintendent of Police, to whom my best thanks are due.

Other auriferous localities in Dharwar, Belgaum, and Kuladgee Districts.

Gold occurs but only in very small quantities at several other places besides the Kappatgode region. Chick Moolgoond in the Kod Talooka of Dharwar District, which I was unable to visit from its distance, is mentioned by Newbold.

Lieutenant Aytoun mentions both Byl Hongul and Belowuddee, in the Sampgaum Talook of Belgaum District, as auriferous localities; but in the case of the former gives no particulars by which to proceed in making search: he merely refers generally to the occurrence of gold sand in some streams. There are very few indications of quartz, except such as occur in laminæ and bunches in the chloritic schist. I only found one small reef which was of diaphanous blue grey quartz, containing no visible gold and no sulphides of any kind. The people at Byl Hongul maintain that gold is unknown there, a statement confirming the report of the talook officials to the Collector of Belgaum with reference to enquiries I made of him. I visited the auriferous nullah of Huttee-Kuttee, an abandoned village near Belowuddee, but was unsuccessful in washing, and a series of samples of the alluvial detritus which I brought away proved on chemical examination by Mr. Tween to contain no gold. A sample of the auriferous sand which I obtained through the Collector of Belgaum was also found to contain no gold. The Patel of Belowuddee informed me that no gold has been washed during the past ten years. The Jalgars who used to frequent this locality came from Hoobly, in Dharwar District. The sand of this nullah contains very little magnetic iron, the almost constant associate of gold.

All the evidence obtainable is not favorable to the idea of gold being found here in any considerable quantity. What little has been found, was probably derived from some quartz reef traversing either the chloritic schists or the pseudo-diorite on which the nullah in question rises. I did not observe any reef in the valley, but much of its surface is masked by cotton soil or ferruginous débris formed by the decomposition of beds of hæmatitic schist which occur in large numbers in the gneissic series. These are the 'jaspideous iron beds' of Mr. Aytoun's report, which he holds to be analogous to the quartz ranges and metamorphic parallel bands of the Ural Mountains and Australia, and thinks they will be found to characterize the gold zone of Belgaum District.

Moorgod, in the Pursgurh Talooka of Belgaum District, is another locality where gold is obtained in small quantities. Unfortunately I was not aware of this when there, and had not an opportunity of re-visiting the place afterwards. My informant, the present mahalkare of Chandgurh, Belgaum Talook, a very intelligent Brahman, who had been mahalkare of Moorgod for some years, told me that from 150 to 200 rupees worth of gold is annually collected in one of the nullahs near the town. The Jalgars in that case are poor Mussalmans. The gold most probably comes from small quartz veins in the chloritic schists, which are

Maps to face

largely developed west of the town. I am inclined to regard this series of chloritic rocks as occupying the same horizon as the Kappatgode series; but this cannot be determined till the geology of the intermediate country shall have been worked out.

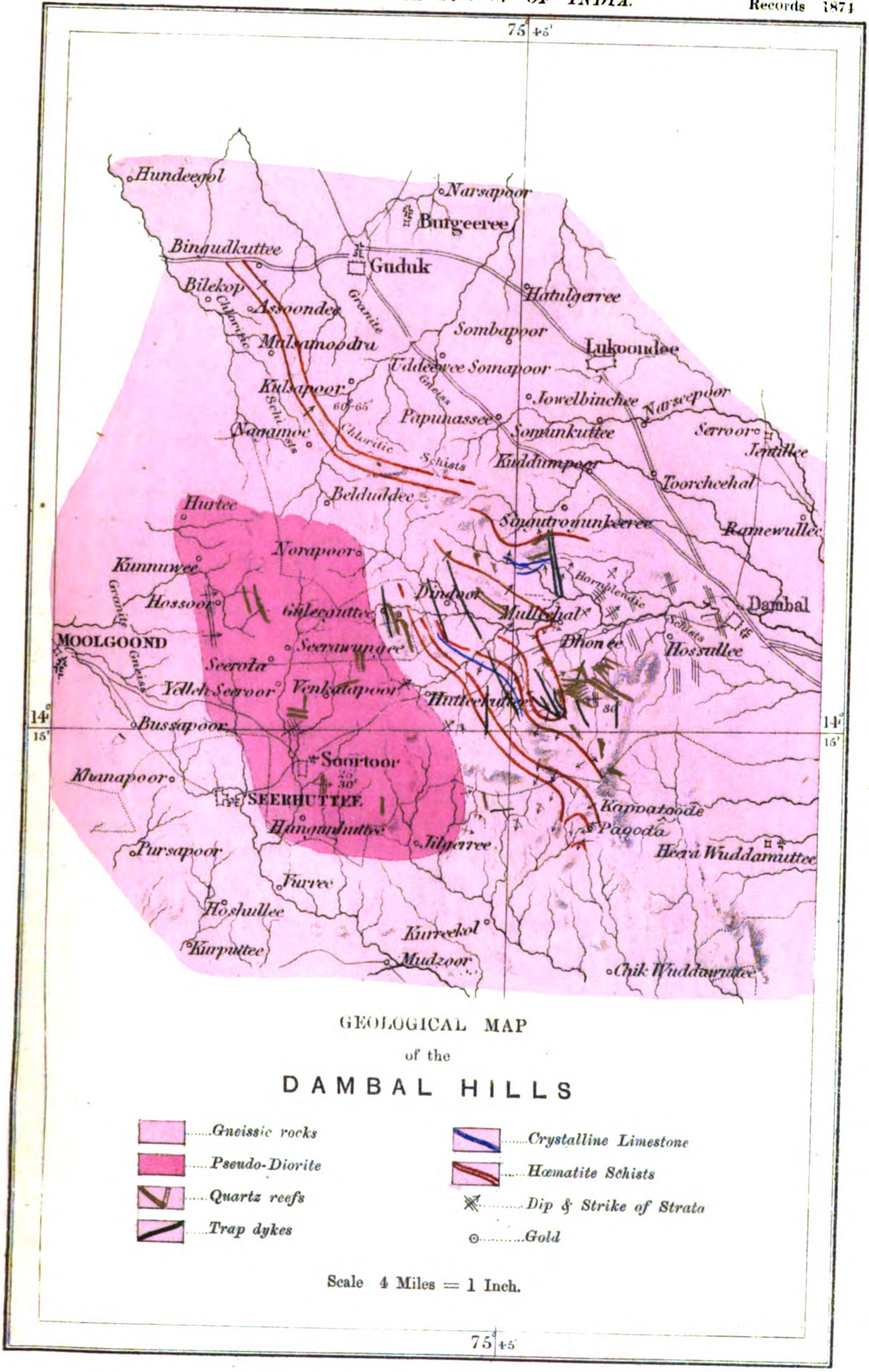
Gold is said to occur at Sogul, four miles south-east of Moorgod, but I could not ascertain which of the two nullahs near the village contains the auriferous sand. The existence of gold there is denied by the talook officials, so it cannot be found in any great quantity.

The last place reported to yield gold is Gooludegud, in the Badami Talook of Kuladgee District. I am inclined to doubt it altogether, as I did not hear of it, though I visited the place three times. It could hardly have been unknown to the German missionaries of the Basle Society who are located there, and I should have certainly heard of it from them.

REMARKS ON CERTAIN CONSIDERATIONS ADDUCED BY FALCONER IN SUPPORT OF THE ANTIQUITY OF THE HUMAN RACE IN INDIA, *by* W. THEOBALD, *Geological Survey of India.*

Few of the writings of the illustrious Falconer possess greater interest to the geologist or anthropologist than the paper entitled "Primeval man and his cotemporaries," written in 1863 (*vide* Falc. Memoirs, Vol. II., page 570), or display bolder or more forcible speculation on a question foremost for interest among those to which the attention of the great palæontologist had been devoted. The question, moreover, is an eminently living one, and great as have been the discoveries already achieved, we may confidently expect still greater accessions to our knowledge of it in the future, especially that particular branch of it relating to India, and the existence of man there, during the latest tertiary times. Whilst, however, every advance in knowledge has tended in the direction of Falconer's arguments, and rendered increasingly probable the main conclusions he advocated, there are certain facts of which he was ignorant, which materially diminish the force of one of the arguments he employed in support of his general proposition.

The first argument in favor of the co-existence of man and the extinct animals of the Sivalik Fauna, was the probability that the idea of a gigantic tortoise met with in the Pythagorean and Hindu Mythology had originated in a traditional acquaintance with the huge *Colossochelys atlas*, which in size was physically comparable with and capable of contending on equal terms with the largest elephant. The tortoise on which the elephant stood which sustained the world, the second Avatar of Vishnu in the form of a tortoise, and the elephant and tortoise which during their combat were borne off and devoured by the bird Garúda, are adduced as instances of this idea. "In these three instances, taken from Pythagoras and the Hindu Mythology, we have reference to a gigantic form of tortoise, comparable in size with the elephant. Hence the question arises, are we to consider the idea as a mere figment of the imagination, like the minotaur and the chimæra, the griffin, the dragon, and the cartazonon, &c., or as founded on some justifying reality? The Greek and Persian monsters are composed of fanciful and wild combinations of different portions of known animals into impossible forms, and, as Cuvier fitly remarks, they are merely the progeny of uncurbed imagination; but in the Indian cosmogonic forms, we may trace an image of congruity through the cloud of exaggeration with which they are invested. We have the elephant then, as at present, the largest of land animals, a fit supporter of the infant world; in the serpent Asokee, used at the churning of the ocean, we may trace a representative of the gigantic Indian Python; and in the bird-god Garúda, with all his attributes, we may detect the gigantic crane of India (*Ciconia gigantea*) as supplying the origin. In like manner, the *Colossochelys* would supply a consistent representative of the tortoise that sustained the elephant and the world together. But if we are to suppose that



GEOLOGICAL MAP
of the
DAMBAL HILLS

Scale 4 Miles = 1 Inch.

the mythological notion of the tortoise was derived, as a symbol of strength, from some one of those small species which are now known to exist in India, this congruity of ideas—this harmony of representation, would be at once violated; it would be as legitimate to talk of a rat or a mouse contending with an elephant as of any known Indian tortoise to do the same in the case of the fable of Garúda. The fancy would scout the image as incongruous, and the weight even of Mythology would not be strong enough to enforce it on the faith of the most superstitious epoch of the human race."—Page 575.

The above argument is plausible, if it may not be termed forcible; but since it was written, additional light has been thrown on the subject, and it has been ascertained that the Fauna, habitually referred to by Falconer as the *Sivalik*, in reality comprised two Faunas, derived from two perfectly distinct groups, which were first discriminated by Mr. Medlicott (*vide* Memoirs, Geological Survey, Vol. III.) under the names of Náhan and Sivalik, in 1864. Now, the co-existence of man with some, at least, of the extinct members of the Sivalik Fauna, though not as yet established, is what the discoveries of any day may put beyond question; and were the *Colossochelys* a member of the more recent, Sivalik, fauna, Falconer's argument, quoted above, would, in my opinion, have great weight: but we now know that *Colossochelys* was not a Sivalik species but a member of the older Nahan fauna, no species of which is certainly known to have survived to Sivalik times. *Colossochelys* was among the fossils forwarded by Colonel Burney from Ava, where it was associated with *Mastodon latidens*, Clift, and *Elephas Cliftii*, Fal. (*Mastodon elephantoides*, Clift, in part). Now, both these mammals are Náhan species, and during the last season a superb palate specimen of *E. Cliftii*, Fal., was procured by myself from Náhan strata, near Talowra, on the Sutlej; whilst *Mastodon latidens*, Clift, was recently procured near Lehri, not far from Jhelum, by Mr. Wynne, accompanied by *Sus hysudricus*, Fal., both fossils differing considerably from Sivalik remains in aspect and mineralization. I have not visited Lehri, but I have good grounds for believing the fossils from it to be all of Náhan age, though this I need not enter on here. I have also myself procured during the last season specimens of *Colossochelys* from Náhan beds near Deyra or the Biás, so that the evidence of the geological age of this remarkable form is tolerably complete. This being so, any arguments short of direct proof of the co-existence of man and the *Colossochelys* are vain; since, with the enormous gap intervening between the groups, it is far more unlikely that remains of man will be ever found in the older, than it is probable that they may be discovered in the younger.

The second argument I would refer to is contained in a paper by Falconer, published posthumously in the Quarterly Journal of the Geological Society for November 1865, and reproduced in the Falconer Memoirs, Vol. II., p. 632. I cannot do better than give the passage as it stands: "The third fossil species (*Hippopotamus Palæindicus*) is perhaps the most important in its indications. A quadruped, so remarkable for its size, form, and habits, must everywhere have forcibly impressed itself on the attention of mankind, and struck with the close resemblance of the Nurbuda fossil buffalo to the existing species, the question arose with me: 'May not this extinct hippopotamus have been a contemporary of man? and may not some reflection of its former existence be detected in the extinct languages or ancient traditions of India, as in the case of the gigantic tortoise?' Following up the enquiry, I ascertained from the profound Sanskrit scholar, Rajah Radhakanta Deva, that the hippopotamus of India is referred to under different Sanskrit names of great antiquity, significant of 'jala hasti,' or 'water elephant,' in the 'Amarakosha' and 'Subda-ratnavali.' This view is confirmed by the opinion of two great Sanskrit scholars, Henry Colebrooke and H. H. Wilson. The former in his annotations on the 'Amarakosha' interprets the words 'Gráha' and 'Avahára' as meaning hippopotamus; and the latter not only follows this version, but gives two other words, 'Kariyádus' and 'Vidoo,' which he supposes to signify the same animal. It is therefore in the highest degree probable that the ancient inhabitants of India were familiar with the hippopotamus as a living animal, and it is contrary to every probability that this knowledge of it was drawn from the African species imported from Egypt or Abyssinia." Considering the important issue here raised, I felt it would be extremely desirable to obtain some confirmatory opinion, if possible, of the philological question involved, and accordingly addressed a note to my old friend, Baboo Rájendralála Mitra, stating the case and requesting his opinion as to whether or no any Sanskrit words were known which could certainly be referred to the hippopotamus. His reply was strongly negative of the idea, and I give it in full.

"The *jalahastí* does not occur in the *Amarakosha*, but in some of its commentaries it is given as a synonym of *avahára*. In the *Nágánanda*, a Sanskrit Buddhist drama, *jalakunjaras* are described as sporting in the waters of a river. *Kunjara* is but another word for *hastí*. The counterpart of this occurs in the *Rájatarangini*, where *jalagandhebha* is used for *jalahastí*. Neither of these books, however, afford any clue to the nature of the animal they describe. The Sanskrit Dictionary of Böhtlingk and Roth gives 'wasser-elephant' on the authority of Hemasuri, who says it is an elephant-like animal, which dwells in water (*jaleshu hastyákárát vá*). The *Amarakosha* takes the *gráha* and the *avahára* to be the same animal, which, according to one commentator, is the same with the shark, *hángara* (*hángarákhye jala-jantau*); and according to another, a slender, long animal that frequents the confluence of large rivers with the sea (*samudra-mahánadyoh sangame latákára jantu viseshah*). At least half a dozen others add to the above definition 'commonly known by the name 'hángara' (shark), but not applicable to crocodiles;' and I see no reason to differ from them. There is nothing in any Sanskrit work which can be accepted as a positive proof of the *jalahasti* being other than the *gráha*, and was used to indicate the hippopotamus. I must add, however, that Wilson, in his Sanskrit Dictionary, gives the word hippopotamus against *avahára* with a mark of interrogation. He has not given the word *jalahastí*."

After perusing the above remarks of so eminent a scholar, I think few will be inclined to attach much weight to any argument resting on so insecure a philological base as the above is seen to be; indeed there is a more formidable difficulty even than the above uncertainty, as to what animal was really meant, in the fact of the words presumed to signify hippopotamus being of Aryan origin, which would at first seem to carry forward the presence of the hippopotamus in India to so late a period as the Aryan occupation of the country. To this length Falconer, however, does not go, as he remarks with respect to this difficulty—"After reflecting on the question during many years in its palæontological and ethnological bearings, my leaning is to the view that *Hippopotamus namadicus* was extinct in India long before the Aryan invasion, but that it was familiar to the earlier indigenous races" (Memoirs, Vol. II., p. 644). Without, then, questioning the probability that this was the case, I think that it must frankly be admitted that the philological argument is totally insufficient *per se* to establish such probability.

It remains, however, to determine what animal the *jalahasti* really was. It was clearly an unwieldy animal frequenting rivers, and not the crocodile. The supposition of most commentators that it was the 'shark' was probably due to the fact that they were acquainted with no more likely animal to which to refer it, though there is no possible similarity or points in common between a shark and an elephant to render it probable that the old Aryans bestowed the name water elephant on the former animal. The observation of one of the commentators quoted by Rájendralála Mitra, to the effect that it frequented the junction of large rivers with the sea, (though coupled with the remark of its being long and slender, which no elephant-like animal can properly be called,) seems to throw a light on what may possibly be the animal intended; for having witnessed the awkward evolutions of dugongs sporting of an evening on the oily expanse of still sea at the mouths of rivers on the eastern side of the Bay of Bengal, I can well understand how the term 'water elephant' might be applied to that animal whose heavy massive head and bulky form, imperfectly perceived beneath the water, is suggestive of somewhat elephantine proportions. I offer the suggestion, however, merely for what it is worth, and as one certainly more probable than that the 'water elephant' can be either a shark or any slender animal or fish, whilst the probability of its being the hippopotamus is one involving too serious issues to be adopted on the slender grounds alone of verbal applicability.

KASAOLI,
July 9th, 1874.

W. THEOBALD.

GEOLOGICAL NOTES MADE ON A VISIT TO THE COAL RECENTLY DISCOVERED IN THE COUNTRY OF THE LUNI PATHANS, SOUTH-EAST CORNER OF AFGHANISTAN, *by* V. BALL, M. A., *Geological Survey of India.*

In the following pages I purpose giving an account of the geological structure of a portion of country which, being situated for the most part beyond the British frontier, where internal strife and raiding is the normal state of things, is one which, except under such special arrangements as were made on the present occasion, could not be visited by a geologist.

For this reason it is important to put on record even the somewhat imperfect observations which were made during a few days hurried ride through these little known regions.

Fortunately, the route taken by the expedition from the plains at Saki-Sarwa to the most distant point reached in the Chamarlang valley (about fifty miles as the crow flies) was more or less at right angles to the strike of the rocks and of the principal hill ranges, and thus in each day's march a section of the rocks was traversed which served to indicate the geological structure. The facility with which such rapid observation could be made being in a considerable measure due to the poverty of the vegetation* which was nowhere sufficient to hide the rocks, and thus the eye was enabled to trace individual beds through all their bendings for many miles. This freedom from jungle renders geologising on the north-west frontier a very different thing from what it is in the central parts of India and in the Himalayas, where, for the most part, the geological structure can only be ascertained by systematic plodding up the beds of streams and hill sides, and where a bird's eye view of the relations of the different formations is seldom to be obtained.

My observations being restricted to a limited portion of the great Sulimán range, I do not attempt at present any generalisations or even comparisons with the geologically known regions to the north and south, but shall confine myself as much as possible to an enumeration of the observations made in this particular locality. So far, then, as reference to previous notices is concerned, it is limited to the correspondence relating to the discovery of the coal, the examination of which was the object of my mission.

History of the coal.—The first discovery of coal in the neighbourhood of the Sulimán range, west of Dera Ghâzi Khân, was, in the year 1863, reported to the Officiating Deputy

* I am indebted to Mr. S. Kurz for the identification of a small collection of the most characteristic plants which occur in these hills.

Perhaps the most common tree on the hills is a species of olive (*Olea ferruginea*, Royle=*O. Europea* Var.). A flabelliform palm *Chamærops Ritchieanum*, the fruits of which are much sought after by the Biluchis, occurs on the hill slopes and in the valleys. *Daphne oleoides*, L., *Grewia populifolia and Dodonea viscosa* are also found on the hills. In the valleys, species of *Acacia* and *Tamarix* are not uncommon, and *Nerium odorum* and *Zizyphus jujuba* occasionally occur. Besides the above, several herbaceous plants, which it is useless to enumerate here, were also collected.

Commissioner, Captain W. M. Lane, by Sirdár Jamál Khán, chief of the Lagári tribe. Specimens were forwarded by the Lieutenant-Governor of the Punjab to the Geological Survey for report. The examination shewed that most of the specimens occurred free *in situ;* the fracture conchoidal; structure obscurely woody—one specimen splintery with a black streak, the other tough with a brown streak. Specific gravity 1·46. Water 13 p. c.

Composition—

Carbon	...	44·0
Volatile	...	50·5
Ash	...	5·5
		100·0

Traces of sulphur were observed.

The locality whence this coal had been brought was visited subsequently by the Deputy Commissioner of Dera Gházi Khán,* who wrote—"The best specimens were found in the Mithanwan pass, near Chota Bála, but even here the seams are so small that they would never repay the labour of working them. The seams of coal lie embedded in the rock chiefly of the sandstone formation."

After much labour for a whole day about 10 seers of coal was obtained "The largest veins are not more than 6 inches long and about 2 inches in depth." It was justly concluded that the deposit was not worth working. The above-mentioned coal from the outer (eastern) flanking hills of the main axis of the Sulimán range was, up to the year 1870, the only known example of the occurrence of the mineral in that latitude, although both to the north and south at Kálabág and at Lynah, in Sind, coal has been known to exist in limited quantities for a long time.

In 1870, the present Deputy Commissioner Captain R. Sandeman reported the receipt from some Biluchis of specimens of coal from a quite new locality situated in a range of hills ninety miles from the British frontier. The account given by the Biluchis represented the coal to be in considerable abundance, and as the assay of specimens which were forwarded at that time indicated a good coal,† it seemed probable that an important and valuable discovery had been made.

Accordingly, in the present year, a favorable opportunity occurring, Captain Sandeman paid the principal locality in the Chamarlang valley a visit, when, in a short time, 50 camel-loads of coal were collected by the Biluchis, and the impression formed from the appearances presented by the seam was that the coal existed in sufficient quantity to be of economic value. The coal collected on this occasion was forwarded to Lahore, where it was tried in a locomotive, and gave fairly promising results. At this stage it was determined that the locality should be visited and reported upon by an officer of the Geological Survey, and the following account embodies the results of the examination:—

Route.—Before proceeding to the detailed account of the rocks, I shall give a short sketch of the route traversed on the road to the coal.

* Letter to Secretary to Government, Punjab, Public Works Department, dated 26th November 1863.

† The composition of these specimens was as follows:—

Carbon ...	...	63·0
Volatile ...	...	34·4
Ash ...	...	2·6
		100·0

Leaving Dera Gházi Khán, which, though within the normal area subject to inundation from the Indus, is protected from injury by considerable dams, the road westward to Vuddore passes over for the most part cultivable land, broken here and there by tracts covered with drifting sand-dunes. Between Vuddore and Saki-Sarwa the soil becomes more arid and sandy, and cultivation is more restricted to what may always be called oases. The wild vegetation, consisting of species of *Tamarix*, *Zizyphus*, *Calatropis* and *Euphorbia*, indicating the character of the soil. At Saki-Sarwa,* which is said to be 926 feet above the sea, the surface is covered with a wide-spreading talus of boulders.

At the foot of the hills, close by, is a narrow margin of horizontal beds of sandstones and conglomerates, inside which again rise an older series of ranges formed of beds with a steep incline outwards, the dip being in places from 60° to 70°. Nothing can be conceived of as being more desolate than the aspect presented by these ridges, scarcely a sign of vegetation breaks the uniform brownness of the arid rocks. Entering the hills by the Siri pass,† four miles to the south of Saki-Sarwa, we find that the marginal zone above spoken of, has spread to a breadth of about four miles; the nearly horizontal beds of which it is composed completely covering up the highly inclined beds which appear near Saki-Sarwa. In the section exposed in the cliffs bounding this pass, a thickness of about 600 feet of beds of sandstone and conglomerate is seen. In places these dip to the south-east or east-south-east at an angle of 10°; and the disappearance of a bed of conglomerate at this angle accounts for the sudden and total extinction of a steady current of water which comes from the interior. Judging from the map, this seems to be the fate of most of the rivers along this frontier, few of them finding their way to the plains, although the continuation of the *nalahs* or dried-up water-courses indicates that they have done so formerly, or even may do so now under the exceptional circumstance of a heavy and long continued rainfall.‡

The gorge of the Siri pass is about four miles long. At its western entrance the horizontal beds are well seen resting on the highly inclined older rocks. Here a valley opens to view, in which, as far as the eye can reach to the north and south, numerous ridges, formed of green and red shales or clays and brownish sandstones, and further in, white limestones, crowd the space. All the beds dip outwards from the main axis of the Sulimán at considerable angles, none under 30°, and in places exceeding 70°. In the neighbourhood of Kadji,§ highly fossiliferous white nummulitic limestones of inconsiderable thickness, alternating with argillaceous beds, first make their appearance.

The open parts of this valley, though stony, support a certain amount of vegetation which is dwarfed and stunted in growth, but produces an agreeable appearance after the dreary waste outside.

Underneath the limestones occur some alum shales, and a succession of shales and sandstones. The ascent to the main axis of the Sulimán range traverses the up-turned edges of these beds.

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* The tomb of Saki-Sarwa is a place of much resort both by Mahomedans and Hindus. A méla, which is held in the cold weather, attracts many thousands of pilgrims every year.

† An old kafila route to Kandahar.

‡ An instance of the latter case, indeed, has come to notice during the past few weeks since my visit; the floods which have caused the Indus to break into the old bed of the Sutlej and inundate the station of Omerkote having been principally due to the access of immense bodies of water from the lateral tributaries which drain the Sulimán range. The rainfall in Biluchistan has been quite exceptional in this monsoon, and the loss of cattle and the injury to houses has in consequence been considerable.

§ In this vicinity I found it quite impossible to fix my position, the courses of the rivers and low ranges represented on the Atlas-sheet maps pursuing purely imaginary directions.

From this the route lay south-south-west, through Chuti Mári, for fifteen or sixteen miles, the rocks, if we except some merely local rapid contortions, gently rolling as ripples do on the top of a great wave. The principal rocks in these higher regions (4,000 to 5,000 feet) consist of dark purple sandstones with highly ferruginous bands and occasionally badly preserved fossils. But there is one marked band of well preserved specimens of a species of *Ostrea*. These rest upon greenish and grey shales and occasional bands of a dark blue and very dense calcareous sandstones in which no fossils were apparent.

A bungalow erected by Captain Sandeman is situated on a partially isolated flat-topped hill about 5,880 feet above the sea and twenty miles south-south-west of Ek-Bai—the highest peak in this part of the range.

From the bungalow our route lay in a north-western direction, or nearly at right angles across the strike of the minor ranges to the west of the Sulimán. Passing down over the western slope of the main anticlinal, the dip of which is much more gentle than the eastern, we reached the Rakni valley, which is situated in a synclinal trough, the rocks on its western side rolling over again in an anticlinal and forming the Deka and Mazára hills.

The Rakni valley is a fine open flat plain, from five to six miles wide and 3,280 feet above the sea. It appears to be tolerably fertile, and is inhabited by a tribe called Hadianis.

In the pass to the north of the Deka hill a good section of the anticlinal is met with, the beds of shale and sandstone, a mile further on, disappearing beneath the nummulitic limestones, which latter—between this and Taghár, another fertile valley—form a synclinal trough. Between Taghár and the Karvada range, which bounds the Chamarlang valley on the east, there are a succession of valleys for the most part formed along the denuded axes of anticlinal rolls of the limestone. On the scarped side of the Harluk portion of the Karvada range the older rocks, sandstones and shales, re-appear underneath the limestones. And in these rocks, close to the western foot of the range, at about 800 feet below the base of the limestone, occurs the principal coal locality, where, associated with layers containing fossils of oysters and *turritellas*, occur two seams of coal; one of them averaging 2 inches, and the other about 9 inches in thickness. Other localities where this horizon was met with will be found mentioned further on. Time did not admit of my examining the Dadar and subsidiary ranges which bound the Chamarlang valley on the west. But so far as a distant view can justify an opinion, all these hills appeared to be formed of the lower rocks, with the reversed dip of the anticlinal; Dadar hill itself, which is 6,280 feet high, not appearing to have even a cap of the nummulitic limestone.

Our return route by the Hinki and Han passes afforded an opportunity of extending, very considerably, our observations on the geography* and geology of the country, as it traversed the ranges at a distance of from twenty to twenty-five miles south-west of our route out.

On the way to the Hinki valley, at the southern end of the Karvada range, a section of the coal-horizon rocks is disclosed. In a pass here, there are some thin layers of coaly matter in blue concretionary shales, the dip of which is 70° to south-south-east. A fault has brought the edges of these rocks into contact with the edges of the limestones. The Hinki valley runs along the denuded crest of an anticlinal roll of the latter rocks.

Between this and a fine open valley called Pasta Mara the lower rocks are in several places exposed. Beyond the latter place they extend for some distance to the north-west into the, for the most part, limestone area which lies between the Karvada and Ujh Hills.

* Captain Lockwood, 3rd Punjab Cavalry, made a sketch survey of the country from which that portion of the accompanying map which lies west of the Sulimán range has been compiled. Most of the elevations given in this paper are from aneroid measurements by the same gentleman.

These lower rocks continue with several rolls until they slope up to the Jhandran range when a sharp anticlinal bend causes them to dip suddenly and disappear under the limestones of a marked range which bounds the Barkan valley, and of which an admirable section is exposed in the Han pass.

The eastern peak of Jhandran is about 1,200 feet above the valley. Vegetation is somewhat more abundant upon it than on the surrounding hills, and medicinal plants, which are reported to have special virtues, are found upon it. It was said that this hill had been the abode of a Fakir, some of whose domestic utensils had been turned into stone. Anticipating that some fossils of remarkable character might have given rise to the tradition, we ascended the hill, but our guides could not, or would not, shew us the cave in which these articles were said to occur.

Close under this peak there is a spring which yields a perennial supply of water. The banks of the river passing through the Han gorge are for the most part formed of a calcareous tufa, in which twigs, leaves, and recent land-shells abundantly occur. This deposit is similar to the well-known *Asarkar* of India. It does not appear to be in any way connected with the above-mentioned spring, which, if any, deposits but a very slight amount of calcareous matter.

The Barkan and a succession of valleys to the north-east present a fertile appearance, and there are several large and populous villages of the Khetrans situated in them. As their name implies, these people are cultivators;* but owing to the constant liability to attacks, cultivation is for the most part confined to the immediate vicinity of the walls of the villages. These valleys run with the strike of the limestones. To the east the ranges, of which Mazára is the principal peak, can at once be recognised as being formed of the older rocks both from their dark appearance and the different form of weathering which they present when compared with that of the ranges formed of limestones.

From this point our return to the Bungalow through the Rakni plain lay along the same route as on our outward march.

The rocks seen in the above sections are referable to several distinct formations as follows:—

	1.	RECENT	(*a*)	Alluvium, hill detrital beds, sand, and calcareous tufa.
Tertiary Period.	2.	PLIOCENE?	(*b*)	Sandstones and conglomerates.
	3.	MIOCENE?	(*c*)	Sandstones and clays.
	4.	EOCENE	(*d*)	Nummulitic limestones.
			(*e*)	Sandstones and shales.†

Recent (*a*).—Regarding the recent beds, in process of formation at present, but little of interest can be said. The alluvial area from year to year receives an increment from the inundation of the Indus and its tributaries. The drifting sand *dunes* constantly changing their positions creep along before the prevailing winds often, in their course, covering up and rendering useless cultivable land. The increase of the hill detrital and talus beds in this country of small rain-fall takes place but slowly. The travertin and calcareous deposits are forming in several places. In the Han pass there is, as already mentioned, a considerable exposure of this rock, but the sources from which it was derived are no longer in action.

Pliocene? (*b*).—In the absence of any fossil remains, it would be premature to attempt to refer the fringing beds of sandstones and conglomerates, which, as I have above pointed out,

* Derived from *Khet*, a field.

† Possibly some of these when more fossil evidence is collected will have to be referred to the secondary period (cretaceous).

are particularly well seen in the Siri pass, to any of the known groups which have been separated by their fossil fauna in other parts of the country. That these rocks will, when they come to be thoroughly examined, prove referable to the age of the Siwaliks is not only possible, but, from their position and associations, highly probable.

The facts observed regarding these rocks are, that in the Siri pass, where there is a good section exposed for a distance of about four miles, they consist of coarse sandstones, conglomerates, and boulder beds aggregating a total thickness of from 500 to 600 feet. In places they appear to be quite horizontal, but are for the most part inclined outwards, having a maximum dip of 10° to south-east and east-south-east. At the western end of the Siri pass they rest upon and against the inclined edges of the rocks next to be mentioned. Judging from the appearance of the map and of the country so far as it could be examined by a distant view, there is a greater breadth of these fringing rocks at the Siri pass than anywhere else in the neighbourhood. At Saki-Sarwa, for instance, the highly inclined lower rocks almost adjoin the plain without the intervention of more than a very narrow fringe. In the plains to the south-west of Saki-Sarwa, however, quite detached from the main mass of elevated ground, occurs a long range of low hills which from their amorphous structure will, I anticipate, prove to be formed of these beds.

On the west of the Sulimán range, in two localities, I met with conglomerate beds resembling in their lithological structure these rocks; the first, situated at the western base of the Deka hill, may very possibly be of this age; but the second, in Karer in the Luni Pathan's country, partakes so completely of the disturbance of the limestones upon which it rests, being included in a vertical synclinal fold, that I am forced to believe that it must belong to the age of the group of rocks next to be mentioned.

Miocene? (*c*).—As to the characters of the whole of this group I am not in a position to speak, since its higher members are covered up by the rocks above described in the Siri section. Much as I should like to have examined these rocks in detail, the season was not one in which it was possible to do so without considerable risk. The general appearance presented by them as viewed from a distance shews that they consist of dark brownish sandstones in beds of no great thickness, alternating with bright red, greenish and grey clays. They dip outward (east) to the plains at angles of from 30° to 70°, and strike with the main Sulimán axis, more or less north and south. I had no time to examine them for fossils, but it is probable that they will be found to correspond with one of the known groups of miocene or older pliocene age (Náhans?) of the Sub-Himalayas and Salt Range.

On this side of the Sulimáns they no doubt extend for a considerable distance, to judge from the distant view and the physical features indicated on the map. I fully anticipate that the beds which are exposed near Saki-Sarwa will be found continuous with those known to occur much further north in the vicinity of Banu.* With the imperfect data I possess it is of course impossible for me to say whether this group is susceptible of sub-division or not. Fossil evidence, in the absence of internal unconformity, can alone decide this. The total thickness cannot, I believe, be under 3,000 feet and may be much more.

Eocene (*d*).—With the appearance of the nummulitic limestones we reach a geological horizon, as to the affinities of which there can be no doubt. Abounding in well preserved fossils and with well marked lithological characters, these rocks can be readily recognised wherever they occur.

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* See map to accompany Dr. Verchere's report on the geology of Kashmir, the Western Himalaya and Afghan Mountains. J. A. S. B., Vol. XXXVI, 1867.

In the east to west section across the country described in the preceding pages the limestones are first met with in the vicinity of Kadji, where they underlie, conformably, the sandstones and shales just described. Here there is but a small development of the calcareous element which is confined to a few small bands associated with shales and sandstones. This local alternation in the character of the beds when compared with the considerable unbroken thicknesses of limestones which occur in the sections further west, and which will be described below, suggest that this locality must have been situated near the margin of the sea in which the deposit took place, and was therefore more subject to the inroad of foreign materials than the areas in which the limestones are now found of great thickness and uniform character.

The fossils found at Kadji consist of *Pelecypoda*, *Gastropoda*, *Echinodermata*, and *Nummulites*, the species being identical with those found in the limestones of the western localities. *Echinodermata* appeared from my collections to be relatively somewhat more abundant in individuals at Kadji than they are in the west.

As to the thickness of these rocks here I cannot venture an opinion, but it appears to be very much less than it is in the west.

Crossing the anticlinal ridge of older rocks which forms the main axis of the hills, we first meet limestones again resting on the flanks of the reverse slope, where to the west of the Bungalow at Sandemanabad they occur as a narrow strip of buff-colored rocks containing nummulites and probably other fossils.

Further west, beyond the line of the Deka and Mazára hills, limestones are again met with, but here we seem to have reached the area of maximum deposit, for we find thicknesses of from 1,000 to 2,000 feet with no breaks in the uniformity of their character save those caused by a few bands of nummulites which are densely compacted in a green silt. These bands are more strongly developed on the east side of the Taghár valley than elsewhere. There the tough limestones may be seen standing out from between the friable nummulitic beds. Nummulites are not, however, by any means confined exclusively to the latter beds, as they occur pretty generally throughout.

At Taghár, for some cause, the molluscous fossils were very badly preserved, being for the most part only in the form of internal casts, but of such there was a great abundance.

The section from the foot of Deka to the Karvada range, which bounds the Chamarlang valley, discloses only these rocks rolling in a succession of synclinal and anticlinal folds; except that towards the end of the Kerar valley there is a very sharp synclinal. which has caught up in its embrace a fold of conglomerate. This bed containing, as it does, fragments of the limestone, must be referred to a more recent period.

Underneath the limestones of the Karvada range, the older rocks, sandstones and shales with coal reappear.

The limestones here, as in all other places where the junction of the two groups of rocks is exposed on the side of a hill, form a marked cliff, the sandstones and shales forming the under-cliff. This cliff extends all along the Karvada range, and is from its top edge to the junction with the older rocks from 400 to 500 feet thick. The accompanying section represents the relations existing between the two groups in this part of the country.

In the Hinki valley, which is at the south-west end of the Karvada, the limestones are crossed by the return route. Between this and Pasta Mara they exhibit an unusual amount of local disturbance, in some cases the underlying shales and some ochreous beds appearing at the broken crests of the anticlinals. Between Pasta Mara and the Han pass the older rocks only are seen, but in the section at the latter place the limestones reappear in considerable thickness, dipping at low angles towards the Barkan valley. Not less than 1,200′ of these rocks is here exposed. Denudation has produced some very pretty effects in them. Isolated conical hills, several hundred feet high, standing out on the sloping flanks of the main range. From this eastwards the beds roll over, sloping up on the flanks of the Deka and Mazára range.

These limestones consist for the most part of soft friable beds of dirty white or very light fawn color. Sometimes, however, they are very dense or even sub-crystalline. From among the latter highly ornamental marbles might be selected. In these the sections of nummulites and other fossils present a very pretty appearance.

On the Karvada range boulders of a peculiar semi-crystalline limestone with green silt interspersed were met with, but the position of the bed from whence they came was not ascertained. The rock is dense and heavy, and at first looked like an igneous product.

In places veins of pure white lime, the result of the percolation of water, are of not uncommon occurrence.

Layers and nests of gypsum, too, are sometimes met with. Some long sticks of fibrous gypsum (selenite) were obtained in the Hinki valley.

Fossils in these limestones were abundant wherever searched for. The collection brought to Calcutta includes perhaps a hundred different species. The places where I obtained these were in the Taghár valley, Chukerani, Pasta Mara, Kadji, Karvada, and the Barkan valley. Besides these I received a number from Captain Sandeman from the Shum plain, which is situated some miles south of Saki-Sarwa.

The following is a preliminary list of the species which were obtained:—

NUMMULITES.

Probably several species, not yet determined.

CORALS.

Pachyseris Murchisoni, J. Haime.
Monivaultia ?
A branching coral, not yet determined.

ECHINODERMATA.

Cidaris Verneuili, d'Arch.
Phymosoma nummuliticum, d'Arch.
Conoclypeus Flemingi, d'Arch.
Schizaster Newboldi, d'Arch.
„ *Belouchistanensis*, d'Arch.
Brissopsis Sowerbyi, d'Arch.
„ Sp. ?
Besides several other species which remain to be determined.

PELECYPODA.

Teredo Sp. ?
Crassatella Sindensis, d'Arch.
„ Sp. ?
Corbula subexarata, d'Arch.
Lucina gigantea, Desh.
„ *subvicaryi*, d'Arch.
„ several other species.
Astarte Sp. ?

Venus subvirgata, d'Orb.
,, *astarteoides*, d'Arch.
,, *subovalis*, d'Arch.
,, *subeveresti*, d'Arch.
,, *Hyderabadensis*, d'Arch.
Cardita Beaumonti ? d'Arch.
,, several other species.
Cardium Homeri, d'Arch.
,, several other species.
Cypricardia Vicaryi, d'Arch.
Arca Kurrachensis, d'Arch.
,, several other species.
Chama Sp. ?
Mytilus subcarinatus, Desh. ? ?
,, several other species.

GASTROPODA.

Nerita Sp. ?
Natica sigaretina, Desh. ?
,, several other species.
Trochus,
Turbo,
Phasianella,
Turritella,
Cerithium,
Fusus,
Cassis,
Cypræa,
} One or more species of each of these genera. These have not yet been determined.
Ovula Depressa, d'Arch.

Eocene (*e*).—Underneath the nummulitic limestones occur a series of rocks which differ from them very much in their lithological characters, and to no inconsiderable extent, too, apparently, in their fossil contents.

But these rocks, so far as is known, contain no fossils whose occurrence would be inconsistent with their being referred to the tertiary period, and it would appear that lithologically similar rocks have been met with elsewhere underlying the limestones, and which have been considered to belong to the nummulitic series. Adopting this view (with the understanding that some of the lower portion of this succession in which my very cursory examination did not result in the discovery of *any* fossils may hereafter yield evidence of their belonging to the cretaceous or some older formation) I shall proceed to describe the sections as I saw them.

Underneath the limestones which, as I have above said, occur at Kadji, there appear some earthy alum shales followed by sandstones and shales. These beds dip at angles as high as 70° away from the main axis of the Sulimán. After crossing some hundreds of feet in thickness of the upturned edges of these rocks, badly preserved fossils commence to shew themselves in the sandstones, and fragments of a thin layer of densely compacted oysters are met with scattered over the surface of the ascent. Associated with this layer are some shales, and it is probably on this horizon some few miles to the north of Kadji that the coal mentioned on p. 146 occurs. I started one evening to visit this coal, but my guide so managed matters that we never reached our destination. The following day I was dissuaded from my intention of proceeding to it in the sun, as a long ride lay before us, and it was represented to me that exposure in these hot valleys could not be undertaken without risk at this season. The opinions on this coal given on page 146, and the universal testimony of the natives, unite in saying that it is in extremely small quantities. And the handful of fragments of lignite brought by a special messenger fully testified to the worthlessness of the deposit. In a geological point of view, these traces of carbonaceous matter, together with the accompanying fossils, are not without interest, as they confirm the views of the geological structure arrived at by examination of the physical relations of the beds.

Crossing over a considerable thickness of these sandstones and shales the road leads over the Han-ki-der, a peak which is situated due south of the lofty Ek-Bai. This peak, as also in all probability Ek-Bai, are formed of dense white sandstones, under which there is seen in a deeply cut valley close by, a considerable thickness of green shales, so that if we except these shales, it is the lowest rocks of the geological succession which form the highest points of the range. From this point the edges of the rock turn over, and it becomes apparent that the main axis of the range is formed by a huge anticlinal roll, along the crest of which there appears to have been a fault by means of which, the upthrow being to the east, the turned over edges of the white sandstones are opposed to those of the upper beds.

I have already on page 148 described the characters of the rocks seen between Han-ki-der and the Bungalow, and as the other intervening sections are few and unimportant, I shall pass at once to those in the Chamarlang valley where the coal occurs.

The first coal seen is exposed on the scarped side of a hill called Kuch-búdi. The section is as follows; the thicknesses of the shales were estimated, not actually measured. Ascending—

1.	Coal, dip 10° W.	2″	10.	Shale	?
2.	Gypseous shales much jointed	25′·0″	11.	*Coal*	4½″
3.	*Coal*	2″	12.	Parting	2″
4.	Same as 2	10′·0″	13.	*Coal*	2″
5.	*Coal*	4″	14.	Shale	5′·0″
6.	Shales	25′·0″	15.	*Coal*	2″
7.	*Coal*	3″	16.	Shale	10′·0
8.	Parting	4″	17.	*Coal*	2″
9.	*Coal*	2″	18.	Shale with oyster layer.	

The hill is capped with sandstones which contain fossils of *Turritellas.*

In this section then there is about a total of 2 feet of coal, which is distributed in nine thin layers throughout a thickness of certainly not less than 100 feet of shale.

In another section of the same hill, three seams, possibly identical with some of the foregoing, locally swell out in places, but do not average more than 2 inches in thickness.

Passing from this hill up a small valley in a westernly direction we meet another section at the end of the Harluk portion of the Karvada range, the geological horizon being precisely identical with that of the foregoing.

Here there are in all about seven seams, the thickest of which does not exceed 6 inches. The dip is much disturbed.

The next locality is in the continuation of the same beds on the western or scarped side of the Karvada range, where it overhangs the open valley of Chamarlang.

It was at this locality that the appearances seemed to justify the hope that coal in workable quantity would be found. The following is the section of rocks exposed in this range in ascending order:—

Blue and green clay shales.
Sandstones with fossils of *Turritella.*
Shales.
Coal, good, averaging 9 inches in thickness, strike N.-E. S.-W.; dip 30° S.-E.
Shales with strings of *coal.*
Oyster bed.
Sandstone with badly preserved fossils.
Green shales.
Sandstones.
Red clay shales.

Limestones about 400 feet thick to the crest: below the crest, on the eastern slope, about 300 feet more seen.

The same section appeared to be pretty constant along the hill side for a considerable distance, the coal continuing for upwards of a mile at least. As to the character of the coal I shall again speak further on.

The next and last section in which traces of coal were found to occur is in a pass at the south-west end of the Karvada range and which leads into the Hinki valley; here some thin layers of papery coal were observed in the bluish green shales, which at this spot are much disturbed, dipping from 70° (to south-south-east and south) up to the vertical; further on, their edges are brought in contact with the limestones by a sloping fault.

Between Hinki and Pasta Mara the lower rocks occasionally crop out under the broken crests of the anticlinal rolls of the limestones. Beyond Pasta Mara again these rocks appear, as has also already been mentioned, and finally rise to form the Jhandran range. The route between these places crosses through one short gorge not 300 yards long, which is cut at right angles through an anticlinal roll of dense calcareous sandstones, probably the same as some seen on the main axis near Chuti Mári. A sudden bend to the east carries these beds under the limestones of the Barkan valley.

Fossils.—The evidence afforded by the fossils which I was able to collect as to the age of these rocks is unfortunately somewhat meagre.

I found no trace of any cephalopods whatever, and some could hardly fail to exist if the rocks are either cretaceous or jurassic.

Both Dr. Verchere and Captain Vicary described somewhat similar rocks; the former in the north of the Sulimáns, and the latter in the south. It hardly comes within the range of this account however, as I have already said, to attempt to closely correlate these rocks with others observed elsewhere.

The following is a list of the fossils which for the most part have only as yet been generically determined:—

PELECYPODA.

Ostrea multicosta, Desh.
O. Flemingi, d'Arch.
O. callifera, Lam. ?

GASTROPODA.

Nerita.
Natica.
Solarium.
Turritella angulata, J. de C. Sow. ?
Cerithium.
Rostellaria Noorpoorensis, d'Arch. ?

Some nummulites also occur in the upper beds of sandstones; and a monocotyledonous aquatic plant was obtained in the shales of the coal horizon in the Deka valley.

ON THE COAL AND ITS ECONOMIC VALUE.

From the foregoing it will appear that the best seam of coal which has been discovered in these hills is only 9 inches thick. This seam is continuous for upwards of a mile just inside a low run of hills flanking the Karvada range, which borders the Chamarlang valley on the south-east.

The subjoined assay by Mr. Hughes, of the Geological Survey, of a specimen of coal from the seam shows that, if found in quantity, it would afford an extremely valuable fuel. It may be described as a light non-coking coal. In the absence of all trace of vegetable structure, it would perhaps be incorrect to speak of it as a lignite.

"The mean of two assays give loss by drying, 6·7 per cent. (=water).

Carbon	57·8	Does not coke even when rapidly heated.
Volatile	38·8	
Ash	3·4	
TOTAL ...	100·0	

Ash flocculent, reddish in colour."

Another sample, taken as it came, that is to say, without the removal of the yellow clay which has infiltrated between the cracks and joints in the coal, gave the following result; from which it will be seen the proportion of water is somewhat greater, and that the percentages of carbon and ash exceed those in the preceding, but the result is still good:—

Loss by drying, 8 per cent. (=water).

Carbon	59·2
Volatile	35·8
Ash	5·2
TOTAL ...	100·2

In my preliminary report I pointed out that, notwithstanding the excellent quality of the coal, a seam of only 9 inches is practically valueless.

Were the seam situated near to any line of traffic, some hundreds of tons could without doubt be extracted from near the surface at a small cost. But, however situated as regards traffic, it is a perfectly obvious fact that such a seam could not be worked to the deep with profit.

It remains then to discuss the prospect of better seams being hereafter discovered. In favor of this prospect the only thing that can be urged is, that since a period did exist during the deposition of these rocks when vegetable matter was accumulated in sufficient quantities to form layers of coal, it *may* have happened that in some places the vegetable growth was exceptionally active, or the period exceptionally prolonged, and, as a consequence, the fossilized vegetable matter or coal was formed in exceptional quantities.

On the other hand, as rendering it improbable that such a thick deposit will ever be found, three arguments may be enumerated:—

1stly.—The experience of all those who have explored, or attempted to work, the coal of the same geological age in Sind and the Punjab is against the probability of coal existing in large quantity.

2ndly.—The country in question has, under Captain Sandeman's orders, been thoroughly searched, and all parts are well known to the different tribes, yet no coal forming a thick seam has been discovered. The slight coaly indications, which have in some places been observed and pointed out by the Biluchis, testify to the intelligence and care with which they have hunted over the ground.

3rdly.—My own examination of the ground has shown that the geological structure warrants the belief that since we have rocks of precisely the same age on the outer or eastern slope of the Sulimán range as those with which the coal is associated in the Chamarlang valley, the prospect of finding coal at the former locality should be as good as it is at the latter; and not only as good primarily, but from the high inclination of the beds, their edges being all exposed, very much better. At the same time these outer ranges being readily accessible to the people of the plains, many of whom, besides the chiefs, have some idea of the value of coal, it seems reasonable to conclude that did a large seam occur, it would long ere this have been brought to light. I have above described the character of such coaly indications as have been discovered east of the main range, and have pointed out how unimportant they are.

Had the Chamarlang valley been the only locality examined, it might possibly have been concluded that boring would be advisable to prove the lower rocks; but as these lower rocks are elsewhere exposed and have yielded no trace of a seam, it may be stated that boring could only involve an almost certain waste of money.*

For the benefit of non-geological readers, I shall allude here to a theory which was mooted in reference to the Lagari coal in the early correspondence, and which theory I have known also to be applied to inferior or small deposits of coal of very much greater age than it. This theory is that the coal is not abundant, or is of inferior quality, because it is only "in process of formation." Geological chronology is not yet so far settled as to enable us to say how many thousands or millions of years have elapsed since the coal became coal; but this we can positively assert, that since that time the only possible change that can have taken place is in the wrong direction, in other words, the abstraction or removal of the combustible portions. Nothing short of a miracle, and miracles find no place in the operations of nature, could convert the substances in contact with the coal, be they silicious, calcareous, or aluminous, into carbon or bitumen.

SULPHUR.—While in the hills I heard of a deposit of sulphur which occurs in the Soree pass; subsequently Captain Sandeman obtained some specimens of the crude ore and the manufactured sulphur. The former proves to be gypsum, which is much penetrated by strings of sulphur. This deposit, if not the result of more direct volcanic action, has probably been derived from a hot spring, recent or extinct. A hot spring at Pir Zinda in the Soree pass not far from where the sulphur was brought is well known and is a place of much resort.

Close by is a hill called Bindar, which, according to the map, is 2,858 feet high, and stands out prominently above the low ranges. The season was unfavorable to my examining that part of the country as I should otherwise have done. If this hill should prove to be an

* I put this somewhat more strongly than in my original report, as since it was written, I had, on the return march, an opportunity of examining the lower rocks more closely.

ancient volcano, the occurrence of the sulphur will find an easy explanation. A visit to the hill in the cold weather would be well worth the trouble of any one who might have the opportunity of going there. Sulphur is manufactured from this ore by the Bozdars and Kusranis, and is stated to be abundant. The process is most simple. An earthen gurrah (a thin spherical pitcher) filled with the ore is placed on the fire; as soon as sublimation begins to take place the fumes are caught in a second gurrah, which is placed mouth downwards on the first; cakes of pure sulphur of more or less crystalline structure are thus produced.

To the south of the country visited by me petroleum is reported to occur in the Mari hills. It is collected and used by the Biluchis principally for external application to the sores of diseased cattle. I have no information as to its abundance.

Some rather indefinite rumours of brine springs, and one of the occurrence of actual rock salt, reached my ears; but I cannot vouch for the truth of the statements.

These, as well as many other subjects, will receive no doubt full attention when the systematic examination of the country is taken up by the Geological Survey.

NOTE OF THE PROGRESS OF GEOLOGICAL INVESTIGATION IN THE GODÁVARI DISTRICT, MADRAS PRESIDENCY, *by* WILLIAM KING, B. A., *Deputy Superintendent (for Madras), Geological Survey of India.*

So far, the Godávari District is one of the most interesting in Southern India, from the number and variety of its rock-series: these being found to represent periods in the palæozoic, secondary, tertiary and recent formations.

Since 1837, the district has been rendered classic through the researches of Dr. Benza, (guided by General, then Colonel Cullen), and the Reverend S. Hislop (assisted by Lieutenant, now Colonel Stoddard, Madras Engineers): the first of whom showed that a band of limestones with marine and estuarine exuviæ occurred interbedded with trap in the low hills of Pángadi; while in 1855 and 1859 the latter announced that a narrow but broken band of the Deccan traps with intertrappean limestone containing lower eocene remains cropped out not far from either bank of the Godávari above the town of Rájahmándri.

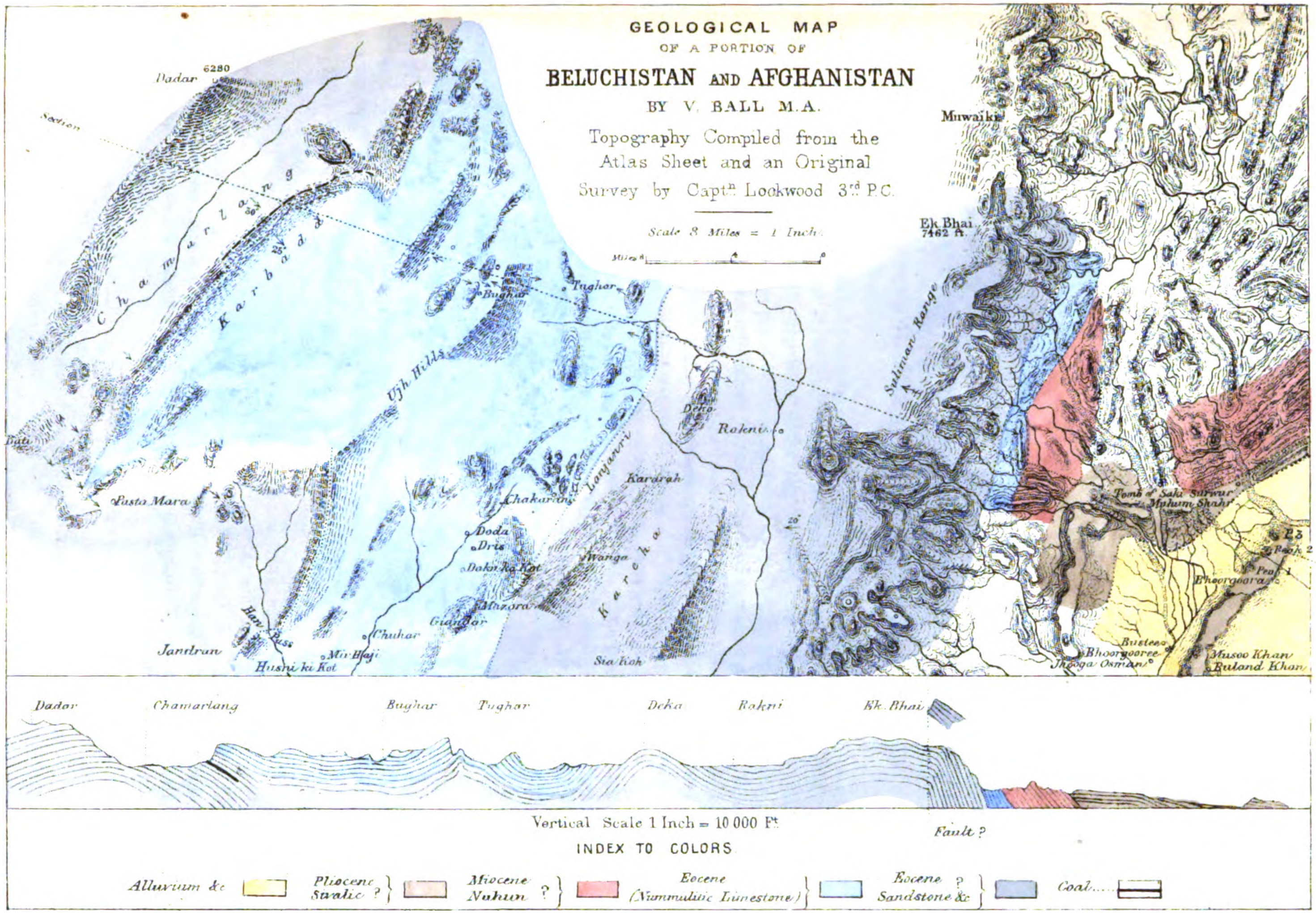
The later investigations of the Geological Survey have added considerably to the above knowledge; announcements of these additions by Mr. W. T. Blanford and myself having been given from time to time in these Records.

Taking the several groups of rocks in descending order, there are:—

1. RECENT DEPOSITS, including the long-known alluvial accumulations of the Godávari and Kistnah which merge into one another and form the wide and extended belt of low-lying plains edging this part of the Bay of Bengal.

2. CUDDALORE SANDSTONES:—These rise up with an easy slope to the westward from under the alluvium as the low plateaus of Samulcottah, Dowlaishwarum, Pángadi, Chinna Tripetty, and Golapilly, and are here and there capped with laterite. The series appears to be identical with a like set of rocks occurring at Cuddalore, the Red Hills near Madras, and again at Nellore, and more or less continuous between these places. They were named Cuddalore sandstones by Mr. H. F. Blanford in 1857.

3. DECCAN TRAP with INTERTRAPPEANS crop out from under the Rájahmándri sandstones at Kártéru and Pángadi; and as Hislop has shown, the intertrappean limestone is of lower eocene age. A few additional genera and species to those already described have been obtained by Mr. A. J. Stuart, Sub-Collector of the Godávari, from the Kártéru locality, my own being more particularly from near Pángadi.


GEOLOGICAL MAP
OF A PORTION OF
BELUCHISTAN AND AFGHANISTAN
BY V. BALL M.A.
Topography Compiled from the
Atlas Sheet and an Original
Survey by Captn. Lockwood 3rd P.C.
Scale 8 Miles = 1 Inch
Dadar
6280
Section
Chamarlang
Karbadd
Ujh Hills
Bughar
Tughar
Deka
Rakni
Karerah
Lonyanri
Chakaran
Doda
Dris
Dokri ka Kot
Wanga
Kareha
Mazora
Gandor
Chuhar
Mir Haji
Husni ki Kot
Jandran
Pusta Mara
Sia Koh
Suliman Range
Ek Bhai
7462 ft.
Muwaiki
Tomb of Saki Surwar
Mulum Shahi
Bhoorgoora
Peak 1
Peak 2
Bustee
Bhoorgooree
Jhoga Osman
Musoo Khan
Buland Khan
Dadar
Chamarlang
Bughar
Tughar
Deka
Rakni
Ek Bhai
Fault ?
Vertical Scale 1 Inch = 10 000 Ft.
INDEX TO COLORS
Alluvium &c
Pliocene Siwalic ?
Miocene Nahun ?
Eocene (Nummulitic Limestone)
Eocene ? Sandstone &c
Coal

4. LAMETAS or INFRATRAPPEANS.—While working out the preceding series in the Pángadi plateau, I discovered a new set of rocks immediately underlying the lower flow of trap a short distance south of the village of Doodkooroo, which is likewise traceable to Gowreepatnam, a mile or so further east. The chabootra, or resting place, of Doodkooroo and the old pagoda of the second village are built of blocks from a fossiliferous bed of this group, which is so crowded with a species of *Turritella* that it may be called in the series the Turritella Zone. This shell is very closely allied to, if not actually identical with, *T.* (*Torcula*) *dispassa* of Stoliczka (Cretaceous Fauna of Southern India, Palæon. Indica). The other associated fossils are *Nautilus, Rostellaria, Murex, Fasciolaria, Latirus? Pyrula, Fusus, Pseudoliva, Pleurotoma, Volutilithes* (very near *Voluta torulosa*, Desh.), *Natica, Turritella* (near *T. Pondicherriensis*, Forbes, and *T. Multistriata*, Reuss.), *Cerithium*, and *Dentalium. Ostrea, Cucullea, Pectunculus, Corbis, Cardita (C. variabilis*, Hisl. and others), and *Cytherea*. There are also a *Ciliopod (Lunulites)* and numerous *chelæ* of a small crab. Only one of these forms, *Cardita variabilis*, is common to this zone and the intertrappeans. There is evidence, I think, to show that the bottom trap of Pángadi is lying unconformably on the Turritella band. Lithologically, this group is very similar to the Lametas in other parts of India.

5. RAJMAHALS.—These dark-red and brown ferruginous sandstones and conglomerates with a zone of fine white and buff shales containing *Ammonites, Pecten, Nucula, &c.*, with *Palæozamia, Cycadites, &c.*, crop out from under the Lametas near Daywarrapilli. In addition to the above and another set of fossils from Innaparazpolliam, which Dr. Stoliczka, just before leaving on the Yarkand expedition, pronounced as having their equivalents in the *Oomia* beds of Kachh (uppermost jurassic strata), I have, during the last season, obtained a good series of plant remains from the Golapilly plateau some twelve miles west of Ellore. They are *Pterophyllum Hislopianum, Palæozamia acutifolium, Pal. rigida, Pecopteris Indica, P.? lobata, Taxodites?, Lycopodium?, Auracarites?*, seeds, leaf-stalks, and stems.

6. DAMÚDAS.—a. *Kamthis*. A further examination of the fossil-locality near Kunlacheroo (pointed out by W. T. Blanford in a previous number of the Records) enabled me to secure the following:—*Vertebraria, Glossopteris Browneana*, var. *Indica*, and var? *Australacia, G. musæfolia?, Nœggerathia, Filicites, Phyllotheca Indica, Yuccites?*, and stems.

b. *Barakars*.—The opinion already given by me in Vols. V and VI of the Records that the sandstones of Béddadanole are of this group, and that they probably contained coal, has been confirmed by the borings selected for Mr. Vanstaveren, the Executive Engineer. Four seams of coal and carbonaceous shale were struck, only one of which is, however, of any thickness. The bore hole of this is near the eastern edge of the field; and at 188 feet 4 inches, a $4\frac{1}{2}$ feet seam of poor coal was found. My colleague Mr. Tween gives the following assay:—

Coal.		*Coke.*	
Carbon	16·4	Carbon	22·5
Volatile	30·6		
Ash	53·0	Ash	77·5
	100·0		100·0

This was evidently from a fair average of the material brought up from the hole, which was more black shale than anything else; for a subsequent analysis, of fragments of fair coal picked from the stuff, gives—

Coal.		*Coke.*	
Carbon	37·0	Carbon	59·5
Volatile	37·8		
Ash	25·2	Ash	40·5
	100·0		100·0

Percentage of moisture, 12·8

As the borings are continued in these and in upper strata, better results as to quantity and quality may be obtained.

There is no other exposure of *coal measures* in this district; neither, from my latest examination, which was carried on to Bezwadah and thence westward to within range of the old work of Messrs. Charles, Æ. Oldham, and R. B. Foote, is there any indication of further outliers in the Kistnah District.

7. CRYSTALLINES.—The gneiss of the Godávari district and down to Bezwadah is to a great extent a highly garnetiferous quartzofelspathic variety, well bedded and foliated. It often weathers into a rock scarcely distinguishable from a sandstone. Bands of very quartzose rock with *graphite* sparingly distributed through it occurs close to Bezwadah, as also some beds of crystalline limestone highly charged with *pyroxene*. Traces of *graphite* are found in the streams of the Béddadanole field, which have evidently been brought down from the gneiss country to the north. Large masses of *tourmaline* of very black color occur at times in the gneiss; and from one region in the Yernagoodum taluq near Koyegoodum pieces of the same mineral have over and over again been sent to me by the district officials * as coal.

The area of crystallines has, however, only been cursorily examined as to its details, and it is therefore premature as yet to refer to it except in this short manner.

NOTES UPON THE SUBSIDIARY MATERIALS FOR ARTIFICIAL FUEL, *by* THEODORE W. H. HUGHES, A. R. S. M., C. E., F. G. S., *Geological Survey of India.*

The manufacture of artificial or brick fuel from small coal and dust, which is becoming an important industry in Europe and America, has a very practical bearing upon the development of the coal resources of this country, owing, not to any pressing necessity to utilise the waste which is gradually accumulating in our chief centres of mining, but to the fact that much of our coal is exceedingly soft and liable to disintegrate, whilst some of it is so crushed in its original bed that it can only be brought to the surface in the form of dust.

It is already apparent that the final remedy for the waste of dust-coal will be the direct one of burning it in a state of powder. The advantages of perfect combustion lately obtained in this way by Mr. Crampton are so important that it may yet prove economical even to crush round coal for the furnace. At present, however, in India, where the chief demand is for locomotive engines, only two plans are open to us to render dust-coal of marketable value; the one to coke it; the other to convert it into artificial fuel. The system which promises least success is that of coking, for the excess of ash and water in some, and the small amount of volatile matter in others, affect the coking property of a large percentage of Indian coals, and the most generally applicable method for their utilisation is that of consolidating them as artificial fuel. It may therefore be useful to bring to notice a very interesting and valuable essay, *De l' Agglomération des Combustibles,* by M. A. Habets, of the École des Mines de Liége, in which the substances are indicated that have found most favor in France and Belgium, where the manufacture of brick-coal has attained its greatest development.

* Some years ago, when arranging the collection in the Madras Museum, I found a piece of tourmaline labelled as coal, and as forwarded by the late Mr. Boswell, M. C. S., who was one of the advocates for the occurrence of coal in the Kistnah District.—W. K.

The principal qualities to be aimed at or avoided in the substances used are :—

1st.—To supply any defect in the combustibility of the raw material.

2nd.—To prevent the fuel from crumbling in the fire.

3rd.—Not to augment the quantity of inorganic matter in the mass.

Tar and, above all, pitch are the matters best adapted to fulfil all these conditions.

The principal substances proposed, or that have been the subject of experiments, are as follows :—

1st.—Vegetable and mineral tars, fluid and dry pitch, asphalt, bitumen, resin, and gutta-percha.

2nd.—Amylaceous substances, damaged starch and farinaceous matter, residues from the manufacture of starch, &c.

3rd.—Fatty matter, animal or vegetable, oil-cake (colza, poppy, &c.).

4th.—Gelatinous matter, gelatine, glue, débris of horns, dung, &c.

5th.—Mucilaginous matter, certain decomposed mosses, &c.

6th.—Potash or soda soaps.

7th.—Oxygenous substances, such as nitrate of soda, chlorate of potash, and peroxide of manganese.

8th.—Earthy plastic substances, clay, plaster, lime, tarry cement, and silicate of soda.

Inorganic substances.—The inorganic matters comprised under the two last headings are evidently only applicable for the manufacture of fuel for domestic purposes, where the object is to sustain combustion for a long time without letting the heat be too strong. M. Habets leaves it to be inferred that the oxygenous substances are added to modify in this case the purely deadening influence of the incombustible earths, which form as much as 25 per cent. of the compound.

Amylaceous substances.—After tar and pitch, starchy matters are those which have been most frequently used. In fuel for domestic consumption they have replaced tar, on account of the inconvenience arising from the odour of the latter material. With a proper draught, however, no annoyance at all is felt.

Tar.—Tar, which is still employed to a certain extent in England, has almost entirely fallen into disuse in Belgium, and is only retained in a few French factories, it having been found that bricks made with tar will not bear long carriage, that they stick together when placed in heaps, and that they give off in burning a great deal of smoke and a disagreeable smell.

Fluid pitch.—The manufacture with fluid pitch, which in 1858 had made rapid progress, is now (1871) only carried on in two factories in Belgium, namely, at Sauwartan—where Knab's system of coking furnishes the necessary pitch—and at Gosselies, where the employment of Evrard's machinery necessitates its use. The plant required for the application of fluid pitch is much larger and more difficult to keep in repair than that required for dry pitch. Heaters, pumps, tubes, mixing screws, and special distributers, &c., must be provided; skilled workmen must be employed, and the drawback arising from imperfect distillation in the drying process must be guarded against, otherwise the bricks will be too smoky and melt in the sun.

Dry pitch.—Dry pitch has almost universally superseded fluid pitch, for experience has shown that less machinery is required to work it with, a more regular product is obtained, and the bricks are less liable to soften. Its employment permits a certain degree of automatism, which has had the most happy result in the lowering of the cost, owing to the doing away with the necessity of having specially educated workmen; and another great advantage lies in the fact that the bricks can be handled almost immediately after leaving the press.

Dry pitch is not a constant product. According as the distillation has been pushed too far, or the contrary, its density varies between 1·286 and 1·275. If the evaporation is carried on to dryness, a product is obtained deficient in agglutinating properties, and it is found necessary to add fluid pitch, tar or some heavy oils. The following is an analysis of dry pitch of 1·28 density:—

Carbon	75·32
Hydrogen	8·19
Oxygen	16·06
Ash	·43
	100·00

The above extracts will suffice to show that M. Habets is an advocate for dry pitch as an agglutinating material; and the experience gained in Belgium and the north of France certainly points to it as best adapted for the purpose. But he points out that this process has not been adopted in the south of France, owing to the heat of summer making it difficult to reduce the dry pitch to the state of powder; and until this difficulty is surmounted, the same objection would hold with even greater force for India. In the southern provinces of France the soft-pitch process prevails, smoke-consumers being adapted to the furnaces to obviate the evil effects of the mass of volatile products: the same system could probably be applied to the case of India. It was no doubt considerations of this nature that led Mr. Danvers in his book on coal to elect in favor of the starchy cements for India; and at present the choice seems to lie between these and the soft-pitch process.

M. Habets makes little or no specific mention of the other substances enumerated in the 3rd, 4th, and 5th sections of his list. We may presume that no practical result was obtained from them. His essay is most valuable for the detailed descriptions and figures of the different processes of manufacture.

Some attempts have been made to adapt farinaceous agglutinants to the semi-bituminous waste of our collieries in the Rániganj field; and considered as mere experiments they were successful, but commercially they were failures. Rice and Indian-corn were both tried, and they formed good cements, but they constituted a very heavy item in the cost of production.

I think the time has scarcely arrived for the manufacture of artificial fuel to be a successful industry in the Ráníganj field while whole coal can be procured at its present or even at a considerably enhanced price; but with regard to the Dárjíling coals (which can only be extracted as dust), and to a certain extent those of the Wardha valley, the only course left for utilising them in the absence of the possibility of converting them into coke is to make them into brick-coal.*

Some trials have recently been made in the Central Provinces to consolidate the coal of the Warora colliery—which is of a very friable nature—by means of rice and gum, &c.

The proportions of the substances used were—

Coal	112 lbs.
Rice	1 lb.
Gum	½ lb.
Water	½ gallon.
Nitrate of soda	4 grains.
Potash	4 "

* My colleague, Mr. Mallet, was the first to suggest that the Dárjíling coal, in order to be rendered available, ought to be made into patent-fuel.

The fuel so prepared was tried at the mint, but it burnt in a dull, smouldering manner, gave a bad welding-heat, and left a great deal of clinker. An assay proved it to contain 10·2 per cent. of water and 22·6 per cent. of ash—an amount of useless matter that could not fail to retard combustion.

As a highly oxygenous substance, it might have been supposed that the addition of nitrate of soda would assist combustion, but any advantage that the presence of this salt ought theoretically to confer would be neutralised by the heat lost in evaporating the water that it absorbs readily from the atmosphere. Four grains are scarcely an appreciable quantity, and would yield only enough oxygen to enter into combination with less than one grain of carbon. To be of any theoretical value, it must be used in larger proportion than that given above. But the use of nitrate of soda is, I think, questionable, on the ground of its deliquescent nature, unless a plan of rendering each lump of fuel thoroughly water-proof can be adopted. It must also affect the formation of clinker.

Gum, which is one of the ingredients, has never been brought into practical use in Europe owing to its price, and the same circumstance will probably militate against its employment in this country.

When a farinaceous cement is employed, it is usual to add some alum in order to strengthen it. The Diamond Fuel Company, which is now working Barker's process, use sulphate of alumina or chloride of alumina in hydro-chloric acid, in the proportion of one ounce to a gallon of solution of starch. Tar, or better still pitch in small proportion, is also added in a small proportion to render the fuel less friable and more water-proof. In the case of the Warora fuel, neither alum nor pitch was used.

The Dárjíling dust coals approach in composition those of anthracitic regions, and will require a cement that does not consume in the fire more rapidily than the coal, for it has been found that "if the agglutinating material burns too briskly, the particles of coal having lost their adhesive coating crumble in the fire and fall through the grate unconsumed."* Some slow-burning farinaceous cement will probably be the best substance. On the subject of Dárjíling coal, however, I refer the reader to the detailed report of Mr. Mallet, in the Memoirs of the Geological Survey, Vol. XI, which is now in the press.

Attempts have been made to coke mixtures of anthracite and bituminous coal-dust, but the coke produced could not bear handling; it had no density, and it was very porous, owing to the fact that the particles of anthracite would not unite with the bituminous particles.

Putting clay aside as an agglutinating material for the reason which has already been given, the most easily procurable cement in this country is that coming under the head of starch; but tar or its derivatives possess properties which render them almost a necessary ingredient in most artificial fuels.

There is not a large native supply of pitch, but the Bengal Coal Company are carrying out experiments in a most spirited way to prove the yields of tar, pitch, oils, &c., from their different coals; and the results will give useful data by which to estimate the capability of Indian coals as a source of supply.

CALCUTTA, 1*st October* 1874.

* The "Journal of the Franklin Institute," 1874, Vol. LXVII, p. 118.

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OF

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UNDER THE DIRECTION OF

THOMAS OLDHAM, LL.D., F.R.S.,

SUPERINTENDENT OF THE GEOLOGICAL SURVEY OF INDIA.

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RECORDS
OF THE
GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1875. [February.

Annual Report of the Geological Survey of India, and of the Geological Museum, Calcutta, for the year 1874.

The labours of the Geological Survey of India have been, during the past season, almost entirely under the control and direction of Mr. H. B. Medlicott, who was officiating as Superintendent during my absence on leave. As stated in the report for last year, I remained for some time at Vienna arranging for the proper exhibition of the collections forwarded by the Geological Survey of India; this delay, however, did not tend to the improvement of my health, and I was in consequence not able to return to duty in India at as early a date as I had hoped. My first duty, on resuming charge of the survey, is now to express my high sense of the great zeal and energy with which Mr. Medlicott devoted himself to the duties imposed on him, and the wide knowledge of Indian Geological work and the high intelligence which he brought to bear on the researches of the survey, for which I am greatly indebted to him.

During almost the entire year, in addition to my own absence, the Geological Survey was also deprived of the aid of Mr. W. T. Blanford. He was, during this period, busily engaged in working out and passing to press the results of his examination of parts of Persia, while accompanying the Seistan Boundary Commission as Naturalist and Geologist. These researches, regarding a country but little known, and at the same time so intimately connected with Western India and Sind, will, I have no doubt, prove of very high value and interest to Indian Geologists. Their publication may now be looked for soon. Mr. Blanford resumed his duties on the Geological Survey about the middle of December, and then visited Surat district with a view to advise the authorities on the probabilities of obtaining fresh and good water in many places where now the supply is bad, salt, and brackish. Mr. Blanford has since then proceeded to take up the general examination of the Province of Sind.

Another of our staff who was absent at the commencement of last year, and whose return we looked for with great interest, has fallen a sacrifice to his over-exertion in the cause of science. Dr. F. Stoliczka, who had been, as reported last year, attached to the Yarkand mission under Sir T. Douglas Forsyth, had, though with much suffering, safely accomplished the journey to Kashgar, and had also on his return had a rapid and hurried ride across the Pamir Steppe, which he had often longed to see, and was returning to his work in India laden with rich and valuable zoological collections and with abundant notes to work out his results, when he again felt the extreme temperature of the Karakorum pass. For a couple of days from 16th June he worked on quietly, and though with suffering, continued the usual marches of the party with whom he was travelling. On the afternoon of the 18th, when more than half the day's march had been completed safely, he noticed something high up on the hill side, which arrested his attention, and dismounting from his horse, which, of course, could not climb up the rugged cliffs of these bare and snow-clad hill sides, he himself with great exertion struggled up, examined what he wished to see, and made his notes, and struggled down again to his companions. They noticed the great difficulty he found in again mounting, and came on to the camp slowly and carefully; the march next day was countermanded, in the hope that a little rest might enable our friend to recover himself, but falling into a semi-unconscious state, he only lingered on until the noon of the following day (19th June). His body was conveyed to Leh, where, with all possible honours, his remains were interred in the presence of his fellow travellers, the officers of the mission.

Thus passed away at the early age of 36 one of the most devoted and able votaries of Natural Science whom India has ever seen.

Gifted by nature with peculiar powers of observation and comparison, trained in an accurate and careful school of Geology and Palæontology, he brought to his labours unbounded zeal, acute intelligence, and large and carefully acquired knowledge, all of which tended to render him one of the most useful and most trusted of our colleagues. But in addition to this, his genial temperament, his sound judgment, and his hearty appreciation of work of any kind in others, together with his clear views of justice, and the unflinching expression of those views, made him also one of our most esteemed and beloved friends and advisers. His loss to the Geological Survey will be long and keenly felt. He has left behind him a noble monument of his research and powers in the Palæontologia Indica, published by the Geological Survey of India, in which, just before his departure for Yarkand, he had completed the description of the Cretaceous Fauna of Southern India in four large volumes 4to., with 203 plates. And fortunately for the Survey, he has also left behind him a very fitting and competent successor in Dr. Waagen, long his trusted fellow labourer and assistant. Dr. Waagen's publications have already secured for him the high approval of all competent to judge of such careful and accurate research.

Dr. Waagen himself was also absent on medical certificate during the year, and has only recently returned to take up the Palæontological labours on which he was so actively and earnestly engaged, when his health gave way. He has, I am happy to say, returned in good health.

Mr. Medlicott's time was so fully occupied by the current work of the survey, and by the pressing necessity for constant revision of the reports and researches of others, and unceasing communication and advice on all points referred to this office, that he found time for only two brief visits to the field. At the urgent request of the Government of Bengal, he undertook to visit the localities where coal was reported to occur within the Garo Hills. Until very recently, it was not possible to proceed into these hills with safety. And when formerly Mr. Medlicott visited the southern fringe of the hills (Memoirs, Geological Survey, India, VII, 151), and described the local exhibition of some poor coal-seams along their outskirts, no repetition of these rocks was known to occur within the range. But on now getting access to them, several detached basins of newer secondary rocks have been found in the heart of the hills, north of the main ridge. In one of these a strong seam of fair coal is pretty generally distributed. An account of this discovery was given in the May part of the Records of the Survey, 1874, p. 58, and it is therefore unnecessary to refer to it more in detail here. A short run into the northern portion of the Rajmehal Hills resulted chiefly in the discovery that no alluvial deposits occurred on the top of Putturghatta Hill north of Colgong, where they had been reported to occur, at a level which made it difficult to account for their existence, excepting on the supposition that the 'old alluvium' of Bengal had a marine origin.

Mr. Theobald continuing his researches in the upper tertiaries, flanking the north-western Himalaya, has made a rapid examination of the area lying between the Ganges and the Ravi. Some of his results, if confirmed by more careful investigation, are of high interest. He considers, apparently on good grounds, that the great mass of the Sivalik range on this side (east) of the Jumna river is really composed of rocks belonging not to the Sivalik group, but to the older and distinct Nahan group, a view in which Mr. Medlicott, who formerly examined this area, is disposed to concur. Trans-Sutlej, Mr. Theobald thinks he has established a northern limit for the Sivalik rocks along the Una dun. These are most interesting results, but as some of the most important palæontological deductions depend on these separations of the rocks in which the fossils occur, they must only be taken for the present as provisional.

Further research has led him to modify the conclusions arrived at in the previous season regarding the pre-Sivalik age of glacial deposits, for he finds typical glacial débris scattered irregularly over the rocks in the typical Sivalik area.

The collection of the very valuable fossils of these areas increases rapidly under Mr. Theobald's hands, and a large number have been received, the majority of which cannot be opened out for want of space in the Museum here.

Mr. A. B. Wynne commenced the examination of the Trans-Indus salt region early in the season. At the special request of Mr. Wynne, Dr. Warth, in charge of the Pind Dadun Khan Salt Mines, was deputed to accompany him, so as to form a sound practical estimate of the commercial value of these extensive salt deposits. Dr. Warth was unable to proceed with Mr. Wynne in the early part of the season, but subsequently joined him on the ground. This work was very well accomplished, and a brief summary of the geological results was at once submitted with the practical report of Dr. Warth. And this was published under the Revenue Department. Before the close of the year Mr. Wynne had completed a detailed descriptive report with full illustrations. And this is now in the press, and I trust will be ready for publication without any serious delay. Besides determining the enormous extent of the rock-salt, the most interesting result is the confirmation, in all probability conclusively, of the supposed old tertiary age of the rock-salt. This idea which had been arrived at during a cursory and preliminary examination in previous years was borne out by the careful and detailed investigation of the past season. No rock older than the salt has yet been noticed, and this salt seems to be intercalated with the lower beds or almost the base of the nummulitic rocks.

During the recess Mr. Wynne was also engaged in revising, and to a considerable extent rewriting, the report on the Salt-range. At the opening of the present season he took the field with the object of working up the country lying between the Salt-range and the Kashmir boundary to the north, and is now engaged in this area. He has sent in a good collection of fossils from the newer tertiary beds of that region, and also some from the small ridge of the Khárián or Pabbi hills on the east of the Jhelum river.

Mr. King, though unavoidably late in taking the field, in consequence of being detained at Vienna, has made, during the season, good progress in following up the interesting questions to which reference was made in the report of last year. He establishes three zones in the Rajmehal series: the uppermost characterized by a marine fauna recognized by Dr. F. Stoliczka as corresponding to his 'Oomia' beds in Kachh; a middle zone also containing marine fossils of somewhat different form from the preceding, and a lower zone with well marked Rajmehal plants. This last is found to be closely superimposed, but with general unconformity, upon beds containing plant remains belonging to the Kampti-Damuda flora, thus leaving little or no room for the zones which elsewhere are thought to intervene between these two formations. Mr. King's work includes a large portion of sheet 94 of the Indian Atlas, but unfortunately the northern portion of this sheet is still unsurveyed topographically, or rather the topography is not yet published.

The exploration of the Beddadanole coal-field was continued under Mr. King's direction with the assistance of Mr. Vanstavern. Some bands of poor coal and coaly shale were proved in the lower parts of the measures. The upper portion has not yet been proved; yet it is there, according to the analogy of the Wardha fields, that the main coal is likely to occur, if at all. This portion will be tested on Mr. King's return from his present duty, and on Mr. Vanstavern returning from the Juggiapettah borings. These have been put down alongside those formerly made by Colonel Applegath, and where he believed he had found coal, but Mr. Vanstavern has not been able to trace any proof whatever of the existence of coal or of any similar substance, although his borings have been carried below the depth to which the previous one had proceeded. All these borings have since been carried down to the metamorphic or sub-crystalline rocks *without a trace of coal.*

Mr. King has been diverted from the systematic continuation of his work for the present season to examine the gold-bearing reefs of the Wynád, and is at present actively engaged on this work.

Mr. Foote accomplished a heavy season's work in the Southern Mahratta country, completing the examination of the quartzite series of that region. Considerable progress has been made in preparing for publication a detailed description of this area. Mr. Foote also examined so much of the adjoining country as enabled him to complete the northern half of sheet 41 of the Indian Atlas, and the north-west quarter of sheet 58. In the preparation of these maps also considerable progress has been made.

At the close of the season, Mr. Foote made an examination of the small gold-bearing tract in the Dambal hills of Dharwar. Of this a report with small map has already appeared. (Records, Geological Survey, November 1874). The smallness of the area and the sparing distribution of the metal seem to offer but little inducement for any large outlay of capital in gold mining or washing.

At the close of the recess Mr. Foote took up the country north of Madras town in order to complete the area lying between the hill ranges and the sea (in sheets 76, 77, and 95), also to close in a large portion of that country. This had been left while urging on the examination of the Kadapah and Karnul districts, as being of less pressing importance at this moment.

Mr. Hughes has again been largely called upon for investigations which are not purely geological, and which very seriously interfered with the systematic progress of the survey. These have been chiefly in connection with the prospects of establishing the manufacture of iron in various places. At the close of last year he had just completed a re-examination of the available ores and associated rocks of Kumaon; this examination only confirmed the views expressed years since by the Geological Survey as to the abundance of ore and flux, and as to the probability of their being also a good supply of fuel for operations upon a limited scale. He is disposed to take a rather less favourable view of the richness of the ores, but this was always the view of the Geological Survey; the great tractability of the ores to a good extent compensating for a certain poorness in quality.

Mr. Hughes was then detained to revise the examination of parts of the Raniganj field, with a special view to the advantages offered by it as a locality for the smelting of iron, and establishment of iron works on a large scale. On these points full reports have been published during the past year in the Records of the Geological Survey.

These investigations detained Mr. Hughes, so that he did not get to his regular work until late in January. With Mr. Fedden's aid he then remapped the northern portion of the Wurrora coal-field, taking advantage of any recent exposure of the rocks in order to revise his geological lines. In a country so largely and thickly covered with alluvial deposits, it becomes necessary to pick out every single point so as to obtain any clue even of a trivial kind which may lead to the identification of the various rocks so badly seen. And this Mr. Hughes appears to have done with much care. It is gratifying to find that the practical conclusion based solely on such geological investigations, as to the existence of coal in the neighbourhood of Bander, has been fully confirmed by actual borings commenced entirely on Mr. Hughes' recommendation. These borings have proved the existence of coal many feet in thickness, the occurrence of which would never have been suspected from any surface exposure of the beds. This fact becomes of higher importance, because the locality of this coal is greatly nearer the very valuable iron ores of the country than any previously known beds of coal in the Wardha valley fields.

Passing into the Berars and the Nizam's territories, Mr. Hughes continued these investigations, and was able to give important advice and aid to the Nizam's officers.

It is a source of much regret that in consequence of the frequently recurring and continued interruptions to Mr. Hughes' progress in that district, the mapping of this Wardha coal-field is not yet completed. There is still a considerable area calling for careful examination, and in which it is not improbable that valuable results may yet reward our search. It would only cause greater delay to put any one else to complete this work now. And we can therefore only hope that it may yet be practicable without any much prolonged delay to complete the examination. The very existence of true coal in these districts and the sound knowledge already obtained of its extent and amount is altogether the result of the labours of the survey, and we should be glad to complete the investigation of the rocks as soon as practicable.

Towards the end of the year Mr. Hughes' aid was again sought for by two separate companies, who have undertaken to remove the all-important trial of actually smelting iron in this country from the field of speculation and writing to that of actual experiment on a commercial scale, in order to point out to them the most favourable localities for the procuring of ores, coal, &c., &c. He had scarcely concluded this work when the year closed. He will thus again have only a brief season to devote to his systematic work. He will, I am sure, do all that can be done in the time, but it will be entirely impracticable to complete the field in one short season.

Mr. Fedden, who, as stated in last year's report, had been absent on sick leave, did not return to work until late in January, 1874. He then joined Mr. Hughes in the Wardha valley field, and worked with him for the remainder of the season, putting in the detailed geological lines in parts of the Chanda district and in the adjoining territories of the Nizam. At one place north of Wurrora, Mr. Fedden was fortunate enough to discover a few specimens of fossil fishes in the uppermost beds of the sedimentary rocks, at about the same horizon as that on which the Reverend Mr. Hislop years since found similar remains. These will doubtless prove a valuable addition to the limited evidence we already possessed on which to base a conclusion as to the age of these beds. Mr. Hislop classed these rocks as belonging to the infratrappean beds of that neighbourhood in which he states that he found shells of the same kind as from the intertrappean layers, mixed with bones of large animals. On this evidence he referred the rocks to the same age relatively as the Lameta beds of the Narbada valley.

During the current season Mr. Fedden is attached to Mr. W. T. Blanford in Sind.

Mr. V. Ball only returned from the great exhibition at Vienna, where he had been, jointly with Mr. W. King, in charge of the valuable collections of the Geological Survey, late in the year. After some few unavoidable delays which prevented his getting to the field till towards the end of December, he was again frequently interrupted in his work in connection with the borings in the Dudhi valley. His survey labours were confined to the country included in sheets 17 and 18 of the Satpura Survey. He had made some progress in this area, when at the beginning of March, he was suddenly summoned to Calcutta, with a view to his accompanying some others on a visit to the Mergui Archipelago. This trip was subsequently abandoned, nor indeed under any circumstances could geological results of interest be looked for from such a visit to a country already examined. It was useless his returning to the field again after this trip was given up. Mr. Ball had thus only a very brief season of work, scarcely more than two months out of the whole season. It would scarcely be fair to look for any large outturn of work in this short time. The ground on which he was engaged was difficult, and the intricate relations of the various groups of rocks must all be more thoroughly elucidated and worked out before any descriptive account of them can be published.

Mr. Ball subsequently visited the wild district of the Luni Puthans, west of Upper Sind, where some traces of lignite had been seen. A full account of this visit has already appeared (Records, Geol. Surv., Ind., 1874, p. 145), so that it will be unnecessary to refer to it here in detail.

The experimental borings for coal in the region of the Narbada have not yet led to any discovery. Early in the year two borings were commenced, at Khapa and at Manegaon, in the valley of the Dudhi. These were in the Mahadeva rocks, and were put down in the hope of striking the coal-measures beneath. At the beginning of the monsoon these borings had reached 260 and 241 feet respectively from the surface, and were still in the covering rock formation, when the work was necessarily closed for the season. The labour was then transferred to the boring at Sukakheri in the main valley, where a depth of 344 feet had already been reached. There, it may be noticed, the endeavour is to reach the rock underlying the valley deposits, there being some grounds for supposing that the coal-measures of the Sitariva extend to the north. This boring has been carried down to the depth of 491 feet still in the stiff kunkur clay. The 3-inch piping having stuck fast at 425 feet, the additional depth was attained with great difficulty, until finally it was found impossible to do more than draw the sludge filling in from the sides; and the work had to be stopped. This boring had been commenced with such material as was available at the time, and with the full expectation that rock would be reached at a less depth. It had also the further disadvantage of frequent interruptions from want of piping; much credit is, therefore, due to the skill and energy of Mr. Stewart, that he was able under the circumstances to push the work so far.

No direct knowledge has, however, been gained upon the question to be solved excepting collaterally, that it would certainly be very costly to sink for coal through such a depth of superficial deposits. It may possibly be that these deposits are exceptionally thick at Sukakheri, and that rocks may be nearer the surface elsewhere, and the question would seem of sufficient importance practically, and of sufficient general interest to warrant a renewal of the trial in another spot. The lowest few feet of clay in the boring at Sukakheri were much charged with black ferruginous granules, single and agglomerated, suggesting perhaps the proximity of a lateritic bed which is by no means uncommon at the base of the old alluvial deposits, and this again most frequently occurs where the trap rocks occur underneath. Both these conditions are seen to obtain at several points along the margin of the valley.

Since the stoppage at Sukakheri near the close of the year, work has been resumed at Khapa and Manegaon, and progress has been already made beyond the depth attained before stopping for the monsoon. In December also two new borings were commenced in the Tawa valley, at Kesla and the Suk Tawa: the latter is certainly in the Dámuda rocks; the former is in lower Mahadeva beds. The hope is to strike the Barakur coal-measures, and thus, if coal be found, to save twenty miles of rough carting from the Shapur or Bétul coal-field to the south. As has already been fully explained, it is impossible to speak of success as anything more than a chance, inasmuch as no outcrop of these measures is seen north of the Shapur field.

Mr. Willson steadily continued his mapping of the northern portion of the Bundelkund Survey and finished several sheets of the 1-inch plans. One of the principal points of interest connected with this area is the great prevalence of quartz reefs or veins, having a very constant and definite direction and occurring in large number and of great size. There are also two systems of trap dykes in considerable number, and Mr. Willson finds evidence, which seems almost conclusive, that both these systems of trap-dykes are younger than the great quartz reefs, a conclusion of the highest interest as bearing on the geological history of the district. Mr. Willson has again resumed this work for the coming season. Mr. Willson's mapping is always distinguished by care, neatness, and accuracy.

Mr. Hacket resumed his labour in Rajputana, mapping in a large area of the country lying between Bhurtpur and Jaipur, and to the south, included in the sheets 27, 35, 37, 38, 39, and 41 of the Rajputana Survey, and in parts of 10*a*, 10*b*, and 12 of the Gwalior Survey, (scale 1 mile = 1 inch). All the rocks met with belong generally to the samec lass as those previously described by Mr. Hacket in the Biána hills, being chiefly quartzites, with very irregularly intercalated zones of schists, limestone, and trappean rocks resting upon or against gneissic masses. Mr. Hacket is disposed to adopt the name attached to the general range of these hills as a general inclusive name for the whole series of rocks, and to call them the Aravali series.

This work will be continued on Mr. Hacket's return from furlough, on which he is now absent. It has been for some time anxiously looked for, as tending to fill in one of the great *lacunæ* on the map of India, with a view to a general geological sketch of the country, and one of such importance that nothing very satisfactory can be done towards such a map until this portion of the country has been examined.

Mr. Mallet accomplished the examination of Sikkim (British) and of the Western Dhuars. The interest attaching to this field, from the probability of the coal forming an useful source of fuel, led to the publication of Mr. Mallet's report as quickly as possible. It has been issued with two geological coloured maps. Excepting in the Darjiling district his examination had to be limited to a mere fringe of the mountains; in places, indeed, even this much is beyond reach of the British boundary. There would appear to be some prospect of the Dámuda coal of that region being made serviceable by the adoption of suitable contrivances for the utilization of such dust or powdery coal.

Mr. Mallet's observations have led him to the conclusion that the Dámuda formation is, in this country, the lowest member of the rock series of the outer Himalaya ranges, the Darjiling gneiss being the topmost and youngest member of the same series. This, if confirmed, is a result of very great interest and importance, and would tend to establish a well marked common horizon between the rocks of the Himalaya and those of the Peninsula of India. Mr. Mallet's researches, excepting in the point to which his attention was specially directed, were necessarily rapid and cursory, and the maps can only be viewed as preliminary sketches. Until the country on either side is worked up to this portion, no really trustworthy or reliable section can be obtained from such isolated areas.

During the past year there have been four apprentices attached to the Geological Survey and paid out of the funds granted for that survey. Of these four, one has now been attached to the survey for nearly two years. During the present season he has been sent to the field with one of the assistants (Mr. Ball), who reports that up to date he has been attentive and willing to learn, but that his progress is very small and very unpromising. Further experience will be necessary before anything definite can be said as to the future prospect of this student. The other three, although nominated at the beginning of the year and receiving pay as apprentices, have been doing nothing in connection with the Geological Museum or Survey, having been, under the sanction of Government, attending courses of lectures and instructions at the Presidency College. Undoubtedly these lessons will enable them to appreciate better than they could otherwise have done the more technical knowledge which they are expected to acquire here. But the necessity for their devoting considerable time to this acquisition of what must be considered purely preliminary and collateral knowledge preparatory to any study of geology or its bearings, will also undoubtedly prolong the time during which they must be merely learning. It may, I think, well be doubted how far the system of paying young men for learning what they ought to be able to prove their acquaintance with, before their appointment, can be very successful. Certainly the system of giving appointments in order to induce the holders of those appointments to make themselves acquainted with their duties has, in every other scientific pursuit, proved a failure. These student apprentices will be subjected to examination at the end of the season, when their general progress can be tested.

As customary, a small map of India is annexed, showing the present rate and general progress of the survey.

Since the commencement of this survey it has ever been my anxious desire and aim to complete a general sketch map of the Geology of India. The conviction has grown stronger each successive year, that until this can be done, nothing really useful can be attempted in the direction of very detailed geology, and that our progress must necessarily be slow and irregular, until we shall have been able to fix even roughly the boundaries between the known and the unknown. I still hope that I shall be able to complete such a map. But I deeply regret to say that during the last few years, very little advance has been made towards the accomplishment of this end. There have been for some years so many and such urgent claims on the time of the officers of the survey for work of various kinds, often not geological, and the staff of the survey has been so reduced by illness and absence, as well as by actual diminution of numbers, that very little progress has been possible in that which has always been recommended to be, and which has indeed been more than once ordered to be considered the first and main object of the survey, namely, the systematic and continuous survey of the country. I am fully aware of the value of the results often obtained from enquiries in isolated areas, and at detached and separate points. Striking instances of this might be given from last year's work. Yet I am also compelled to think that these isolated enquiries are rarely of such immediate and urgent importance as to counterbalance the great and heavy disadvantage resulting from this very fact of their isolation. Each becomes a separate individual case, which it is impossible to colligate into a whole simply because we have no knowledge of the connecting links in the chain. Indeed many cases might be given where it seems more than doubtful whether anything is really gained even in time from such necessarily imperfect and unfinished results. A few years of devotion of the greater portion of the staff of the survey to this one object would enable such a general preliminary map to be published, subject of course to additions or corrections as the more detailed work progressed in future years.

A glance at the little map which accompanies this report will at once show what large areas there are regarding which the Geological Survey of India as yet knows nothing of its own research. But the difficulty in compiling a general map does not depend so much on the size or frequency of these gaps or *lacunæ*, for, of course, they could be left out, to be filled in afterwards, but on the fact, that without some knowledge of these intervening spaces, it is impracticable to correlate the rocks in one part of the country with those elsewhere. Each district or area examined in itself is necessarily described by itself, the rocks which occur in it are reduced to a system, their succession traced out, and their relations one to the other determined so far as possible. Local distinctive names are given to such separate groups, and all is rendered as complete as may be possible *for that area*. The survey operations are meanwhile directed to some other locality, and the same process of examination is gone through, but the results are not exactly the same; new sub-divisions of the rocks become necessary, new names are given to distinct groups, for local convenience of description. This result is equally correct and equally satisfactory for its own area. But for any general map, it becomes essential that all these differences should be eliminated, however roughly, and all reduced to one general system or scale, and this is precisely what it is impracticable to do without some knowledge, however imperfect, of the country generally, which knowledge there is no means of obtaining while the officers of the survey are engaged in isolated localities and on special researches.

Seeing then the very distant prospect which was before the survey of being able to work out any general map from their own researches, I have for some years devoted much attention to preparing separate descriptions and in some cases separate maps of certain divisions of the country, so far as these were possible. Passing over papers descriptive of the general geology of districts, or collectorates, (such as Surat, Gwalior, neighbourhood of Madras, Godavari, &c.,) a general sketch of the Geology of the Central Provinces was given so long since as 1871, of Orissa in 1872, of the Bombay Presidency in 1872, of the North-Western Provinces in 1873, of part of Punjab in 1873, and a general sketch of the Punjab is now just ready for press, while a general sketch of Bengal will be taken up also. These are all in addition to the regular and more detailed descriptions of separate areas, coal-fields, &c., &c. The most cursory reference to these sketches will show the impossibility of combining all into one system, without more knowledge of the intervening areas, as yet unexamined, or, as the other alternative, reducing the map to such large generalities as would get rid of these minor difficulties, but would at the same time make such a map of extremely little value.

It is our earnest hope, however, that the survey will be permitted to complete such a general sketch map as may prove useful and within a limited time.

PUBLICATIONS.—Of the MEMOIRS of the Geological SURVEY OF INDIA, Vol. X, part 2, announced as nearly ready at the close of last season, was issued early in the year. This contained a descriptive account of the Geology of Pegu by Mr. Theobald, with map, &c. And at the close of the year, part 1 of Vol. XI, containing a report by Mr. Mallet on the Geology of Darjiling and the Western Dhuars, with two geological maps, &c., appeared.

Of the RECORDS of the Survey, the usual quarterly publication was steadily maintained, and the volume for 1874 contains no less than twenty-three separate papers on varied points in the Geology of India. Four of these are valuable summaries of the geological results obtained during the visit to Yarkand with the mission recently returned from that country by our lamented colleague, Dr. F. Stoliczka. These with the note on the Altum-Artush, which will be found below, complete all that he had brought into shape for publication. Of practical papers, there are notes on the iron ores of Kumaon: on the raw materials for iron smelting: on Petroleum in Assam: on the subsidiary materials used in production of artificial fuel: on the building and ornamental stones of India: on Potash salts: on Manganese ore, &c., &c., while descriptive notices are given of parts of Northern Hazaribagh; neighbourhood of Murree; of Kangra; of the Garo hills; of the Luni Puthan country west of Sind, and of the Southern Godavari country. These with annual report, and an interesting paper by Mr. Theobald, on some speculations as to the antiquity of the Human race in India based on Hindu legends, form the volume for the year.

Of the PALÆONTOLOGIA INDICA, only one part was actually issued during the year 1874. As already stated in previous reports, the concluding parts of the Cretaceous Fauna of Southern India had been pressed forward in anticipation of their regular time of issue in order to complete this valuable series before the writer, Dr. Stoliczka, went away. This series was issued in full for the year 1873. And in addition, the commencing part of the Cephalopoda of Kachh by Dr. W. Waagen was published in anticipation of the regular time of issue, namely, for the first quarter of 1874. The absence with the mission to Yarkand of Dr. Stoliczka, and from ill health of Dr. W. Waagen, has prevented further publication during the year. Progress was, however, made in the preparation of plates and drawings, and since the return of Dr. Waagen, the continuation of his detailed descriptions of the Kachh Cephalopoda has gone to press. The part issued contained full description and figures of a very interesting form of Rhinoceros (*R. Deccanensis*) found by Mr. R. B. Foote in fluviatile deposits in Belgaum.

LIBRARY.—One thousand and eighty-four volumes or parts of volumes have been added to our Library during the past twelve months. Of this total more than one-half, or five hundred and fifty-seven, have been presented by different Societies and other institutions in exchange for the publications of the Geological Survey cf India, or as donations, while five hundred and twenty-seven have been purchased. The usual quarterly lists of these have been regularly continued in the RECORDS of the Survey, and as customary, a summary of the various institutions from which donations or exchanges have been received during the twelve months is appended. We continue to render access to this very valuable library as general and as easy, as is consistent with the preservation of the books. And in very many cases, we find that from the special character of our collections, books have been available here, which could not be referred to elsewhere, either in Calcutta or indeed in India. In geological matters, quick and ready reference to the published results of other enquirers is perhaps more essentially necessary than in most other scientific enquiries, and we continue to look most anxiously for the transfer of our collections to premises where they can be rendered more easily accessible, and more generally useful, than it is possible to effect in our present greatly overcrowded apartments.

MUSEUM.—During the year all the collection forwarded to the International Exhibition at Vienna, which was intended to be returned to this country, was safely received back, and was again embodied with the general series. General notices of donations have been given in the Records for the year, while we continue to receive from the officers of the Survey itself valuable additions constantly. Of the so-called Sivalik fossils, a large and valuable series has been procured by Mr. Theobald in his recent examination of the country. The examination in detail of these is, I regret to say, almost completely impracticable from want of any space or room in which to open them out, though individual specimens have been taken up. But very important results bearing on the sub-division and age of the different horizons of these rocks and of the imbedded fossils will undoubtedly arise, as soon as they can be carefully compared and described. From Mr. A. B. Wynne also a good series of similar fossils have been obtained, procured from parts of the Rawal Pindi and Jhilam districts in which he has been working, and from the small range of hills on this side the Jhilam, called the Pabbi hills. Some fish remains and other things were procured by Mr. Fedden, and a good series of specimens from the upper, secondary, and tertiary rocks of the Lower Godavari basin by Mr. King. To Mr. Hughes also the Museum is indebted for a very interesting series of fossils from the country adjoining the Milam pass, to the north of Kumaon, which prove the continuity of the formations first described as occurring near the Niti pass by Colonel R. Strachey: thus extending our knowledge of these formations considerably north-east. The fossils represent at least five different formations, Cretaceous, Jurassic, Triassic, Permian, and Carboniferous and Silurian. A detailed list will be given in a future number of the Records.

METEORITES.—Our series has been enriched by pieces of the fall which took place on the 23rd September 1873. These are of much interest from the fact of their having been procured at different places, though the structure and composition of the stones show that they are identical in their nature. One piece was found near the village of Mylsi, fifty miles to south-east of Múltan, and two others at Khairpur, thirty-five miles east of Bhawulpur. The distance between the two places being probably more than ten miles.

The collections have been kept in good order and safety during the year.

T. OLDHAM,
Supdt. of Geol. Survey, India,
and Director of Geol. Museum, Calcutta.

CALCUTTA,
January, 1875.

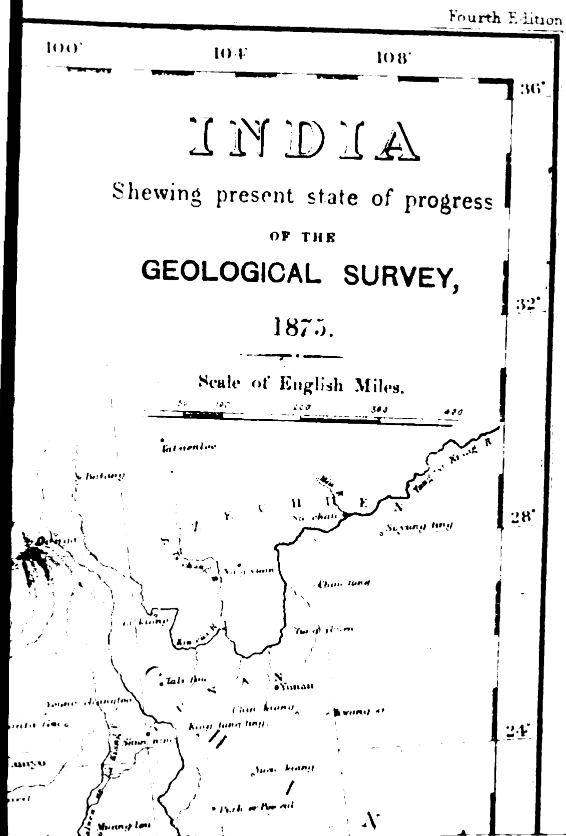
List of Societies and other Institutions from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1874.

BATAVIA.—Royal Society of Batavia.
BERLIN.—German Geological Society.
DITTO.—Royal Academy of Sciences.
BONN.—Naturhistorischen Vereins.
BOSTON.—Society of Natural History.
BRESLAU.—Silesian Society.
BRISTOL.—The Naturalists' Society.
BRUSSELLS.—Royal Academy of Science.
CALCUTTA.—Agricultural and Horticultural Society.
DITTO.—Asiatic Society of Bengal.
CAMBRIDGE, MASS.—American Academy of Arts and Sciences.
DITTO.—Museum of Comparative Zoölogy.
CAMBRIDGE.—Woodwardian Museum.
COPENHAGEN.—Royal Academy.
DIJON.—Imperial Academy of Dijon.
DRESDEN.—The Isis Society.
EDINBURGH.—Geological Society of Edinburgh.
DITTO.—Royal Scottish Society of Arts.
DITTO.—Royal Society.
GLASGOW.—Geological Society of Glasgow.
DITTO.—Philosophical Society.
GÖTTINGEN.—The Göttingen Society.
LAUSANNE.—The Society of Natural Sciences.
LIVERPOOL.—Literary and Philosophical Society of Liverpool.
LONDON.—British Museum.
DITTO.—East India Association.
DITTO.—Geological Society of London.
DITTO.—India Office.
DITTO.—Royal Institution of Great Britain.

LONDON.—Royal Society.
DITTO.—Royal Geographical Society.
MANCHESTER.—The Manchester Geological Society.
MELBOURNE.—Royal Society of Victoria.
MOSCOW.—Imperial Society of Naturalists.
MÜNICH.—Royal Bavarian Academy of Science.
NEUCHATEL.—Society of Natural Sciences.
NEW HAVEN.—Connecticut Academy.
NEW ZEALAND.—Geological Survey of New Zealand.
PARIS.—Geological Society.
DITTO.—L'Administration des Mines.
DITTO.—National Institute of France.
DITTO.—The Academy of Sciences.
PEST.—Royal Geological Institute of Hungary.
PHILADELPHIA.—Academy of Natural Sciences.
DITTO.—American Philosophical Society.
DITTO.—Franklin Institute.
ROME.—Geological Commission of Italy.
SALEM, MASS.—Essex Institute.
DITTO.—Peabody Academy.
STOCKHOLM.—Bureau de la Recher. Geol. Suede.
ST. PETERSBURG.—Imperial Academy of Sciences.
TASMANIA.—Royal Society.
TOKEI.—Geological Survey of Yesso.
TORONTO.—Canadian Institute.
TURIN.—Royal Academy of Sciences.
VICTORIA.—Government Geological Survey of Victoria.
DITTO.—Ditto ditto ditto, Mining Department.
VIENNA.—The Vienna Academy.
DITTO.—K. K. Geologischen Reichsanstalt.
WASHINGTON.—Department of Agriculture, U. S. A.
DITTO.—Smithsonian Institute.
DITTO.—United States Geological Survey.
WELLINGTON.—New Zealand Institute.
YOKOHAMA.—German Natural History Society.
ZÜRICH.—Natural History Society.

Governments of Bengal, Bombay, India, Madras, North-Western Provinces, and P
Chief Commissioners of British Burma, Central Provinces, Mysore, and Coorg; the Re
Haiderabad, the Surveyor General of India, the Superintendent of the Great Trigonom
Survey of India, and the Superintendent of the Thomason College of Civil Engin
Roorkee.

January, 1875.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INDIA
Shewing present state of progress
OF THE
GEOLOGICAL SURVEY,
1875.
Scale of English Miles.
Yunan

THE ALTUM-ARTUSH CONSIDERED FROM A GEOLOGICAL POINT OF VIEW, *by* F. STOLICZKA, PH.D.

(*Veni, sed non vidi.*)

As soon as the most important political business had been concluded by the signing of the commercial treaty by the Amir, His Excellency Mr. Forsyth expressed a wish to visit the renowned tomb of Sultan Satuk at Altum-Artush. The king accorded his permission, and instructed the Hakim Mahomed Khoja to assist us in travelling over the province under his care to whatever extent Mr. Forsyth might desire.

Under the personal guidance of the Envoy, we—Dr. Bellew, Captain Chapman, Captain Trotter, and myself—left Yangishar on the 14th of February, reaching Altum-Artush at a late hour the same day. As an introduction to the difficulties in travelling, our baggage did not arrive till next day, and we had to accommodate ourselves for the night on the carpets of the floor in a spacious but tolerably warm room. A halt of two days was desirable to enable us to make all necessary arrangements for our further movements. However, before I proceed, I shall endeavour to give the reader an idea of the geographical position and limits of the country of which I shall speak in the subsequent lines.

The data are derived from a general survey by Captain Trotter and from information given by the Hakim Mahomed Khoja.

Altum-Artush, which is the chief place of the province, lies approximately in east long. 76° 8′ and north lat. 39° 41′, therefore about twenty-three miles north by east of Yangishar. It is situated in the western part of the Yilak on the Bogos, here called Artush river, and north of a low ridge which separates the Artush valley from the plains. The southern boundary runs along this ridge for about ten miles west of Altum-Artush, and from there almost due north to the crest of the Koktan range; then along this range eastwards of the Belanti pass (east long. 77° 47′ and north lat. 40° 41′), and from thence in a south-eastern direction to the village of Kushtignak, some fifteen miles north of Fyzabad in long. 76° 42′ 30″ and lat. 39° 28′ 30″. From here the southern boundary rnns close to the right bank of the Kashgar river, until almost opposite to where the Artush river runs into the plains.

During the first four days we all marched in company up the valley of the Bogos river to the fort Tangitar, about twenty-three miles to the north by west; then to a Kirghiz camp, Bashsugum, in a north-easterly direction; Tugurmatti almost eastern; and Ajaksugun in a south-eastern direction; the directions being from the last camps respectively.

At Azjak-sugun Captain Trotter and I separated from the rest of the party, marching northwards along the road to Ashtifan, to Jaitava, and from thence across the Jigda Jilga in a north-east by east ? direction to the camp at Nibulak, crossing the Nibulak pass, passing a second jilga, and turning then for almost nine miles more northwards to the Belanti pass, beyond which lies the valley of the Kakshal or Aksai river. On our return we passed Ayak-sugun, Karaul, about a mile from our former camp of the same name, and visited Kultislak and Fyzabad, returning to Yangishar on the 3rd of March.

It was not a very favorable time for travelling in these regions, not so much on account of the cold, as in consequence of the heavy falls of snow which appear to occur over the whole of Thianshan during the second half of February and first half of March. During the last few days of February we were almost constantly wading in fresh fallen snow, though on the saline plains it melted very rapidly.

The snow naturally interfered seriously with our observations. However, obtaining even but a little addition to our knowledge of these hills, was a better way of occupying our time than remaining in our somewhat gloomy quarters.

From a geological point of view the trip proved in many respects to be of considerable interest, particularly as supplementing some former observations made more to the west. Although there is not much variety in the rock formations we may distinguish three successive series. The most southern part of the province, along the foot of the hills, is formed of alluvial gravels and sand in whose unfathomable depths are swallowed both the Artush and Sujun rivers, before they can reach the Kashgar daria. Wherever irrigation from the latter is possible the fields appear to be fertile; but in the contrary case, the land is not much more than a mere desert covered with low and scanty scrubs of *Ephedra* Sp.? The marshy grounds along the river are the breeding places of innumerable waterfowl. Brahmini ducks and pintails were already selecting sites for their nests on the 1st of March. The latter must have only just arrived.

Where high grass occurs wild pigs are not uncommon.

The second series includes the low hills which extend diametrically from north to south over about thirty miles, while the prevalent strike is from north-east by east to south-west by west. All these lower hills are occupied by Artush beds, of which I spoke in a former communication. They are separated into two groups. The lower beds consist of greenish or reddish clays or sandstones, and the upper ones of coarse conglomerates, which on a hill south of Tangitar have a thickness of about a thousand feet. At their contact both groups generally alternate in several layers. An anticlinal runs almost through the middle of their superficial extent. At the fort Ayak-sugun it is caused by a low ridge of old dolomitic limestones on which the Artush clays and sandstones found a firm support. To the south of it the beds dip at angles of about 40° and 50° towards the Kashgar plain, in remarkably regular and successive layers. North of the ridge, which has no doubt a considerable subterranean extent in an east to west direction, all the beds dip towards north by west at a similar angle. Approaching the higher range more recent diluvial gravels cover most of the slopes. The geological puzzle of finding strata of young beds as a rule dipping *towards* a higher range composed of comparatively much older rocks seems to me to be due, at least in this special case, to the phenomenon that the atmospheric waters which, descending on the crest, flow down the slopes of the high ridge, gradually soften them, and if a subterranean outlet facilitate it the softened beds are worn away. While this process is going on the more distant beds simply subside in order to fill the vacant spaces. In some cases a sinking or rising of the main range, or even an overturn of high and precipitous cliffs, seem to go hand in hand with the action of erosion, but it is not always the case. I hope to illustrate this idea by a few diagrams, partly derived from actual observations on some future occasion.

A third series of entirely different rocks forms the main range of hills which are a continuation of the Koktan range, and in which, more to the westward, are situated the Terek and Chakmak forts. The average height of the range is here between 1,200 and 1,300 feet, single peaks rising to about 1,500 feet. The whole of the southern portion consists, as far as I could see, of carboniferous rocks, in which, however, there is a great variety of structure. The lowest beds are very often a peculiar breccia-limestone passing into regular limestone conglomerate. Above this are beds of solid grey dolomitic limestone, partly massive, partly stratified; the former possessing the character of reef limestone, and portions of it are indeed full of reef-building corals, crinoid stems, and a large *Spirifer*, the sections of which, when seen on the surface, have a striking resemblance to those of *Megalodon*.

North of Tangitar and about Bash-sujun I met in several places great numbers of fossils, but they were so firmly cemented in a calcareous matrix that only a few could be extracted. Among these I could recognise a small *Bellerophon*, *Productus semireticulatus*, and an *Athyris*. A new *Terebratula* was also very common. Here about Bash-sujun and Tugurmatti greenish shales occurred often interstratified with the limestones, beds of which were highly carbonaceous; the shales appeared to be unfossiliferous.

The limestone hills, which, as already stated, are a continuation of the Koktan range extend in a north-easterly direction the whole way to south of the Belanti pass, where they are overlaid by a particularly well-bedded dark limestone very similar to that containing *Megalodon* north of Chungterek. On this limestone rest greenish and purplish sandstones and shales which occupy the pass and the adjoining hills to the north-west of it; mineralogically these last rocks are quite identical with what we understand under the name of "*Bunter sandstein,*" and it is by no means improbable that the Belanti beds are also of triassic age, as they succeed in regular layers those of the carboniferous formation.

A peculiar feature in this part of the hills consists in the occurrence of extensive plains to which the name *jilga* is generally applied. It means originally, I think, merely a water-course, and, on a large scale, these plains may be looked upon as water-courses of former water-sheets. They occur at the base of the high range, and in some respects resemble the *dúns* of the southern slopes of the Himalayas. North of Tangitar one of these large plains occurs within the limestone rocks, being surrounded by them on all sides. It must be about thirty miles long from east to west, and about sixteen from north to south. Several isolated limestone hills and ridges occur in it, and it is drained off by the Bogos and Sujun rivers, the former rising in the south-west, the latter in the south-east corner. The average elevation is about 5,000 feet. The greater portion is covered with a low scrubby vegetation, and, near the rivers, with high grass. The principal camping grounds are Bash-sujun and Tugurmatti. The whole plain, which affords a good pasturage ground, is occupied by about 120 tents of Kirghiz during the summer.

The next jilga is the Jigda Jilga. It differs considerably both in its physical situation and in its general character from the former. It stretches from west by south to east by north for about thirty-five miles, while the diameter of the eastern half is about twenty and that of the western about twelve miles. Save for a few low hillocks it is almost a level plain throughout. On the north-western, northern, and north-eastern side it is bounded by the Koktan range, from which several water-courses lead into it, one about the middle from the north and one from north-east of considerable size, this containing a large quantity of crystalline pebbles; the rock from which they are derived must be *in situ* near the axis of the ridge. A third big stream comes from the east, leading from the Nibulak pass. None of these streams had any water in them. On the south, east, and south-east the plain is bounded by the much lower hills composed of Artush beds, their slopes covered with gravel.

An elevated gap or saddle situated in the south-west corner appears to connect this jilga with that of Tugurmatti. There is no drainage from this jilga; all the water is absorbed by the enormous thickness of sand and mud which fills the entire basin. This accounts for the comparatively rich vegetation which exists in it. There are several stretches of regular poplar forest (*P. nigra* or *P. balsamifera*) up to ten miles long and four to five miles in breadth. Besides which there are several places occupied by regular jungle of *Tamarix*, *Myricaria*, *Ephedra*, and the peculiar wormwood, from the seed of which the Kirghiz prepare *satú*. The *Tamarix* and poplars must absorb during their growth a very large quantity of the mineral salts with which the entire ground is saturated; the wood on being burnt gives out a strong smell of sulphur and chlorine.

The poplar trees are not healthy; they resemble oak trees covered with mistletoe. The branches are short, stumpy, and bushy. It is evident that the trees only exist in consequence of the subterranean moisture. There are a great number of springs through the forest and on its edges, but on account of the level character of the plain no flowing streams exist except where there has been a very heavy snowfall and very rapid melting.

It is satisfactory to observe that within three marches of Kashgar there is such a large supply of wood, though it is by no means good wood. I have already stated that the entire soil is very saline, and it is remarkable to see how snow melts on this saline ground. Thus about four inches of snow fell while we were there. In one day all was melted away on the saline ground, while near springs. where the saline matter has been gradually dissolved out of the ground, hardly any snow had melted. Where the soil is most moist or even swampy, and in river-courses, high reed-grass is abundant. The southern part of the jilga, particularly south-east of Taitma, is lowest, and here a large quantity of pure salt in small cubical crystals is collected. The fact that there is such a large quantity of saline matter, together with salt swamps in the southern part, seems to prove that this jilga at least and probably most of the others had been washed out by the sea, and that while others had gradually, though only partially, drained off the saline matter, this one retained it because it has at present no outlet. It is in fact a dried up saline lake, which at some remote time was cut off from the sea of which it was a fjord.

Jigda Jilga is occupied by about 150 to 170 Kirghiz tents; each tent may be taken as containing five souls. There are a few fields near Jigda camp, and if there has been a large quantity of snow the crops are said to prosper very well. During the winter the Kirghiz are encamped in small groups near the different springs. They do not keep many horses, but large numbers of sheep and goats and a few camels. One whole *akoi* is a light load for a camel; when packed the blankets are made into saddles over the hump of the animal.

A third jilga is south of the Belanti pass and north-east of the Nibulak pass. It is about eight miles in breadth and the same in length. There are two large water-courses leading to it from the range. On the southern side it is enclosed by Artush and gravel beds, but whether an outlet exists is not known. It has no forest, nor any kind of trees or large bushes, and the grass vegetation is scanty, evidently on account of the dryness. A southerly outlet very likely exists. We met a few Kirghiz encamped here from Ush-Turfan. The only supply of water they had was melted snow, and as soon as the snow-beds about are exhausted, they have to retreat with their flocks to the Kakshal valley.

ON THE EVIDENCES OF 'GROUND-ICE' IN TROPICAL INDIA, DURING THE TÁLCHÍR PERIOD, *by* F. FEDDEN, F.G.S., *Geological Survey of India.*

Since the announcement by Mr. Blanford in 1856 (Memoirs, Geological Survey, India, Vol. I, page 49) of the occurrence of deposits supposed to be glacial in formations occupying the low lands of India south of the Tropic—those formations, moreover, being presumably of palæozoic age—the fact has hardly engaged the attention due to one so opposed to every-day experience at present. This neglect must, of course, be in a great measure attributed to doubt. Even among ourselves, observers of the Tálchír boulder-clay have subsequently attempted to offer explanations of its mode of formation without the agency of ice. But this view never obtained favour from those having the largest acquaintance with the deposits in question, who have confidently looked forward to the confirmation of the judgment given by Mr. Blanford.

Although it had been pointed out from the first, that the mode of ice-action involved was of a kind in which striation would be the exception rather than the rule, still, striation was almost the only independent testimony to be looked for in confirmation of the general evidence. The boulder-bed had no resemblance to the till, or the deep-moraine, of a continental ice-sheet, except perhaps that the fine greenish silt so frequently forming the matrix of the boulder-bed has a great similarity to the well-known glacial mud. It was equally unlike the ordinary moraine deposits of glaciers; the boulders exhibit, most commonly, considerable weathering or water-wear. The boulder-bed, too, is not usually a bottom bed, but is generally intercalated with very regular and sharply bedded deposits. Lamination is moreover not unfrequently displayed in the boulder-bed itself. These features all point to the familiar circumstances accompanying ground-ice, where loose materials are picked up by the freezing of the water in rivers or on the shallow margins of water-basins, and floated away to be deposited elsewhere. Even so it must happen that such ice-rafts get stranded with more or less violence, producing striation and polishing of the imbedded boulders and of the rocks with which they may come in contact, as also when urged onward by the accumulating force of an ice-blocked river. It was therefore confidently expected that sooner or later evidence of this kind would be forthcoming in the Tálchír boulder-bed.

In January 1872 I had the good fortune to find an excellent example of this missing link of evidence. The place was visited shortly after by Dr. Oldham, who dug out and removed a fine specimen of hard dense close-grained syenitic granite, of which one side is beautifully polished, scored and striated. This specimen is now in the Museum of the Geological Survey in Calcutta. Notice was given of the discovery at the time by Dr. Oldham in a foot note to a paper by Mr. Blanford on the Geology of Nágpúr (Mem. Geol. Sur., India, Vol. IX, p. 324).* The section was not then very well seen. But on revisiting the ground during the past season, I found the rocks much better exposed. A special record of the case is made, as it is not unlikely that the elements may before long obliterate what they have now laid bare. The locality is near the little village of Irai on the right bank of the Pem river, not quite a mile above its confluence with the Wardha, and ten miles to west south-west of Chánda.

The surface features of the neighbourhood for a considerable distance always form an important consideration in the discussion of any particular case of ice-scratching; and even for these most ancient deposits we are not without some plausible conjectures on this point. From the very general fact of the Tálchír group, and the other lower members of the series to which they belong, occupying low ground in the actual drainage basins, and being commonly overlapped by the succeeding members of the series, it is apparent that the actual basins are in a manner the reproduction of the pre-Tálchír ground-configuration. No doubt the ancient highlands had been greatly denuded to furnish materials for the thick deposits overlying the Tálchírs; and they must have suffered further reduction from the denudation which has for the most part removed again those overlying groups. Yet it is probable that the existing contours give an indication of the pre-Tálchír surface. If it be so, there is nothing here to support the notion of a glacier having reached the spot under notice. For many score miles round there is no commanding elevation of rock older than the Tálchírs from which an ice-stream could have descended. The supposition of an expansive ice-sheet would be still more difficult to reconcile with the observed features.

The general circumstances of the case under consideration thus lead us again to the supposition of ground-ice; and this view is remarkably strengthened by the coincidence that this single instance of scratched boulders is found in immediate connection with the only known example of a scored and polished rock-surface. The boulder-bed is here a bottom rock, resting upon compact Pem-limestones (Lower Vindhyan). For a length of 330 yards along the river's bank this underlying rock is exposed, displaying a large surface, polished, scratched, and grooved after the fashion so familiar to glacialists. The surface has a slope of 12°—15° to the west, obliquely overcutting the strata, which have a dip of 8° to west, south-west.

* Mr. W. Blanford also gave a brief notice of the fact, and of the general evidence for the existence of glacial forces at this early geological epoch in India, at the meeting of the British Association at Bradford, 1873, Sections, p. 76.

The striæ and grooves run in long parallel lines, having directions between north-east and north-north-east, oblique to the slope of the surface; and from the manner in which the rock is affected at the edges of the few planes of jointing, it can be inferred that the movement was *up* the slope. It is, of course, not certain that the present inclination of this surface is the same as when the scoring was produced. The Tálchírs have undergone considerable crushing and displacement, though this might well have occurred in soft strata without much affecting the hard rocks against which they rest; but the actual conditions are so far confirmatory of the view we have been led to—of an ice-raft being drifted against and impelled up an opposing rock surface.

The boulder-bed itself is strongly developed in the district, especially to the north, where the contained masses of foreign rock—limestone, quartzite, granite (*pegmatite* and *protogine*) &c.—are of huge size and very numerous. In the immediate vicinity of Irai, the boulders are for the most part small, a few attaining a major diameter of 2 feet and even 2 feet 6 inches. Some of these boulders are worn smooth on certain sides only, and in the direction of the longest diameter; others more rounded have a beautifully polished surface: they are moreover striated and scored in fine parallel straight lines, precisely similar to the rock-surface above described, and resulting evidently from glacial motion or 'ground-ice.'

These boulders are enclosed in a fine gravelly bed of heterogeneous material, conglomeratic near the base, and intermingled with angular rough blocks and rock fragments.

It would appear that the freighted ice-mass had travelled a long distance from the south-west, through the Utnúr and Edlabád (Idulabad) districts, where rocks occur of the same composition as that of the several boulders.

The evidences for the glacial origin of these deposits is as conclusive as that for the ice-age formations of Europe.

The latitude of Irai is 19° 53′, elevation under 900 feet; the most southerly known position of the Tálchír boulder-bed is latitude 17° 20′, and only a little above the level of the sea.

BOMBAY,
September, 1874.

TRIALS OF RÁNIGANJ FIRE-BRICKS, *by* T. W. HUGHES *and* H. B. MEDLICOTT, *Geological Survey of India.*

Amongst other investigations connected with the projects to utilize the Indian iron-ores, some fire-bricks that were furnished by the firm of Messrs. Burn and Company were examined and tested in September last.

They were made from various clays obtained in the neighbourhood of Ráníganj and elsewhere, and were highly recommended as having stood the wear and tear of ordinary cupolas, and it was hoped that they would be found capable of standing the more heavy work of a blast furnace. It will be seen, however, from the subjoined details of my experiments, that there were some defects in their composition, and that although they were quite as good, or rather somewhat superior to the Stourbridge fire-bricks which could be procured at the time, they fell short of the excellence of Glenboig.

Subsequent trials, however, of the same kind and degree as those conducted in the first instance were made by Mr. Medlicott on bricks improved as suggested in the first report, and his verdict was "that several of them stood the test perfectly, showing no sign of cracking or of vitrification." These latter trials were made in the presence of Mr. Whitelaw, Manager of the Bengal Iron Company's proposed work, and others, who agreed in the favorable estimate formed of the quality of these bricks.

The experiments were, with the kind permission of Colonel H. Hyde, R. E., Master of the Mint, conducted at the Mint furnaces.

Mr. Hughes, who conducted the first trials, reported—

1. "The fire-bricks tested by me were furnished by the firm of Messrs. Burn and Company, and are stated to have been made from fire-clay obtainable in the neighbourhood of Mallapúr.'

"The results of my experiments are—

"*1st.*—That the material from which they are made is very refractory, and capable of resisting high temperatures without sensibly fusing.

"*2nd.*—That the bricks, however, have failed to sustain the high character for excellence which Mr. Cowhan (the Manager of the Ráníganj Pottery Works) has attributed to them, inasmuch as they shrink on being subjected to strong firing, and show a tendency to fissure.

"*3rd.*—That compared with Glenboig fire-bricks they are inferior; but compared with Stourbridge fire-bricks they are somewhat superior.

"I attribute the shrinkage and fissuring to the texture being too fine; and this can only be remedied by the addition of a proper amount of burnt clay in coarse powder, or some infusible substance like silica. The particles of silica (quartz) must not be too fine, otherwise they may enter into combination with the clay.

"The usual proportion of raw to burnt clay is $\frac{2}{3}$ of the former to $\frac{1}{3}$ of the latter, and I believe this proportion was adopted in the manufacture of the fire-bricks from Ráníganj. It does not appear to have answered however; but this was probably due to the burnt clay having been ground up too fine. On a purely practical point of this kind, I do not like to give a decided opinion, as experience alone can determine what the proper proportions ought to be, and I would suggest that separate sample bricks be prepared, containing varying proportions of ground brick and silica, and the particles to be of varying sizes. A series of experiments carefully conducted will, I feel sure, enable fire-bricks to be made that will possess all the qualities requisite for the special purposes to which they may be applied."

12th September 1874.

DETAILS OF EXPERIMENTS.

(A).—The brick marked A was subjected to a temperature of over 3,000 Fahrt. in a wind furnace, the fuel being English coke. It was purposely broken in half.

Remarks.—The edges have stood well.

(B).—Was heated in the same furnace as a Glenboig brick, at a temperature considerably higher than the smelting point of cast-iron.

Remarks.—It cracked, and was fissured throughout.

(C).—Was submitted to conditions similar to (B).

Remarks.—It is superior to (B), but it is internally fissured. It contains an excess of alkaline earth, which has vitrified.

(D).—Was inserted in a plumbago crucible to avoid contact with the coke. This was carefully weighed and measured previous to insertion and after extraction. Its tenderness was also noted.

Remarks.—The edges have resisted fusion, which is a good quality, and its tenderness was not of an appreciable amount. It contracted, however, more than I expected. The following were the measurements and weights:—

Measurement before insertion	...	$9\frac{7}{8}''$ long.	$2\frac{1}{3}'$	deep.
„ after extraction	...	$9''$ „	$2\frac{3}{16}''$	„
Weight before insertion ...	...	...	277	tolas.
„ after extraction ...	...	...	$275\frac{1}{2}$	„

This brick when externally examined appears to approach in texture much nearer the required standard than any other.

(E).—Was heated like the last in a plumbago crucible. It is made of pure fire-clay.

Remarks.—I think it was too strongly burnt in the first instance, *i. e.*, before it passed into my hands. It cracked on being taken out of the furnace and deposited on a cold floor.

(F).—Was tested in the same manner as (B) and (C).

Remarks.—Like the other bricks, it exhibits fissures internally.

(G. & H).—Glenboig bricks, purposely broken, submitted to conditions similar to (B) and (C) and (F).

Remarks.—It will be observed that there are no fissures. No contraction and no softening.

In the second series of trials conducted by Mr. Medlicott, ten bricks, made at the Rániganj works, were tested with one of Stourbridge brick and one of Glenboig brick, and also one common machine-made brick. They were kept for four hours in the gas furnace in plumbago crucibles—for the last two hours at the full blast. None showed any sign of fusion. The machine-made brick and the Stourbridge brick were badly cracked, and one of the Rániganj bricks slightly so. The loss of weight was very marked in the Glenboig brick; next so in the Stourbridge, probably due to the coarser texture of the former, and in both to their having been less well dried than the others.

Five of the bricks were put into a coke furnace with a Glenboig brick, and five in a second furnace with a Stourbridge brick. The former furnace seems to have been most heated: even the Glenboig brick bent and broke, and showed as much vitrification as the others. In the other furnace, all were more or less damaged—the Stourbridge least so.

GEOLOGICAL MUSEUM,
January 1875.

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January 1875.

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BARRANDE, JOACHIM.—Système Silurien du centre de la Bohême, Part I, with plates, Supplement to Vol. I, and Vol. II, pt. 3, (1872-74) 4to., Paris.

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PFEIFFER, L.—Kritisches Register zu Martini und Chemnitz systematischen Conchylien-Cabinet, (1840), 8vo., Kassel.

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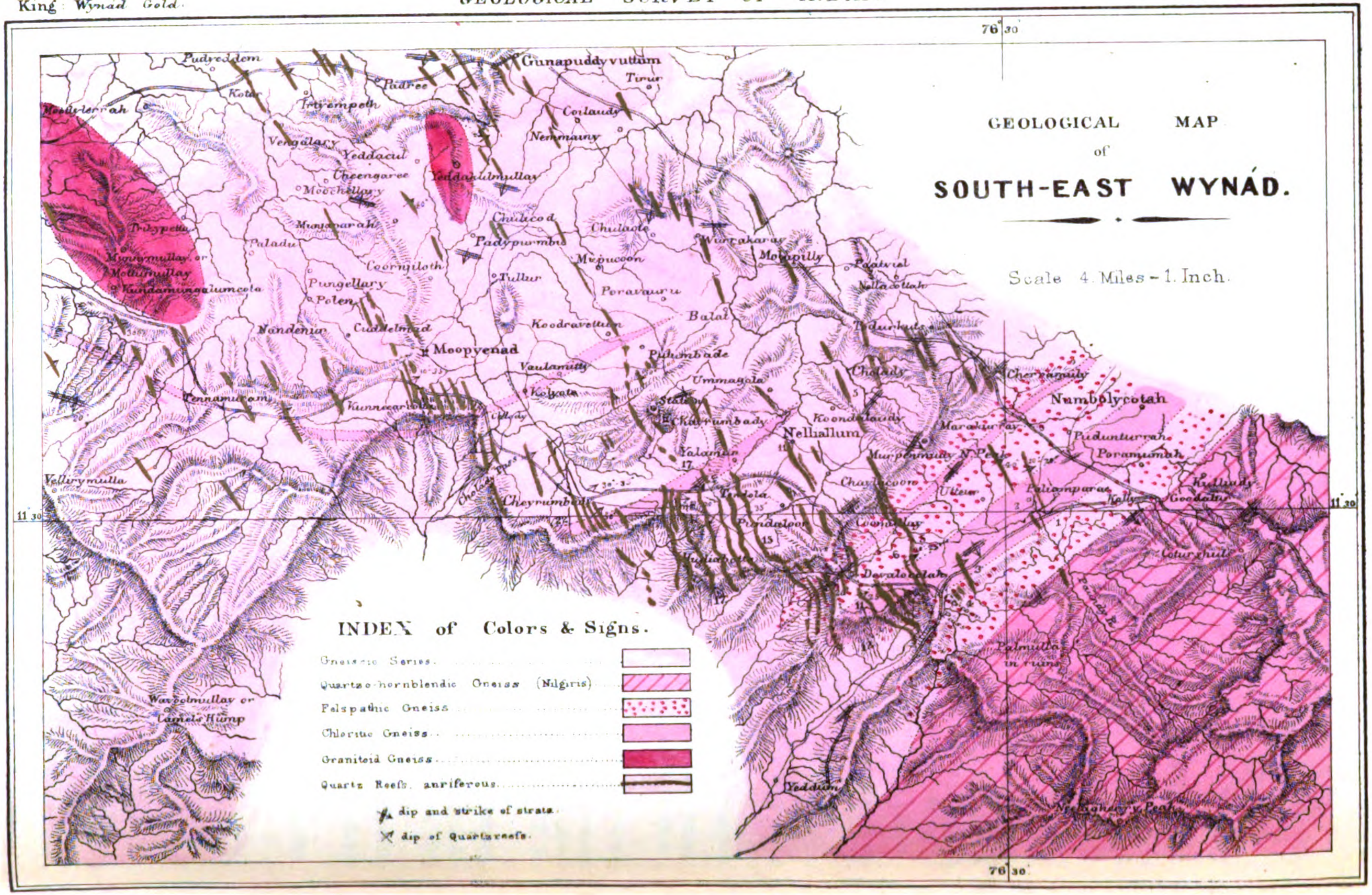
GEOLOGICAL MAP
of
SOUTH-EAST WYNÁD.
Scale 4 Miles = 1 Inch.
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Quartzo-hornblendic Gneiss (Nilgiris)
Felspathic Gneiss
Chloritic Gneiss
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Quartz Reefs, auriferous
dip and strike of strata
dip of Quartz reefs
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Nemmainy
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Pennamuram
Kunnearlotta

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1875. [May.

PRELIMINARY NOTE ON THE GOLD-FIELDS OF SOUTH-EAST WYNÁD, *Madras Presidency*, *by* WILLIAM KING, B. A., *Deputy Superintendent, Geological Survey of India, Madras.*

Reason for present brief report.

The attention of the Madras Government having been again called, after a lapse of nearly forty-two years, to the occurrence of gold in the Malabar District, it was considered advisable that an examination of the country should be made by the Geological Survey of India. It now, however, turns out that the area over which the auriferous deposits and quartz reefs extend is so large, that a considerable period of time must elapse before a full report of the whole district can be made. In the meanwhile, as a gold mining company had been started with the intention of opening up the quartz reefs known to exist in Wynád, and more particularly those near Dayvállah, my attention was first directed to this region. The country examined up to this time constitutes a local division of this part of the district and is sufficiently large and important in itself to be described separately in these Records.

Topography of Wynád plateau.

The intermediate elevated terrace of mountain-land lying between the low country of Malabar, the loftier plateau of the Nilgiri mountains, and the Mysore territory, called the Wynád, has been conveniently separated (principally by the Coffee Planters) into three divisions: North Wynád, South Wynád, and South-east Wynád; and these larger areas are again parcelled out after a native classification into *Amshams*. South-east Wynád includes among others the Nambalicode, Moonád, and Moopia-nád Amshams, the latter being the most north-westerly of the three, and touching on South Wynád or that in which the central village of Vythery is situated. Manantoddy, the principal town of the plateau, is in North Wynád.

The present paper has to do with so much of South-east Wynád as lies to the south-south-west of and alongside the road from Gúdalúr to Sultan's Battery (Gunnapuddy-vuttom of Atlas-sheet). The other boundaries are the Nilgiri plateau and Ouchterlony valley on the east-south-east; the great line of precipices of the Western Ghâts from Nádgáni (Carcoor ghât) to the mountain of Vellaramulla on the south-south-west, and a high watershed running from Vellaramulla to Sultan's Battery on the north-north-west.

Elevation.

This mountain terrace has an elevation on an average of above 3,000 feet; but out of it rise peaked ridges and hills of considerably greater heights, varying from 3,500 to nearly 7,000 feet above the sea.

Forest covering, cultivation.

Along the edge of the ghâts, occasionally for short disatnces inside of these, and down the great ribs and intermediate trenches to the low country, all the ground is covered by dense and lofty black forest. Inland, there are rounded grassy hills enclosing valleys, interspersed with good belts of forest, most of which is, however, of poorer tree jungle than that of the ghâts. Nearly all the valleys contain swampy flats, which are largely cultivated as paddy or rice-fields. The coffee gardens, which are the European specialité of Wynad, have, as a general rule, been made in clearings near the edge of the ghâts in the black forest, or in the denser parts of the inland jungle.

Climate.

A good deal of misconception appears to exist as to the healthiness of Wynád. As far as my own personal experience goes, the climate from the end of September to the middle of January is tolerably well adapted for Europeans. I am informed by the planters that it is even healthier from May to September; so that there are only three months in the year when the country is not healthy. Many planters leave during these months for the coast, or the Nilgiris; but others are known to have remained with their wives and children for two and three years continuously.

On the other hand, the climate is not suitable to the natives, except such as belong to the country, as the Chetties, Mopahs, Korumbars, Pannirs, &c.; but much of this unsuitability, may, however, be due to carelessness of the men brought into the country, and the fact of their being away from their homes.

Next to the tremendous rains of this region and the two or three unhealthy months, the land-wind is perhaps one of the worst evils to be encountered. Bungalows are built so as to present a sheltering side to it; it is dangerous to sleep in; and it is about as disagreeable to be felt or heard as the bleakest east wind in England. Fortunately, it seldom lasts all day except for a short time in the year; and in its place comes the oppositely mild and soothing wind from the western sea.

History of the gold question.

The Malabar District has been famous for gold from time immemorial. Gold is still washed for in the low country and in Wynád; and it used to be got in old days from quartz 'leaders' in the hill country around Dayvállah, Nellialum, &c. Two tribes of people obtain the gold. The *Pannirs* wash for it in the alluvium, surface soils, and river sands. The *Korumbars* dug down to and excavated the quartz leaders. Tradition says that large finds of gold have been made at odd times by the Korumbars. The Pannirs rarely find more than four annas' worth of gold in a day each man. The latter only wash for gold now (in the Wynád) in the off season, when they cannot get work in the coffee gardens at five annas a day.

In 1793 the gold mines of Malabar appear to have been noticed by the then Governor of Bombay, who tried to get information on the subject; and they were farmed by the Madras Government in 1803.

In 1831 Mr. W. Sheffield, Principal Collector of Malabar, wrote an interesting report on these gold mines, upon which Lieutenant Woodly Nicholson, 49th Regiment, Madras Native Infantry, was deputed to explore the country with a view to the development of this industry. The latter officer visited the Nambalicode Amsham, examined all the old workings of the Korumbars on the Chulaymullay near Dayvállah, and obtained gold from the surface washings in the same neighbourhood. He also visited all the known gold localities in the low country of Malabar. He does not seem to have thought much of Dayvállah, and the gold obtained was not so pure as that from the plains. His acquaintance with the practical business of the matter and his knowledge of the geological structure of the country were very poor, but his perseverance at the work was marvellous under the difficulties, real and imaginary, with which he had to contend. A committee was then appointed, consisting of Mr. F. Clementson, Principal Collector, Major A. Ross, Superintending Engineer, Malabar and Canara, and Dr. F. W. Ward; and an able report, dated 25th May, 1833, was the result. These three gentlemen practically condemned the working for gold, as an European industry, in the low country of Malabar. My own examination of the plains has as yet only been a cursory one; but without going so far as this decision, I am inclined to agree to a great extent with it, more especially as it would appear from what we now know that there is sufficient evidence to show that European energy is more likely to meet with success in the Wynád.

In 1865 or 1866 Mr. Stern (of Australian experience) paid a prospecting visit to Wynád and made trial of the alluvial deposits, of which there are several in the form of flat swampy land along the courses of the streams. He tried near Dayvállah by sinking pits to 'bottom rock' and always got gold, but not in sufficient quantity to make it worth while continuing his work.

Within the last year or so attention was again called to the occurrence of gold in the Wynád. Some of the planters had lived in Australia previous to their coffee experiences, and being more or less acquainted with quartz and its occasional associated minerals, they were naturally struck with the quartz in Wynád, while they also knew that gold was, and is, obtained by the natives. There was, however, a want of capital, and no one had seen gold in the quartz until Mr. Withers, the present Manager of the Alpha Company, came down to Wynád. Mr. Withers, who knows how to wash for gold, and is acquainted with quartz reefing, prospected the country for a long time until he felt convinced that nothing was to be done at alluvial and surface washing. He then explored the old pits and workings of the Korumbars and finally settled on a quartz reef in which he found gold visible. This reef and the ground alongside had been extensively worked in old times by the Korumbars. In one of the numerous caves he found the remains of one of these native miners, and thus the lode came to be called the "Skull Reef."

The Alpha Gold Company was then started, the prospectus of which states on the authority of "the Company's Manager and two of the Directors, who have had much experience of quartz-reef mining in Australia," that the stone will yield about one ounce of gold to the ton of quartz.

Alluvial sources of gold, not rich.

The most common mode of occurrence of gold in South-east Wynád is naturally in the Recent deposits, such as the surface soil on the hill-sides, the stream sands and gravels, or the true alluvial flats (Vayals or Veils) which are so frequent a feature in this upland as to have given it the name of the "land of swamps"; but in none of these ways does it seem that any large quantity of gold is stored up, except perhaps in the swamps which have as yet only been tried by Mr. Stern, when they were found to be as poor as the rest of the land.

From surface soils.

The surface soils are generally very thin, and they are not extensive enough to justify any large attempt at washing by hydraulic sluicing. Still they are perhaps the favorite resort of the Pannirs who can always from known patches of ground produce a certain small amount of gold. On four occasions these men worked for me at places around Dayvalláh, but they never got as much gold as would pay for their employment at five annas a day for each man. Occasionally, however, they chance on richer finds. The largest known fragment of gold found within the last few years in Wynád weighs over seven pennyweights, but it contains some quartz. It is of pale color, and is not much rolled; in fact it has evidently not been washed far from the present reef, and has thus not been subjected to that exposure and attrition which seem necessary for the production of the finally purer metal usually obtained from alluvial washings. In addition to this, a further small rolled fragment of good yellow gold without quartz, weighing nearly 11 grains, was lately found by the Pannirs of Dayvalláh; and a larger one, weighing 21·9 grains, is in the possession of Mr. H. V. Ryan of Glenrock—Mr. Minchin and Mr. Ryan have each occasionally employed coolies on their estates to wash for gold, but they do not find that the quantity obtained is sufficient to encourage any further exploration. The latter gentleman has collected 8·1 dwts. of gold, amongst which is the small nugget just mentioned. Out of this, 150·9 grains had to be collected by amalgamation and there were 21·6 grains of dust. The gold generally found by the Pannirs is in very fine dust, or in small flat spangles only collectible from the black iron-sand, finally left with them, by amalgamation in the wooden washing dish or *murriya;* but at times there are somewhat larger pepitas. This size of the grains agrees with what I have seen of the precious metal in the matrix.

From stream sands, &c.

The stream sands are next resorted to, but they are of no extent in this part of Wynád, as there are no large reaches, or hollows in the river beds in which gold could be stored up, while, as I shall presently endeavour to show, there is not much likelihood of its being retained in them, even if it were washed down in any quantity. As it is, the usual small amount of gold is obtained here also by the washers. In both conditions of deposit, as surface soil, or as river sand, the men nearly always only scrape a few inches of stuff from the surface; they do not dig down to bottom-rock, or to any bottom-layer of compact stuff answering to pipe-clay.

Poverty of these accounted for.

It will thus be seen that a somewhat different mode of occurrence of the gold dust (not in pockets, or at the bottom of lighter and permeable materials), and system of washing adopted (surface scrapings only being sifted) exist in Wynád from what is known in Australia and California. Much of this may be attributable to the heavy denuding force of the south-west monsoon; or, in other words, a very large proportion of the ore weathered out of the quartz veins and adjacent country rock is carried down during the rains to the low country of Malabar. At such times every stream in Wynád is a rushing torrent in which no sediment is allowed to rest until it reaches the slower-flowing, wider and deeper, rivers of the plains. As the monsoon slackens, a little new auriferous soil is allowed to remain on the cleaned hill sides, and the old basins and reaches of the stream beds are again filled up with their usual accumulation of mud, sand, and gravel, and thus a small supply of gold is collected. There is no doubt that in the decreasing flow of water, gold dust and heavy iron sand must necessarily at many places settle down first in the hollows, but these are few and far between, irrespective of their being difficult of access by the natives. At any rate such places are not known or searched to any extent in Wynád; and it seems to me that the fact of the men preferring generally to wash stuff scraped from the surface of the coarsest gravel and sand banks (the very places where the drifting gold would be retarded by the rough bottom and then permitted to settle down among the stones) points directly to the transporting power of the monsoon streams. This is also borne out by the habit which the men have of going at certain intervals to places known to them as having yielded gold on previous occasions, where they do not find the accumulations of centuries of denudation, but the gatherings up of only one or two seasons.

Proper alluvial deposits.

In certain parts of Wynád, and more particularly around Sultan's Battery, or in the neighbourhood of Manantoddy, the valleys are filled in with extensive and thick alluvial deposits through which the streams almost immediately after they leave the steeper hill-sides, often pursue a long and devious course, or become lost for a time in deep and dangerous swamps. In Nambalycode and Moonád these alluvial flats are not so frequent, and they are small in extent. There are no traces anywhere of their having been searched for gold, except in so far as the patches of surface soil alongside the streams, or on the edges of the flats, where auriferous soil could gather, may have been searched by the Pannirs.

There can hardly be a doubt but that gold in some quantity must lie in these deposits, for when they were being laid down, even if the present rainfall existed, it is quite evident that the flow of water was sufficiently retarded, possibly by lakes which then occupied the places of the present flats, to allow of a great thickness of separate patches of the denuded material of Wynád being retained. It is, however, very questionable whether this amount would be sufficient to repay the washing of such places, for they are throughout the year charged with water for the greater part of their depth, and they are largely made up of very unstable materials. The cost of excavation, puddling, and pumping engines necessary to keep large works free of water would be enormous. In addition to this, it is probable that work could only be carried on in the dry season, three months of which are unhealthy for both Europeans and outside natives, particularly in these low-lying grounds.

Difficult to be worked.

The places where gold washing has been carried on in the area under description are frequent in the Nambalycode and Moonád Amshams; but there is now no tradition of such work ever having been carried on outside of these, although in Mr. Sheffield's Report of 1831 mention is made of places, such as Choolyode, purporting to be in the neighbourhood of Sultan's Battery, where indeed there are Pannirs, though these men are not skilled in the use of the washing dish. This apparently unsearched condition of the northern part of the field, and the ignorance of the Pannirs as to the use of the *murriya* would seem to indicate that there should be no expectation of finding any gold dust in that part of the country were there not the view that there was possibly always sufficient occupation for these men in the well cultivated lands of these northern Amshams, while in the Nambalycode country, &c., they were driven by the land-owners to search for gold, the land not being so well adapted for agricultural work.

No traces of gold washing in northern Amshams.

The next source of Wynád gold is the matrix or the quartz veins, and to a slight extent the rocks traversed by these; and here again the natives of Malabar have been beforehand in mining operations though only in a very small way when the enormous extent of veinstone is taken into account. These Korumbars have worked the smaller and more easily broken up veins often to a depth of 60 or 70 feet. The western slopes of many of the hills in the three *Amshams* already enumerated are burrowed like rabbit warrens with pits, often only four or five feet apart, and communicating by short galleries. Chulaymullay, one of the conspicuous headlands of the Western Ghâts near Dayvalláh, was once extensively mined in this way. Lieutenant Nicholson thus describes what he saw in April 1831: "After cutting our way for several hours in the thickest part of the jungle on the mountains, we came upon the mine in question, consisting of three shafts about five feet each in diameter, and ten from each other, forming an equilateral triangle, the deepest of them extending to about seventy feet, since a stone dropped in took four and a half seconds to reach the bottom. We soon found that this mine was not the only one, for, having penetrated as far as we possibly could through the jungle towards the summit of the mountain, we discovered no less than twenty-seven shafts all sunk in the same manner and forming a chain of triangles as before described, the disposition of which with regard to each other led me to suppose that they have all subterraneous counter-shafts communicating with each other, and probably extending to a large main shaft which I trust may be discovered on the arrival of the pioneers." The same style of work is to be

The conditions of gold in the matrix.

seen near Nádgáni Bungalow and westwards, towards Chulaymullay, near Nulliallum, and away on to Cheyrumbadi. In these places these men seem to have led water to the steeper hill slopes and got at the numerous small veins on the foot-walls of the larger reefs by regularly sluicing down the hill-side even to the extent of causing occasional landslips. In the Glenrock Estate the upper part of the great valley or *churrum* in which it is situated is all of fallen earth, and there are still evidences of large sluicings having been carried on, while the face of the ridge north of Hudiabettah is pierced all over with pits as in Chulaymullay.

Wynád generally a country of quartz reefs

According to every information that is to be obtained, the whole of Wynád appears to be traversed by quartz reefs, some of which appear in the low country of Malabar, while others are traceable into the Ouchterlony valley; and even, it is said, on to the spurs of the Koondah mountains to the south. At present it is only known certainly that they are very strong and numerous in South-east Wynád.

Auriferous reefs.

In the Nambalycode Amsham there are at least eighteen reefs, nine of which are auriferous; and the immediate neighbourhood of all has been worked by the Korumbars, or washed by the Pannirs, for gold. Most of these eighteen reefs are traceable northwards into the Moonád Amsham.

Still further westward, by Pandalur, Cheyrumbádi, and Cholády to Vellaramulla, there are at least twenty-four more reefs, those in the neighbourhood of Pandalur having had their 'foot-walls' and 'leaders' very extensively worked in old times by the Korumbars. Those of Cheyrumbádi and Cholády have not yet been sufficiently examined; but it may be here stated that one of the richest gold-washing regions (Kathaparaye) of the low country could only have been supplied with its gold from the Cholády and Vellaramulla drainage basins.

Appearance of gold from reefs and washings.

The gold obtained from the reefs is of a pale color; that from the leaders and washings is generally yellow; and that from the surface washings nearly always of a good yellow color. The natives know this difference, preferring the 'mud gold' to the 'stone gold,' which last they designate also as 'white gold.'

Fragments of stone gold are found at times by the Pannirs in their washings of surface soil; but there is nothing known of pale gold dust having ever been got in the washings.

Quality of alluvial gold.

In an assay made of some of the gold obtained by Lieutenant Nicholson in 1831, the following result is given:—

DAYVALLAH.

Gold ...	90·88
Silver ...	8·86
Copper ...	·26
	100·00

This was evidently gold obtained by the washers; for Nicholson does not seem to have got any reef gold.

Two samples from auriferous surface soil near Dayvalláh have been assayed by my colleague Mr. Tween, one of which, as will be seen, is very near Nicholson's specimen, while the second is richer.

				Carats.	C. grains.	
No. 1, Gold	... ...	93·00	=	22	1	Fineness.
Silver	... ...	7·00	=			
No. 2, Gold	... ...	90·00	=	21	2¼	Fineness.
Silver	... ...	8·67	=			

Neither of these three assays comes up to the quality of the dust obtained by Nicholson in 1831 from the Malabar low country, which varied from 94·53 to 99·22 in the percentage of pure gold.

When the matrix gold is analysed a very different result is obtained showing a considerable falling off in the fineness of the ore. There is also a much greater disparity between it and the alluvial gold than is usually displayed between the two kinds in Australia, or even in California; though the percentage of pure gold in the Wynád ore is nearly the same as in that of the latter country.

Mr. Tween has supplied me with the following assays :—

1. Skull Reef.		2. Monarch Reef.		3. Mixed sample.	
Gold ...	67·07	Gold ...	82·69	Gold ...	86·86
Silver ...	32·93	Silver ...	11·32	Silver ...	10·96

and these according to the scale of fineness make the ore of—

		Carats.	C. grains.	
Skull Reef	... ...	15	3	Fine.
Monarch Reef	... ...	19	2¼	„
Mixed sample	... ...	20	2⅝	„

An ounce troy of the mixed sample, taking the mint price of standard gold at £3-17-10½, would be worth £3-13-6¼, or about Rs. 36-12-2.

The sample from the Skull Reef is remarkably poor, and if it be a fair average (which I do not think it is, as I have seen gold at times in the richest part of the lode having a much better color than that of the amalgamated sample tried), it would reduce any calculation as to the return of this reef by nearly one-third. The specimen from the Monarch Reef is only from one crushing of four pounds of stone; and cannot be considered as so fair a sample of gold right across the lode which was the case with that taken from the Skull. The mixed sample is from amalgamated ore taken from six reefs; and it may be taken as an average for Wynád gold as far as it has been yet tried. It is very probable that the fineness of the gold in the different reefs will vary just as frequently as it is known to do in other auriferous countries.

Mode of occurrence of gold.

As is usual in most gold regions, the precious metal occurs here in the reefs or large lodes, in the leaders and spurs, and in the 'casing' or nondescript rock lining or casing these.

In leaders and small veins.

The ore of the leaders and casing is mostly visible, and is what is technically called 'coarse gold;' that is, it occurs as small segregations in the interstices of the quartz, or of the assembled cubical crystals of what is now limonite, or even in the interior of these cubes. It is also very often visible in the unaltered iron-pyrites which is not quite so frequently seen in the leaders as its pseudomorph limonite. A very common mineral in the casing of some of the leaders is pyrolusite, in which also the gold is often visible. The blue-black variety of pyrolusite occurs also with the gold visible at times.

It is this variety of gold which the Korumbars evidently always sought for, principally from its splendid color; then, because it is so easily seen and often obtained without the trouble of amalgamation; and lastly, because it occurs in the casing and leaders or small veins of quartz, all of which were easily broken up in the extemporized mortar holes which are still to be seen cut in adjacent blocks of gneiss or quartz, or calcined prior to pounding. The old miners seem never to have broken up the big reefs, though they 'cayoted' or dug in among the 'riders' or masses of country rock and casing enclosed or contained in the interior of the reefs.

In the reef.

The gold of the reefs or great lodes is generally 'fine gold,' or such as is disseminated through the gangue in extremely fine particles quite invisible even with the magnifier. After the quartz is crushed and washed, this fine gold may be seen on the furrows of the rude wooden dish used by the Pannirs like little painted waves of color. At times, however, the gold is visible even in the white quartz in short streaks and little angular masses; though it is more generally seen in the same form in the red and brown stained ferruginous and cellular quartz.

Appearance of reefs.

The quartz reefs are, without exception, white colored on the outcrop or when they come to 'grass'; so that it is utterly impossible to say from a surface inspection whether they shall be richly auriferous, or not. The Skull Reef of the Alpha Company which has as yet shown most gold is as white on the surface as any other of the reefs.

All the reefs are badly defined at the outcrop: they just show a few feet over the ground and never stand up as marked walls cutting across country as some quartz reefs do in other parts of this Presidency. Occasionally, they show well on the eastern slopes of the grassy hills, as when their upper surfaces or 'backs' just happen to form parts of these slopes.

Lie of reefs.

In such an undulating, or deeply denuded, country as the Wynád, it is difficult for an ordinary observer at first sight to make out the true direction of the great quartz-lodes, their dip or underlie being rather low; but when followed out for long distances they are seen to have a prevailing north-north-west, south-south-east strike or 'run' across the country. At places there may be a slight deviation from this; and for short distances there are slight curves; but, on the whole, this is the direction for South-east Wynád, and it is always across, not with, the stratification of the rock of the country. The dip is always to the eastward, generally at an angle of 25° to 30°. There is, however, a tendency in the 'underlie' to be lower on the tops of some of the hills, and to increase in the valleys. For example, the Skull Reef at the present place of quarrying dips at 20° to 25° east-south-east, while on the top of a hill a short distance to the north, some 200 feet higher, it is 10° and nearly flat. The same feature shows in the Hamsluck Reef; and the Monarch Reef, at its lowest level, has a much higher dip than on the hills.

Of the leaders.

The leaders and spurs, or side veins, strike off to the westward from the foot-walls, or undersides, of the big lodes. They dip and wave about in all directions, very often rather to the northward.

Extent of reefs.

The great ledges or reefs of quartz appear to vary much in thickness both in their length and depth, sometimes dying out, or at least becoming very thin for short distances in their length; and, as I am inclined to believe, even behaving thus in their depth. Some of the reefs are traceable with occasional breaks or thinnings-out for great distances. The Monarch Reef would seem to be traceable for about nine miles; other reefs show their outcrops at intervals for two, four, or six miles.

It is much more difficult to say anything as to their depth in the underlie. Very many show by their outcrop on the hills and valleys that they are 300 or 400 feet in depth. The Hudiabetta Reef, on the edge of the ghâts, gives indications of being 1,300 yards down its underlie; while there is slight evidence that some of the reefs west of this show down in the low country. On the other hand, two large reefs, as they run south of the Nádgáni-Gúdalúr road, are not seen in the deep trenches, and it is difficult to say whether they are covered up or have actually thinned out.

The thickest actual section is 15 feet in the quarries of the Skull Reef, though there must be greater thicknesses than this close by. A good average thickness in most of the reefs may be taken as from 4 to 9 feet. The thickness of the leaders naturally varies very much. They appear to run generally up to 2 feet or so; but there is one under the Dunbar Reef which is 6 to 8 feet in thickness.

A very common feature in the outcrop of the big 'ledges' is, that they show strong on the higher parts of the ridges and hillocks traversed by them, and thinner or not at all in the saddles. This at first sight points to a probable thinning out in depth; but there is the view that the higher ground is more open to denudation while the saddles would to some extent be covered up by débris of the country rock, and their slopes are not so steep as those of the ridges; the outcrops, too, are deceptive, for they are often encumbered with big lumps of fallen quartz. Indeed, the masses of fallen quartz are in some places so large and so tumbled together down the western slopes of the grassy hills that they give the appearance of stone *in situ*.

Rock of the country. Gneiss.

The rock of the Wynád, or as it would be termed in mining regions the 'country rock,' is gneiss, belonging to the oldest known series in India, termed variously the *Crystalline, Gneissic*, or the *Metamorphic series*; and is of very variable constitution in different parts of the country. Ordinarily, there is a massive foliated quartzo-felspathic, or quartzo-hornblendic variety, with intercalations of micaceous and talcose schists; but all these are, except in the hill-ridges, generally weathered or decomposed into a more or less tough clayey rock, granular and friable with the undecomposed quartz, dark red and brown from the hornblendic and chloritic constituents, or white, pale colored, and cheesy, or soapy from the felspathic, micaceous, and talcose ingredients of the original rock. There is a large quantity of ferruginous matter distributed through the gneiss in the form of minute granules or crystals of magnetic iron; and in one particular band in the Marpanmúdi ridge, as laminæ of gray hæmatite. Hence the red and brown colors of much of the decomposed rock; and also its occasional lateritoid character: while at every working of the surface soils or the river sands by the Pannirs there is the unfailing accompaniment of black iron sand.

The strike of the foliation, or indeed of the lamination and the bedding of the gneiss, is usually east-north-east, west-south-west, the dip being mostly at high angles to the southward; except in the Vellaramulla and Sultan's Battery country, when a west-north-west, east-south-east foliation is prevalent with some folding, and even reduplication of the beds.

Several bands of gneiss.

In South-east Wynád four belts of gneiss are recognizable. Along and south of the Nádgáni-Gúdalúr high road there is the northern edge of the highly syenitoid and quartzose gneiss of the Ouchterlony valley and the Nilgiris. North of this and striking about east-north-east, west-south-west, is a highly felspathic band with two minor belts of chloritic gneiss. In this, the Dayvállah zone, there is very little true massive rock until—still going north—the conspicuous and picturesque serrated and lofty ridge of Marpanmúdi and the Needle Rock is reached. Here a very hard and thick band of highly quartzose and ferruginous gneiss is met with, in which the run of the strata is rather tortuous; while there are indications of a synclinal roll in the great wall of rock crowning the ridge above old Dayvállah and in the Needle Rock. In the depression north of the Marpanmúdi range there is a wide belt of much more varied gneisses, which, on the whole, are not so felspathic as the Dayvállah band, nor so quartzose and hornblendic as that of the Ouchterlony valley. This zone is traversable to beyond the Cheyrumbádi hill station, when a further curved belt of gneiss with more schistose bands comes in as in the Vythery Cholády and Sultan's Battery country.

Two 'cores' of granitic rock.

In the country just mentioned there are two large hill masses of granitic rock; namely Yeddakulmullay near Sultan's Battery and Mumramulla or Culpetta hill nearer to Vythery. These are, as it were, great rocky cores around and over which the foliated gneisses were laid down, the great arches or undulations of which are now evidenced by the westerly dip and subsequent synclinal displayed in the Chambra, Yellambalari, and Panora peaks and the rest of the Vellaramulla range, the easterly dip of strata on the Sultan's Battery and Manantoddy side of the country; and the narrow strip of folded beds in the wall like crests of the Marpanmudi ridge near Dayvalla, south of which there is the generally southern dip of the Ouchterlony valley strata. The rock of Culpetta hill is a very rough weathering, pale flesh-colored, rather coarsely crystallized compound of quartz, felspar, and silvery mica, showing no trace of foliation. It wears away into huge rounded masses of still harder rock, giving the hill rather a resemblance to those of the Mysore country in which the gneiss is often highly granitoid. Yeddakulmullay is made up of a much finer textured rock of quartz and felspar, and minute particles of black and greenish mica, which when weathered looks very like a coarse buff sandstone. On the western flanks of the mass, the rock is rather laminated or foliated. With both these cores of granite there is a decrease in the number and thickness of the quartz veins; but these appear again quite strongly to the northwards crossing the Sultan's Battery—Culpetta road.

Hardly any intrusive rocks in South-east Wynád.

Otherwise, the country is remarkable for the non-occurrence of any strictly intrusive rocks except in a very small way. There is a dyke of hard, compact dark-green diorite seen for a very short distance in the Hamsluck estate to the west of Dayvállah. The width of this dyke is about 35 feet; and it is striking east by north, west by south, nearly vertical. It cuts off the northern end of Hamsluck Reef. A few small largely crystallized granite veins occur here and there over the Dayvállah band of felspathic gneiss, as near the dyke just mentioned and around Gúdalúr. Large flakes of mica from these are common on the Nádgáni-Gúdalúr road.

Quartz reefs become granitic.

In connexion with this rare occurrence of granite veins it may be noticed that the quartz reefs of Cheyrumbadi are in some cases charged with assemblages of large plates of mica of 2 to 3 inches in diameter; and there thus seems to be a tendency in the western veins to become granitic rather than simple quartz lodes. Likewise from Cheyrumbadi the quartz of the reefs is becoming rather granular and saccharoid.

Variation in country rock does not affect reefs or their contents much.

Sufficient data have not yet been gathered to be able to write with any confidence as to how the quartz reefs may have been affected by the different belts of gneiss in which they were deposited. The ledges certainly seem to show stronger in the Dayvállah belt. They nip out very thin, and even disappear in the hard Marpanmúdi range; but they come to grass again to the north of this. There are perhaps not so many reefs to the north of the Marpanmúdi range as to the south of it. The occurrence of gold in the leaders does not seem to have been affected one way or other on either side of this ridge, for the old Korumbar works are as frequent about Nellialum and Pandalur as on the Dayvállah side.

The quartz reefs which have been traced out, or are sufficiently marked, are as follows commencing from the Gúdalúr side of the country, where and eastward of which there do not appear to be any ledges, auriferous or otherwise, for some miles at least:—

Enumeration of quartz reefs.

Name of Reef.	Character.	Average proportion of gold.	Lowest proportions.		Highest proportion.
1. Eastern	Worked on foot-wall ...	......	...	...	...
2. Paliampara	Ditto ...	......	...	...	...
3. Bear	......	......	...	...	...
4. Nádgáni	Worked on foot-wall ...	......	...	...	...
5. Monarch	Auriferous ...	......	½ dwt....	2 dwt....	69. 19 dwt.
6. Hamlin	Worked on foot-wall ...	......	...	...	...
7. Un-named	Ditto ...	......	...	...	...
8. Korumbar	Auriferous ...	4 dwt. to ton	½ dwt....	7½ dwt....	180 dwt.
9. Un-named	Worked on foot-wall ...	......	...	...	...
10. Cavern	Auriferous ...	......	...	...	...
11. Skull	Ditto	11 dwt. to ton	2 dwt....	25 dwt....	...
12. Hamsluck	Ditto	3 dwt. to ton	1 dwt....	7 dwt....	...
13. Hamsluck, middle ...	Ditto	10 dwt. to ton	8 dwt....	12 dwt....	...
14. Hamslade Waterfall ...	Ditto	11 dwt. to ton	3 dwt....	19 dwt....	60 dwt.
15. Balcarras	Ditto	3 dwt. to ton	½ dwt....	...	...
16. Puntaloor	Worked on foot-wall ...	......	...	...	...
17. Hudiabettah	Auriferous ...	......	...	...	...
18. Glenrock	Worked on foot-wall ...	......	...	...	...

By 'auriferous on the foot wall,' it is to be understood that the foot-wall of the reef and the side veins therefrom have been dug at by the Korumbars, and that they are reported by the natives to have given gold. In these cases, I think tradition may be believed to a large extent.

Details of auriferous reefs.

The *Monarch Reef* is, as stated above, traceable for about nine miles from the western side of the bridge below the Nádgáni Bungalow, across the Dayvállah road (about a quarter of a mile east of the toll bar), up the long grassy ridge to the summit of a lofty cross-ridge overlooking old Dayvállah; and on to the wide gap in the Marpanmúdi range, down through the Dingley Dell Estate, and on past Koontalaudy towards the Gúdalúr—Sultan's Battery road. At its southern end a drive was put through this reef, where it was found to be 4 feet thick; but I am inclined to think that this is only part of the reef, a 'rider' or large enclosed piece of the country rock having been met with. The varied results given in the table from this reef are accounted for in this way: At first, color of gold was got in the samples taken from the drive sufficient to warrant the expectation of about 2 dwts. of gold to the ton of quartz. Subsequently, a fragment of stone from the surface, weighing 3 lbs., was crushed and 2·3 grains of gold obtained, which is in the proportion of 69·19 pennyweights to the ton. Stone, in fragments of which gold was clearly visible, was then taken from the same place and 350 lbs. of it subjected to rough crushing in a stamper belonging to Mr. J. W. Minchin, and passed over a large blanket cradle, but the outturn was extremely disappointing, as only about 3 grains of gold were got, and yet more than this had been seen before the stone was pounded up. It was soon found, however, from subsequent experiments, that the gold must have been lost in the stamping box which was merely a planked structure round the stamp-head, and as no more trials could then be made on this reef, an average result has not been entered in the table.

The quartz of the Monarch Reef is generally a milky-white coarse-textured rather glassy-lustred compact rock. At times it is stained brown or red along the fractures, and shows thin sheets and seams of brown iron rust. Flakes of bright golden colored mica are frequent; and there are rare seams of greenish talc and chlorite. White iron-pyrites occurs at rare intervals. The quartz is rudely laminated with the lie of the reef, and spurs of talcose schist are frequently running into the body of the lode. The casing is partly of talcose schist, with frequent laminæ of pyrolusite. This description applies to so much as is exposed in the drive or cross-cut.

The foot wall and leaders of this great reef have been extensively worked on the slope of the ridge overlooking the old Dayvállah valley in Mr. Hughes' clearing, and in the valley itself.

Korumbar Reef and others.—Between the Hamlin and Skull Reef, there are at least five lodes, but they are only traceable at intervals to the district road. One, called after the native miners who pointed it out, gave another set of curious returns, which will illustrate the faulty condition of the extemporized crushing apparatus with which work had to be done.

Seven pounds of stone from the Korumbar Reef were hand-pounded and gave 12·40 grains of good yellow gold; and a further crushing of the tailings of white iron-pyrites, of which there was a large quantity, added ·40 grains to this; being in the proportion of 8 oz. 10 dwt. 16 grains to the ton. One hundred and sixty pounds of this stone were then pounded, and all but 10 lbs. crushed and passed over the cradle, when gold at the rate of half a pennyweight to the ton was got. But from the 10 lbs. remaining which was hand-crushed there was gold at the rate of 7½ dwts. to the ton. In the meantime, another sample of 4 lbs. of stone was brought in from a new reef (Hamslade Waterfall) which gave 7 grains of gold, I then went to this reef with the men and quarried out about 70 lbs. of stone which was divided for separate trial by wet crushing and by hand work, when the following outturn appeared:—

30 lbs. hand work	...	...	...	6·3 grains of gold.
40 lbs. wet crushing	...	...	...	1·3 „ of „

The latter sample showed more gold than this in the uncrushed stone. Even if the wet-crushed result be true, the proportion for this reef is 10·19 pennyweights. It was evident, however, that gold had been lost in the stamping box; had indeed possibly never left it, for the bed plate (fixed) could not be completely boxed in.

The outcrops of these reefs are very short for any continuous distance, but there can be little doubt that they will be found continuing northwards nearly up to the Marpanmúdi ridge; and some of them show down in the Nádgáni estate in the Carcoor *cherrum*. They are thin, about 3 to 4 feet on the edge of the *cherrum*, and look at other points as though they kept to this. Their appearance is very favorable, being more or less colored with oxide of iron, laminated, and full of white iron-pyrites; and they show gold at times; in fact, they are just as promising-looking except in the matter of size as the reef to be noticed next.

The *Skull Reef.*—The outcrop of this lode is traceable nearly continuously for about seven furlongs, but it is in all probability connected with other outcrops of quartz to a complete length of at least four miles. Only a small part of the southern end of this reef has been taken up by the Alpha Company. At the southern end it commences on the edge of the Western Ghâts, a little more than a mile and a half due west of the Nádgáni Bungalow, on the rounded grassy knolls of this part of the Dayvállah country. Thence it runs up to the top of a high hill overlooking Dayvállah and down to the road a short distance east of the bazar. Strong leaders from its foot-wall cross the road nearer the village and run through the wooded hillock on which the old fort is situated. Its next appearance is in a high ridge on which the Roman Catholic Chapel is built, and again in the Harewood and Kintail Estate east of Mr. Hamlin's bungalow. Beyond the cross range of Marpanmúdi, it again shows in the bottom of the Strathern Estate: and still further northward in the Nallialum country.

The direction of the vein is, as usual with these south-east Wynád lodes, *viz.*, north-north-west, south-south-east, with a dip or underlie varying from 10° to 25° east-south-east. On the top of the hill overlooking Dayvállah the angle is low, in fact becoming flat, but it increases as the reef descends, being at the quarries about 20° to 25°. At the place of quarrying there is a large irregular surface of the vein exposed on the eastern slope of a grassy spur of the hills. This is full of caverns excavated by the old native miners who evidently scraped and dug at every bit of casing, enclosed country rock, and the leaders. The Manager of the Alpha Company is at present quarrying in at this exposed surface, and preparing stone in readiness for the crushing machinery which is to arrive in a few months from Australia. At the quarry the reef is about 15 feet thick, of rudely laminated quartz; laminations with the dip and strike. The back or upper surface of the lode is of coarse white quartz. From this, as was seen by a cross-cut through the reef, the rock becomes more and more ferruginous and stained of dark brown, black, and reddish colors, cellular or mouse-eaten, and charged at times with white iron pyrites much of which is decomposed, sulphate of iron and even traces of sulphur being left behind. At about 12 feet the quartz is more highly colored, very ferruginous, very cavernous, and gold is often visible in minute strings and masses. The quantity of rock worked out has not been sufficient to show whether there is any definite 'gold streak' in this lode.

Through the kindness of the Directors of this Company and their Manager, Mr. Withers, I have been supplied with a fair set of specimens from this cross-cut, which have been crushed, washed, and amalgamated in a rough manner. Very good color of gold was got in nearly every dish of pounded stone; but the results from amalgamation were very poor at first. The enormous quantity of iron pyrites associated with the gold came in the way of amalgamation, causing the mercury to granulate and become coated with the iron, sulphide; in fact 'flouing' (Australian term) set in.

I have not been able, owing to the difficulties in the way of crushing, failure of some experiments, and a want of time, to obtain a complete series of specimens and results from one cross-cut in this reef, much less from different parts of the lode, which would, of course, be the fairest way of testing the quartz, but such as have been got are now given—

Specimen of quartz.	Weight.	Appearance, color, &c.	Results.	Depth in cross-cut from 'back' of reef.
1	20 lbs.	Compact, coarse texture, laminated; white color ...	2 dwts. to ton	1st foot.
2	28 lbs.	Still white in color, but stained with ferruginous matter	2·5 dwts. to ton	3rd foot.
3	......	Whitish, more discolored with iron	None.	5th foot.
4	30 lbs.	Ditto ditto ditto	Good color in dish: lost in amalgamation.	7th foot.
5	18 lbs.	Still white, but ferruginous	5·18 dwts. to ton	10th foot.
6	18 lbs.	Highly colored, red and brown, ferruginous, cellular, with white iron pyrites. Gold visible... ...	19·44 dwts. to ton	12th foot.
7	18 lbs.	Ditto ditto ditto washed and amalgamated in my presence by Mr. Withers. Gold not visible	25·92 dwts. to ton	13th foot.

For this cross-cut there is therefore an average result of 11 dwts. to the ton. At this point the richest part of the reef is a band of the laminated quartz about two feet thick within a couple of feet of the footwall or underside of the reef. The average of this rich band is 22·68 dwts.

Mr. Withers informs us that he has got almost as good results out of a shaft and cross tunnel which he made at the southern end of the outcrop, but that the reef is there narrower, about 9 feet in thickness.

Hamsluck Reef.—About half a mile west of the high hill-outcrop of the Alpha Company's Reef overlooking Dayvállah village there is another strong lode cropping up in Mr. J. W. Minchin's estate of Hamsluck. The lowest part of this reef, or what is seen in the bottom of the valley at its foot, is about three furlongs in length; and from this as base the reef slopes up the eastern side of a hill about 300 feet high. The strike of the reef is about the same as in others: the dip being about 20° to the eastward, though it is at a much lower angle on the summit of the hill. The known thickness of this reef is from 4 to 8 feet. The lode is cut off to the north by the dyke of green stone already noticed. It is traceable southwards into the Chullaymullay mountain, and probably runs under the northern end of Perseverance Estate. The eastern slope of the Chullaymullay alongside the latter estate has been perfectly riddled by the pits and excavations of the old miners who evidently worked at the side veins on the underside of the lode. Small samples of quartz were crushed, and gold was always got showing clear in every dishful of stuff; but the result was small owing most probably to the presence of a great quantity of iron sulphide. Subsequent crushings gave the proportions shewn in the table.

Dunbar and Balcarras Reefs.—About two miles further west, but on the northern side of the deep trench leading to the low country by Carambat, there is a good outcrop of a reef about 4 feet thick in the Dunbar Estate. Mr. Powell, the Superintendent of this garden, when down showing me the reef, was successful in knocking out pieces of quartz in which small streaks of gold were visible. The underside of this lode is very like in color and contents to that of the Alpha Company, the richer seam in the quartz being on this side. Leaders are numerous and large. The casing is of talcose schist, and seamed with ferruginous and manganese streaks.

The lode is traceable northwards into the Balcarras Estate, where there is a great show of white quartz on the eastern slope of one of the low hills. This part of the reef has been very extensively riddled by the old miners. In fact, all its extension northwards towards Pandalúr has been washed, and its immediate neighbourhood on the underside is still a favorite locality for washing during the rainy season. It runs through the Elizabeth and Sandhurst Estates, and close alongside the Caroline and Mr. Holmes' application, and thence northwards.

Prospects of Wynád up to date.

My observations so far appear to show that quartz-crushing should be a success, in the Nambaly-code Amsham at any rate. Here, there are eighteen reefs which are more or less auriferous in themselves, or as to their leaders. The leaders and underside of these are all known, or reported, to be auriferous with coarse gold; and it is probable that the great reason they are not worked now is that the pits necessary to be dug by the Korumbars would be too deep for their style of work, water being the great obstacle likely to be met with. The big reefs were not worked by these men on account of the difficulty of breaking up the stone, and because the gold is distributed too finely through it to have paid hand labor. With machinery and modern appliances, the reefs should pay even if only 3 dwts. of gold are got always from the ton of quartz.

The average proportion of gold for fifteen trials on different reefs is at the rate of seven pennyweights to the ton; and it is almost certain, that many of these would have given a better outturn, could more perfect crushing apparatus have been used at the time.

The fineness or touch of the ore is inferior to that of Australia, but it compares favorably with Californian reef gold. The percentage of 86·86 is given above as a fair average, for on looking at the differences between alluvial and matrix gold in other regions, it is found that they agree very closely with the difference between this sample and the alluvial ore of the upland; while the assays of the Skull reef, and the upland and low country washings do not exhibit any gradation consistent with the amount of exposure to which the two alluvial golds must have been subjected.

In Australia these ratios are as follows :—

	c.	c.g.	Percentage of pure gold.
Alluvial gold	23	$1\frac{4}{8}$	... ... 97·500
Matrix gold	22	$0\frac{7}{8}$	... ... 92·875
Difference ...	1	$0\frac{5}{8}$	... ... 4·625

Californian tables give about the same difference, but the fineness of the gold is much lower, *viz*., 21 c. 0 cg. or 88·00.

The Wynád experiments give—

	c.	c.g.	Percentage of pure gold.
Alluvial	21	$3\frac{7}{8}$	... ... 91·95
Matrix	20	$2\frac{6}{8}$	... ... 86·86
Difference ...	1	$1\frac{1}{8}$	... ... 5·09

This close approach of differences for the three countries implies also that a richer gold than this is not to be expected from the reefs; though it must not be forgotten, as already stated, that the ore from the small veins and leaders is evidently superior.

The reefs are easily got at, the gneiss traversed by them being often wonderfully decomposed almost to any reasonable depth. For a long time there may be no necessity for deep sinking, as a large quantity of stone is held in the many rounded hills so common over the country, and thus little trouble is to be anticipated in getting rid of water in the mines when drives can always be made at low levels. The very prevalent idea that the gangue must necessarily be richer the deeper it is searched, will doubtless be brought to bear on any mining which may be carried out; but the safer plan in a preliminary opening up of a country like this will be to work at what will pay, rather than venture to mine ground requiring expensive pumping apparatus, in which there is—after all that has been written on the subject—no absolute knowledge that there must be more gold. It is worthy of notice that the present surface of Wynad has probably only been exposed after a slow wearing away of over 2,000 feet of superincumbent gneiss which was once continuous between the Nilgiri mountains and the Vellaramulla range, in which also these quartz veins may have been continued in their upward hade to the westward; and supposing that reefs become richer in depth, then the richness now got of 7 pennyweights, by denudation of 2,000 feet, is not any great increase on whatever may have been the state of things at the then higher outcrop; while, if the same ratio of increase is to be counted on, any further considerable increment of gold can only be expected at a greater depth than is likely to be reached on the plateau. A reasonable view is that the occurrence of rich streaks of gold will be exceedingly variable; while the prevalence of very fine gold dust in Malabar indicates that fine gold is perhaps most evenly distributed through the matrix, and therefore that beyond the first fifty feet, to which depth weathering may be supposed to extend, the return shall be tolerably constant.

The working of the mines may possibly not be as cheaply done as the present rate of wages in Wynád would lead one to expect. The coolies employed on the coffee estates get from 4 to 5 annas a day per man; but there is a decided scarcity of labor, and thus a higher rate must follow if the quartz reefs are to be worked. A further addition will be in the employment of a small number of skilled European or Australian workmen in the handling of machinery, and in directing the getting out of the largest quantity of stone, and timbering up. Still, with these additions, the labor in Wynád may be expected to be always cheaper than in other gold countries.

Great facilities towards the crushing of the stone are presented in the way of water-power, which might in some cases be obtained direct from perennial streams with sufficient fall for any ordinary wheel; or it might in most other instances be led or stored up without much difficulty or expense. The stampers, &c., of the Alpha Mining Company are to be driven by steam; but there would have been no difficulty in applying water-power at the site of their works.

Having then the presumable average proportion of gold in the stone, the value of the gold obtained so far, and the quality of the labor to be employed in getting it out, an estimate can be made of the possible paying capabilities of the Wynád reefs from the statistics of the cost of extracting gold in Australia, where the labor is manifestly much more costly than it can be in Wynád.

In Mr. Brough Smyth's "Gold Fields and Mineral Districts of Victoria" the following returns are given of the cost of complete extraction of the ore from a ton of stone:—

	£	*s.*	*d.*
Ballaarat District	0	8	8½
Clunes	1	0	3
Bright	0	4	4
Wood's Point	0	11	6
Sandhurst	0	11	8
Maryborough	1	9	8
Castlemaine	0	11	5½
Maldon	2	1	8¼

Some of these rates are very high and paid on stone got from a good depth in places ill-situated as to supplies of wood and water, so that the average of 17*s.* 4¾*d.* is far beyond any expected estimate of this kind in Wynád.

The value of Wynád reef gold, when compared with the mint standard of £3 17*s.* 10½*d.* is about Rs. 36-12-2 per ounce, troy, which is, of course, somewhat lower than the mercantile rate. Seven pennyweights, or the outturn of 1 ton of stone, would then be worth Rs. 12-13-10, which would leave a balance of Rs. 4-2-8 on every ton crushed, even if the high Australian rate were ever attained.

The country must now be tried cautiously, while better or worse results may in the meanwhile be obtained from experiments which are being carried out, even before the arrival of the machinery of the pioneer Company now waiting to venture in the field. There is no promise like that of the Australian or American gold-fields; no great nuggets have been found; the washings have always been poor, though there is a small supply of gold swept down the hill sides every year from the wear and tear of the quartz ledges, and the areas over which they can be applied are very small; and the gold which has been seen in the reefs is only in minute strings and grains. The ground can only be worked out by capital, the most perfect machinery, and skilled hands to guide the cheaper labor of the country in getting out the stone in the safest and readiest manner. And naturally, where the percentage of gold in the quartz is as yet so small, everything will depend on getting out a sufficient tonnage of stone in a given time.

Until more is known of the gold-producing powers of the Wynád, no better guidance can be given than the following by Mr. A. R. C. Selwyn, Director General, Geological Survey of Canada:* "It should not be forgotten that the most favorable indications are not always reliable, and the sanguine prognostications they so frequently give rise to are not borne out by the result of actual working; wherefore I should, even under the most favorable circumstances, not advise any one to invest in such enterprises to an amount beyond what he can afford to lose without serious embarrassment."

Land tenure in Wynád.

Hitherto the land in Wynád has been principally parcelled out in coffee gardens, either free-hold, or paying an annual rent to the Rajahs who hold a great quantity of the ground, or direct to Government. At the same time, after a certain period, a revenue is derived from all the gardens by the Government, whether it be Rajah's land, or not. Now that gold mining is likely to become an industry, a new set of land interests are being developed. The Rajahs, of course, retain their right to all minerals and can sell these as they like. The Government of Madras has not yet, I believe, decided as to how they are to act in the matter, except that applications for land for gold-mining and for agricultural purposes on which quartz reefs are supposed to exist, are being reserved for consideration until the question of mining interest is settled.

In the meantime the Rajah of Nellambor has (according to their prospectus) leased a block of 15 acres of land near Dayvállah to the projectors of the Alpha Gold Company for twelve years at an annual rent of Rs. 225. Since then it is reported that the Rajah in recent applications demands 10 per cent. on the out-turn of any gold-mining which may be carried on; and it is very probable he may change this rate. Nearly all the land in the Nambalycode Amsham is owned by the Rajah of Nellambor. Equally, as with the revenue derived from estates on Rajah's lands, it may be found advisable that the gold from these reefs should pay a royalty to Government.

In conclusion, I have to tender my thanks to all the planters whom I have yet met in Wynád for their great kindness and hospitality, and for their assistance in every way. Also for the readiness displayed by the Directors and the Manager of the Alpha Gold Company in allowing me to examine their quarry and giving me such specimens as were required. To Mr. J. W. Minchin of Dayvállah the greatest debt is due for having allowed all the specimens to be crushed at his extemporized stamper and subsequently manipulated by his Pannirs and Korumbars.

* Notes and Observations on the Gold Fields of Quebec and Nova Scotia

GEOLOGICAL NOTES ON THE KHAREEAN HILLS IN THE UPPER PUNJAB, *by* A. B. WYNNE, F.G.S., *Geological Survey of India.*

The Khareean* hills are perhaps better known, to the natives of the country at least, by the name of Pubbí, which seems to have an application to their low but broken forms. They are situated in the Upper Punjab, seven or eight miles southward of the river Jhilam, and station of the same name, forming the southern of the three minor chains which link, as it were, but without absolute continuity, the salt range to the Western Himalayan mountains.

These Pubbí hills extend from near the battle-field of Chílíanwala, and closer to the banks of the Jhilam, in an east-north-easterly direction for about twenty-eight miles in the direction of Bhimber (in Kashmere territory), but sink into a sandy nallah about four miles short of that town. They form throughout a low rugged chain, cut into by numerous ravines, having a general width of three or four miles, and a summit elevation of some 4 to 500 feet above the plains of the Jhilam and the more extensive ones of the Goojrát district.

Their culminating point is towards the western end of the range, and their declination eastwards is very gradual. In the latter direction they are crossed by the grand trunk road from Calcutta to Peshawur and by the Northern State Railway in progress of construction.

The aspect of the hills is monotonously arid, barren and rugged, presenting everywhere steep or precipitous descents into dry sandy nullahs. Towards the eastward, the 'Pubbís' are further apart, and scattered cultivated patches occur between the hills, which are separated by that peculiar labyrinth of ravines known in this country and the Pot'war as '*khuddera*.'†

The hills are composed of an enormous accumulation of sandstones, sands, conglomerates and clays belonging to the upper part of the tertiary rocks of the Northern Punjab.

From their position it was thought probable that here the Sivalik sub-division of these rocks might be developed, and their relations to the underlying beds discovered if the same marked unconformity, as occurs in other places, existed. On examination no trace of unconformity within these hills has been found, and though the soft and friable nature of most of the strata would answer well enough for the description of Sivalik rocks in other regions, their whole character suggests their identity with the uppermost deposits of the Pot'war to the north, similar clays and sandstones there having been always found to pass regularly downwards into the lower and older portion of the series, so far as has been gathered from observations hitherto made.

The arrangement of the Pubbí rocks is simple; they form a distinct anticlinal, the axis of which coincides with the higher parts of the range, a downward inclination of this at either end bringing at least a portion of the beds round to form the opposite sides of the hills. With the general form described there are many undulations of the rocks in bold

* The word is pronounced by the natives Kháree-in, and the famous battle-field of Chílíanwala they speak of as Cheĺianmojeearrí.

† As characteristics of these Pubbí hills it may be mentioned that the chief obstacles to pedestrian progress, besides the innumerable khuds and ravines, are the difficulty of obtaining foothold on steeply sloping clay surfaces covered with small pebbles, sandstone fragments or nodules of kunkur which slide under the feet, the insecure nature of vertically weathered parts of the soft sandstones and clays, and the trying strain in the dry sandy beds of nalahs.

A striking feature of the ground is the contrast between its dryness and the abundant evidence of abrasion by water.

Although now so dry and barren, these hills were once populous and even thickly inhabited, as is evident from the very numerous large village ruins scattered over them, and the size of some of the graveyards belonging to these villages,—fast yielding to the atmospheric erosion which frequently exposes the graves, showing that the potsherds left by the inhabitants were more lasting than their bones.

Other relics of a perhaps still older period are brick blocks of large size, though the buildings formed of these have all but disappeared.

confluent curves; they sometimes assume horizontal positions, sometimes dip steeply into the plains, but never present any high opposing dips to the general anticlinal conformation. The highest point of longitudinal curvature of the axis upwards coincides with the summit of the hills at Koar Great Trigonometrical Station, east-south-east of the village of that name and some eight miles westward of the trunk road. From this point the beds both slope to the ends of the range and curve downwards upon its sides. Here, therefore, in the bottom of the ravines the oldest rocks of the exposure ought to occur.

These are drab-brown and slightly pink or purplish red clays alternating with zones of coarse friable gray or greenish speckled sandstone formed of comminuted waste of granitic or crystalline rocks, grains of quartz, felspar, hornblende (or such a mineral) and spangles of mica. Layers and runs or scattered pebbles of hard crystalline rocks are not uncommon, increasing in quantity as the section ascends, with a predominance of white quartzite fragments well worn, until on the flanks of the hills these pebbles of larger size and in greater numbers, including a few of hill-nummulitic limestones in many places thickly sheet the ground, pointing to the local destruction of loose conglomeratic pebble beds, which, from their friable nature, are seldom found *in situ*. The various and repeatedly alternating zones of clays and sandstones are often thick, ranging from 6 to 30 feet or upwards. In eastern parts of the range the clays are more developed, deep khuds often showing little else than zones of thick purple clay, each band purple below and of a bright ferruginous yellow above, while the intercalated sandstone bands are by no means prominent, save where they form caps to the hills or hard ledges defining the outlines of the ground in a widely extended and multitudinous series of scarped out-crops.

Through the whole of the sandstones, but rarely (if ever) in the clays, teeth and fragments of large bones are thinly scattered. The beds may be searched for long distances without finding anything more than an obscure fragment broken before becoming embedded, yet in the debris between sandstone out-crops the fragments are more numerous, though seldom sufficiently perfect to be worth removal. These fragments have not been found in the clays, yet some dark liver-coloured bones seem to have come from the purple portions of these. Fossil wood has not been met with. The bones are usually whitish or buff, the teeth too hard to be touched by a knife, the bones often softer and calcareous, while some huge tusks are replaced chiefly by a pinkish white soft marly looking brittle clay or earth.

The state of fossilization exactly resembles that of the Lehrí bones thought by Mr. Theobald to be of Nahun age (see Records, Geological Survey, No. 3, 1874).

The remains found in the above described beds include parts of large bones, such as the humerus, scapula, jaws, teeth and tusks of huge pachyderms. One of the former had a girth of 2 feet 7 inches, and fragments of a pair of tusks measured 12 feet in the aggregate with a girth of 2 feet in places. Large molar teeth resembling those of ruminants also occur, with some smaller teeth; portions of joints of less sizeable, leg bones, vertebræ, fragments of large deciduous, deer horns nearly as thick at the attachment as a man's wrist, many mammalian rib bones, numerous unrecognisable fragments, and one small piece of the armature of a tortoise (?) none of which have as yet undergone comparison or determination.

From the general aspect of the rocks no hesitation would be felt in referring them to the upper portion of the Pot'war tertiary series, but it remains to be seen if the fossils will give any support to the idea that they may be newer, or that these and some upper beds of the Pot'war may both be Sivalik.

Perhaps the only feature which relieves the stratigraphical monotony of these beds is an indication of a slow transition upwards into strata even more incoherent and more recent looking than those of the mass of the hills. These upper and outer beds are coarse sandy gravelly and conglomeratic layers with drab or yellow clays containing kunkur (as indeed do many of the clays lower in the series). These clays are of the same color, and present but little difference from the alluvium of the neighbouring plains, while the sandstones and gravelly beds or base of conglomerates are of a duller and more muddy aspect than the clean gray sandstones beneath. In the sandstone or gravelly parts of these rocks an occasional rolled bone fragment or broken tooth may be found, and in some of the conglomerates pebbles of the tertiary sandstones themselves occur; but notwithstanding the derivative aspect of the bones and of the last-mentioned pebbles, the containing rocks present no visible unconformity to the beds on which they rest. On the contrary, as stated, the transition to the softer and more recent looking layers appears to be gradual, while the dips are conformable and the newer beds are found all round the elongated oval formed by the hills.

Limits to these upper beds can only be approximately and arbitrarily assigned, but they may have a usual thickness of from 200 to over 400 feet.

The thickness of the whole Pubbí series must also be estimated with caution. For 18 or 20 miles from the eastern end of the exposure, a continuous succession of layers coming out from beneath each other may be traced, all lying at low but very perceptible inclinations which would, even at angles less than 5°, give a large total depth. When the cross-section, however, is considered, between 2,500 and 3,000 feet would seem a sufficient estimate for them all, and the probability is that the amount may exceed rather than fall within 3,000 feet.

Outside the inclined newer light colored layers the alluvium of the plains may be found horizontally abutting against and resting upon these rocks. It is of the common drab argillaceous or somewhat sandy, and occasionally kunkery or otherwise calcareous character, the only traces of fossils observed in it being small, white, dead Bulimus shells and part of the skull of some large bovine animal (perhaps a buffaloe) of recent appearance, but buried beneath from 8 to 10 or 15 feet of clay and exposed in the bank of a nullah. In neither case can these indications be taken as contemporaneous with the alluvium itself, for in so easily shifted and shifting a deposit, organisms of even more recent age might readily become enclosed. Much of the eastern part of the broken Pubbí country is formed of the deeply ravined alluvium.

It is to be hoped that the fossils collected, few, imperfect and fragmentary though they be, may afford sufficient evidence to relegate these Pubbí tertiary rocks to their proper place. Pending the examination of these fossils, the only conjecture that can be hazarded, based upon structural and petrological grounds, as well as Mr. Theobald's paper previously referred to, is that the fossiliferous portion of the Pubbí rocks is probably of Nahun age, while the age of the uppermost and more recent looking layers remains an open question.

CAMP, November 1874. — A. B. WYNNE, *Geological Survey.*

The following is a rough list of the fossils collected by Mr. Wynne during his examination of this small range of hills, drawn up by Mr. R. Lydekker, Geological Survey of India.

1.—*Equus sivalensis*, from north-west of Sundpúr.
- (*a*). 2nd premolar, right ramus of mandible.
- (*b*). Molar and parts of mandible.
- (*c*). First molar, Maxilla.

2.—*Equus sivalensis*, from near Changas, Pubbí hills—distal extremity, right metacarpus.

3.—*Bos*, Purr Kuss, inside of stream, in bank 8 to 10 feet below surface,—part of maxilla of left side, containing 1, 2 and 3 premolars, and first molar.

4.—*Bos*, near Changas, Pubbí hills—

(*a*). 2nd molar, right ramus of mandible,

(*b*). Fragments of molars.

5.—*Bos*, near Changas, Pubbí hills,—3rd molar, left maxilla.

6.—*Bos*, north-west of Sundpúr or Sandepúra,—distal extremity, right metacarpus.

7.—*Bos*, from Gotriala to Besa,—fragmentary teeth, mandible.

8.—*Equus sivalensis*, from Gotriala to Besa,—1st molar, right ramus of mandible.

9.—*Bos*, from Gotriala to Besa,—external second phalange, left foot.

10.—*Equus*, Pir Jaffir, Pubbí,—left calcaneum.

11.—*Bos*, Pir Jaffir, Pubbí,—distal two-thirds, left calcaneum.

12.—*Bos*, Kniara, Pubbí,—neural arch and laminæ, thoracic vertebræ.

13.—*Bos*, Kniara, Pubbí,—proximal head of radius.

14.—*Cervus*, Pir Jaffir, Pubbí,—base of left horn.

15.—*Cervus*, Pir Jaffir, Pubbí,—base of right horn.

16.—*Cervus*, Pir Jaffir, Pubbí,—portion of horn.

17.—*Elephas hysudricus*, Pir Jaffir, Pubbí,—portion of molar.

18.—*Elephas insignis* (?) *Ganesa* (?), west of Pir Jaffir,—part of molar; stated to have been found with tusks two feet in circumference; from this probably belong to *Ganesa*.

19.—*Elephas*, Pir Jaffir, Mosque,—part of tusk.

20.—*Elephas*,—part of tusk belonging to No. 18.

21.—*Crocodilus*,—fragment of carapace.

Note.—As the fossils of *Bos* are only molar teeth and fragmentary bones, it is impossible to determine the species.—R. L.

REPORT ON WATER-BEARING STRATA OF THE SURAT DISTRICT, *by* W. T. BLANFORD, F.R.S., F.G.S., *Deputy Superintendent, Geological Survey of India.*

It appears to me, so far as I can form a judgment on the question from the correspondence forwarded to me, that the problem presented may be briefly stated thus: To determine how far the irregularity in the distribution of sweet and salt wells in the Surat district is due to the geological structure of the country, and to ascertain whether that structure renders it probable that sweet water will be found in those parts of the district in which none has hitherto been discovered.

In endeavouring to solve this problem, the first point for consideration is the geological structure of the district, and the second the knowledge which is available of the distribution of sweet and brackish water. On the latter head most of the information obtained is from local sources and not from my own observation, I am consequently not responsible for its accuracy, but any error I may make will doubtless be corrected by the local officers.

The geology of the Surat district is simple.* In the extreme east, about Mándvi and elsewhere, hills of basalt and other volcanic rocks are found. Upon these rest limestones, sandstones, gravels, &c., of tertiary age, the lowest of which abound in nummulites. These

* A sketch of it was given by Mr. A. B. Wynne, of the Geological Survey, in the Records, Geological Survey India, Vol. I, p. 27. I also described it in the Memoirs, Geological Survey, India, Vol. VI, p. 163.

rocks are seen in the Tapti river below Bhodhán and in the Kim river as far west as the neighbourhood of Eláo, but throughout most of the intervening area they are covered up and concealed by alluvial deposits, and they are nowhere exposed, except in one or two small isolated hills, throughout the country south of the river Tapti. By far the greater portion of the country consists of an alluvial plain, the surface being covered with a thick coating of black soil. Along the sea-coast are low hillocks of blown sand.

The alluvial deposits furnish nearly all the water obtained in wells, and these deposits demand therefore rather fuller notice. They consist of clays, sandy clays, and sand, much interspersed in places with concretionary nodules of carbonate of lime. Towards the surface they pass into black soil. They may contain beds of gravel (rolled pebbles) in places, but such appears to be uncommon, so far as my information extends. The different layers of sand and clay are probably very irregular in thickness and extent, but sections are rare, and very few borings have been taken. In those made for the Tapti bridge at Surat, however, as I am informed by the Executive Engineer in charge, a bed of hard clay with calcareous nodules, in which it is proposed to lay the foundations of the piers, was found to be very much thinner on one side of the river than on the other, the difference, which was not precisely determined, amounting to several feet. It is evident that this bed has an irregular and possibly a lenticular section, and the same is probably the case with all the strata in the alluvial deposits, whilst the more sandy layers in which, owing to their greater permeability, water is generally found, may very often thin out and disappear in the distance of a few yards.

I quite concur in Mr. Medlicott's remarks on the different reasons which may be assigned for the occurrence of brackish water in wells. These are, briefly, the presence of salt in the strata when originally formed, salt springs, and infiltration from spots in which salt is being deposited at the surface of the ground. To these may be added percolation from the sea or from estuaries, which, however, is practically identical with the third form. In the case of Surat, I believe that the salt was originally deposited in the alluvial strata.

The plains of Guzerat have every appearance of being estuarine or marine deposits formed from the clay and sand brought down by the Tapti, Narbadda, and other rivers. The deposits forming in the salt marshes and flats submerged at high tides near the mouth of the Tapti, which I had an opportunity of examining during my recent visit, are covered by a deposit differing so little from one form of the black soil, that it is impossible to draw a line separating the two, the blackish argillaceous dried mud of the estuarine flats and marshes being similar, both in colour and texture, to the black soil of the fields a few inches above the level of the highest tides, and this soil again differs but slightly, either in colour or texture, from the ordinary 'cotton soil' of Guzerat. Such differences as exist are, I think, due to surface action; to the effect of rain and chemical changes, impregnation with organic matter,* and agricultural processes, and I see no reason for doubting that the whole of the surface formations in Surat may have been deposited from salt and brackish water in tidal estuaries and salt marshes, precisely similar to those which are now being reclaimed and converted into arable land in places on the sea-board of the district. The more sandy beds must have been deposited where some current, due either to tidal or stream action, existed; the fine argillaceous black soil has probably been formed in back-waters and marshes.†

Evidence of recent rise in the land has been found in several places on the western coast of India: instances are known at Bombay, in Katthiawad, and in Sind. There is every reason

* It is probable that great part of Guzerat has been covered by forest, and the soil thus impregnated with decayed organic matter. In this manner the best and richest cotton soil has very probably been formed.

† My brother, Mr. H. F. Blanford, several years ago pointed out a similar mode of origin of black cotton soil on the Madras coast, and I found a similar deposit forming under the same circumstances in Orissa.

for believing that Surat has shared in this movement, and that the plains of south-eastern Guzerat have been raised above the sea-level at no very distant geological date.

Such being the geological nature and origin of the alluvial formations which cover the country, it may be inferred that more or less salt must originally have been left in the soil, and that the occurrence of saline impurities at present will depend upon whether they have been removed by the percolation of rain water—whether, in short, they have been washed out—since the deposits were formed. If other conditions remain similar, it is reasonable to anticipate that the salt would be removed more completely from those strata which have been raised to a greater height above the sea and from the more permeable beds, because the first, owing to their elevation, and the second, in consequence of their porosity, have been traversed to a greater extent by water seeking a lower level. It is also probable that elevation has been gradual, and, if this has been the case, it is evident that the surface deposits at a greater height above the sea have been first raised, and have consequently been longer subjected to the action of sweet water. But these more elevated portions of the plains are farther from the sea, and consequently it appears probable that the amount of salt in the alluvial deposits diminishes gradually in passing from the lower ground on the sea board to the higher inland plains, the presence or absence of saline impurities also depending on the more or less porous nature of the beds; or, which is the same thing, the proportion of sand and gravel to clay in their composition. Moreover, as the beds thin out within short distances, and the intercalation of sandy and gravelly layers with the less pervious argillaceous strata is variable, much irregularity in the extent to which the water is impregnated with salt may be anticipated. If the brackishness of the water depended directly on the permeability of the beds, we should expect that the wells yielding the largest supply of water would be the least impregnated with salt, and although this does not appear to be universally the case, some instances in its favor have come to my knowledge in the town of Surat, but the amount of salt in each instance is much complicated by peculiarities in the course taken by the water in reaching the well from the surface, and the beds it passes through during the process of percolation.

So far as I am aware, this theory of the mode in which the alluvial deposits of Guzerat have been formed, and of the distribution of beds containing brackish water, agrees with observed facts. With the important exception to which I shall presently refer, and which I can, I think, explain, of certain perfectly sweet wells close to the sea, the water found near the coast is more or less salt, whilst that obtained in the higher portions of the plains away from the sea is sweeter; but there is much irregularity. I have dwelt at some length on the theory by which I account for the brackishness of the well water, because it is upon the correctness of this theory that the conclusions formed depend; because, by explaining my views fully, I afford an opportunity to the civil officers and engineers of the district to test and confirm or refute them, and because, in one instance at least, I have found theories put forward which appear to me erroneous.

There are two circumstances at least which appear at first sight to be opposed to the views above expressed. One of these is the occurrence, already alluded to, of sweet water in wells close to the coast. I was only able to investigate one instance; this is at some bungalows between the villages of Dumas and Bhimpúr, just south of the mouth of the Tapti river, and about ten miles from Surat. At and around Surat city, on the road between Surat and Dumas, and in the village of Dumas itself, every well which I tried, and so far as I could learn, every well existing, is more or less brackish, some being sufficiently pure for use, whilst others contain water much too salt for either drinking purposes or irrigation. But at the bungalows just mentioned, which are within less than half a mile of the sea, the water in the wells is perfectly sweet. Now, the bungalows stand on hills of blown sand; the village about a mile away is on black soil. The wells at the bungalows are very shallow, not more than 15 or 20 feet in depth; those at the village, which is, I think, on rather lower ground, are double that depth. It appears evident that the water in the bungalow wells is derived from the sand resting upon the comparatively impervious black soil, and that the water in the sand is sweet, because any salt originally contained in the porous sand has long since been washed out of it, as water can percolate it freely in descending to a lower level.

I am informed by Mr. Clarke, the Executive Engineer, that the case at Vaux's tomb, especially mentioned in Mr. Hope's letter, is precisely similar to Dumas, whilst at Bhugwa Dandee, where no good water could be found, there are no sand hills. If my explanation be correct, the sinking of deeper wells at the Dumas bungalows or at Vaux's tomb will probably result in brackish water being found in the beds underlying those which now supply the wells.

The other difficulty to which I have referred is the existence of numerous wells in various parts of the country, the water of which is said to have become gradually salter. This is rather opposed to the view above expressed, because it is probable that percolation removes the salt in any given stratum, and consequently wells should become sweeter by use if they undergo any change; that is, provided that the water always finds its way from the surface into the wells by the same route, and traverses the same beds in its course. But the removal of water from a well may occasionally produce an inflow from other strata than those from which the supply was originally derived, and thus salter water may be introduced. The question is a difficult one, and I think some further information on the subject of wells becoming salter is desirable. In the first place, I think the evidence of increasing saltness in wells should be rather carefully examined; of course no analyses of the water have been made, and, so far as I can learn, complaints about water becoming salt have been frequently made in order to obtain remissions of rent, as irrigated land is more highly taxed than land which is not irrigated. I should like to suggest the possibility that, in some cases at least, the change has not been in the water, but in the soil of the fields. As all the well water contains salts in solution, and as the water poured upon the land is evaporated, leaving the salts behind, a gradual concentration of the salt must take place in irrigated lands until it may, unless remedial measures be taken, become so saturated as to be unfit for cultivation, as in the case of the 'reh' lands of Upper India. In this case the blame would infallibly and justly be laid on the water used for irrigation, although no increase has really taken place in the saline impurities contained in the water.

I cannot say how far the wells in and around Surat represent those of the district generally, but if they do, I may add that the impurities of the water are not confined to common salt (sodium chloride). Some rough tests which I have applied with such means as were available showed the presence of lime, alumina, and of an alkaline earth, which I believe to be magnesia, in considerable quantities.

If the views above expressed are correct, it is evidently improbable that better water will be obtained by deep boring, unless the strata at a depth below the surface are much more permeable than the superficial deposits; on the contrary, the deeper beds will have had less chance of being purified from salt by percolation than those near the surface. Where the beds at a greater depth are very porous, they may contain sweet water, but this is by no means certain, and I can see no reason for anticipating that the lower strata will prove very different in character from those exposed at the surface of the ground. Should rock be found, it is impossible to form an opinion without actual trial as to what the character of the associated water may be. The rock may very possibly belong to the lower tertiary strata, and similar beds in Kachh and Sind often yield brackish water.

Before concluding I may briefly advert to the water-supply of the town of Surat, to which my attention has been particularly drawn. I went over the town with Mr. Pandurang

Balkrishna, the Secretary to the Municipality, to whom I am indebted for most of the details mentioned.

Surat is a large town, with a population exceeding one hundred thousand. As in most old cities, the surface has been greatly raised in places by the accumulation of ruins of buildings and rubbish of all kinds. The town stands on the bank of the Tapti, here a tidal river, the water of which is sweet in the rainy season, but brackish at other times, and especially so in the hot weather.

There are in Surat numerous wells, one to nearly every house. The water of only two or three of these is used for drinking purposes; nearly the whole of the inhabitants obtain their drinking water from the river, from cisterns in which rain water is collected, or from wells outside the town. The depth of the wells inside the town varies from about 30 to about 70 feet, and the height at which the water stands in the wells above the datum to which all levels within the municipal limits are referred (100 feet below a fixed mark in the castle) varies in different wells from 50 to nearly 70 feet. As a general rule, the wells inside Surat city contain very brackish water; those outside the city proper, but within the old walls, vary in quality, a few being just drinkable, whilst outside the walls there are some wells of so called sweet water. This last, however, though far purer than that obtained from the wells inside the city, is decidedly more brackish than good drinking water should be, and on testing it, it was found to contain lime, magnesia, and other impurities in considerable quantity besides common salt. The same remark applies to those wells inside the city which contain drinkable water.

The latter are only two in number: one in the castle and close to the river bank, the other at the house of a Maharaj named Mandir. The former very probably derives its supply from percolation from the river when in flood,* another well not 100 yards away, but farther from the river, yielding brackish water. The well in Maharaj Mandir's house is rather deeper than usual, the bottom of the well being 48 feet, and the surface level of the water 56 above datum, and the supply is so large that an attempt to pump the well dry by a 6-horse power steam-engine scarcely produced any sensible diminution of the water level. At the same time other wells nearly of the same depth contain brackish water.

Two other incidents connected with the Surat wells may be here mentioned. The first is that there is a well in the public park used for watering the gardens: it is 63 feet deep, and contains, when full, 35 feet of water, the surface of the water being about 65 feet above datum. The supply is considerable, but the water can be pumped dry by a 8-horse power engine in 3 hours, and requires 24 hours to refill. After pumping for a short time the water improves, but when the well is left to refill it becomes brackish again. Another well, not 50 yards distant, contains very brackish water. The supply is, I believe, less than in the other well, but I have no certain information.

Another circumstance worthy of note is referred to by Mr. Hope in his letter No. 2280 of 1871. A well was sunk at the Surat race-course about half a mile outside the city walls, at a spot in the middle of four existing wells, none of which are more than 150 yards apart. All these wells are comparatively sweet, certainly much better than any well inside the town of Surat, yet Mr. Hope's well proved brackish. In this case I think it is to be regretted that the well was not pumped for some time before being abandoned, since the salt may have been derived from the sides of the well and pumping might have caused an inflow from the stratum which supplies the other wells, but the saltness may have been due to the water finding its way into the well by a different channel to that pursued by the flood supplying the others.

* The statement in a report by Mr. Sowerby on the water-supply, &c., of Surat, dated 7th November 1868, that the level of the water in the Surat wells is above that of high spring tides in the Tapti, appears to be incorrect.

With reference to the impurity of the wells within the city walls, it is probable that water percolating through the accumulated debris of old mortar, ashes, burnt clay, &c., which have raised the surface of the ground inside the city from 10 to 20 feet, may dissolve a considerable quantity of various salts, and thus increase the saline ingredients of the well water.

So far as I can judge, however, none of the wells in or around Surat furnish water so pure as ought to be obtained for drinking purposes. I am told that no complete analyses of these waters have ever been made, and I should recommend that such be obtained of different waters, including the best and the worst, since the kind of salt present and the relative quantities may afford some clue to their origin.

The details just given concerning the Surat wells are certainly in favor of the conclusions already expressed as to the causes of irregular distribution of fresh water in the soils of Surat. These conclusions I will briefly recapitulate, pointing out their practical application—

1. There appears reason to believe that the greater portion, if not the whole, of the alluvial deposits near the coast of Guzerat were originally impregnated with salt in consequence of their having been formed in salt-water. Where they are now free from saline impurities, this is due to the removal of such impurities by the percolation of fresh water.

2. Such percolation of fresh water has been efficient in proportion to the elevation above the sea, and to the greater or less permeability of the beds; consequently, as a rule, those wells which are at the greatest height above the sea and those which yield the most water are the sweetest.

3. The distribution of permeable and impermeable beds is very irregular, most of the strata being lenticular in section and thinning out within short distances.

4. It ensues from the above, that there is no reasonable prospect of fresh water being obtained from deep borings, unless the strata beneath the bottoms of the existing wells are generally more pervious than those near the surface. This is possible, but there appears no sound reason for anticipating that it will prove to be the case, and it is probable that deep borings will give as irregular results as surface wells.

5. It is also improbable that fresh water will be found in wells sunk in the salt lands now being reclaimed. Should such be found, its occurrence will be, I think, accidental, and due to the existence of unusually pervious strata, and I think that these may very possibly prove local.

6. The presence of fresh water in some places on the coast, as near Dumas and at Vaux's tomb, appears due to the existence of sand-hills resting on impervious clay. The quantity of water will probably bear some proportion to the extent of the sand-hills. Although a considerable supply may be derived from such places for local purposes, I do not think it probable that the quantity is sufficient to supply large irrigation works, nor should I be surprised if in some similar localities the water proved more or less brackish, owing to the presence of salt in the sand, or contamination from the subsoil. Deep wells amongst the sand-hills would probably yield brackish water.

7. None of the wells about Surat town supply really good water, nor is there at present sufficient prospect of improvement to justify the sinking of deep wells, and, as an ample source of excellent water exists in the river Tapti a few miles higher up, and I am informed that it is proposed to introduce the same into the city, it appears scarcely worth while to incur expense in experiments which are very likely to fail.

Finally, I can only suggest that if further information be required, and to test the accuracy of the views here expressed, borings should be made to a depth not exceeding

150 to 200 feet. To attempt to raise water from a greater depth would probably involve greater expense than the value of the water for irrigation would cover. It would be well to make borings along lines, and at a fixed distance apart, in such parts of the district as it is particularly desired to explore. There appears no reason for selecting any locality in particular, for, as I have above shown, the probability appears to me that sweet water will not be found, at all events not as a general rule; at the same time, the matter is of such importance that the trifling cost of a few borings would be fully justified in order to obtain certain information, for, after all, the opinion given above is based upon very imperfect information.

When borings are made the water from every water-bearing stratum traversed should be separately tested, and, at all events, the quantity of salts in solution ascertained by evaporating to dryness, care being taken that some water is always pumped out before collecting specimens for analysis.

I would further recommend that complete quantitative analyses be made of a few of the Surat waters, especially of those in and near the town of Surat,* and I would also suggest that the water of some of the wells which are said to be gradually becoming salter be analysed, or, at all events, the quantity of salts in solution estimated (a very easy matter) from time to time.

As already pointed out, common salt is by no means the only impurity present in considerable quantities in the well water of Surat, and other salts may be equally deleterious both to human health and to vegetation, although their presence is not so easily detected by the taste of the water. It is useless, without more exact information as to the nature and quantity of these salts, to attempt to trace their origin; some have, in all probability, been derived, like the common salt, from the sea; others from the decomposition of the materials forming the alluvial strata.

11th January 1875.

SKETCH OF THE GEOLOGY OF SCINDIA'S TERRITORIES, *by* H. B. MEDLICOTT, A. M., F. G. S., *Deputy Superintendent, Geological Survey of India.*

Configuration.

Scindia's possessions are so scattered, that any connected physical description of them must include much adjoining ground. The extent and uniformity of the natural features further involve this comprehensiveness, so that the following notice of the geology of the region comprises much of Holkar's territory, all of Bhopal and of the British district of Ságar, all of Kotah, a great part of Búndi, besides some other petty States of Rájputána. All this ground belongs to the Vindhyan plateau, defined on the south-south-east by the Vindhyan range overlooking the Narbadá valley, on the north-east by a scarp overlooking Bandélkand, and on the north-west by cliffed ranges facing Rájputána. Although its limits are so well defined, the character of this area as a single plateau is not well marked. The entire drainage is from the southern edge, the crest of the Vindhyan range; and in their progress to the Jamná the rivers have formed deep and wide valleys, so that a very large area of the so-called plateau consists of pláins but little raised above the level of the country to the east and west: still the plateau form is everywhere maintained; the smallest elevations are little table-lands or terraces.

* It should be borne in mind that the greatest care is necessary in collecting samples of water for analyses; such samples should be taken by a responsible officer personally, never on any account by a native servant or subordinate, and both bottles and corks must be perfectly clean. Unless these precautions are taken, the analyses when made will be useless.

2. These features are directly connected with the rock-structure. The well known geographical name for the southern crest of elevation has been adopted for the great sedimentary formation which forms the basis of the whole plateau. Except along the edges of their area, the Vindhyan strata are horizontal; and this arrangement, combined with alternations of hard and soft rocks, induces the flat scarped form of elevation. In the south-west part of the plateau in Málwá, where the Vindhyans are so completely covered by eruptive rocks, the same form of elevation is constant, illustrating admirably the step-like arrangement for which the name of trap-rock was originally given to these ancient volcanic products.

Structure.

3. To proceed in regular order from the youngest to the oldest formations, brief notice must be taken of the superficial deposits. There is little or no ALLUVIUM proper in this country, actual land-formation now in progress from river deposits; unless we are to include under this head the almost ceaseless and everywhere present action of wind and rain in shifting and arranging the earth particles at the surface. The soil and subsoil covering is on the whole inseparable from the thick accumulations of clays, sands and gravels occurring over the plains and valleys; although the great depth of these and their forming steep banks high over the extreme flood level of the great rivers, clearly point to conditions of formation separated from the present by marked physical changes, involving a lowering of the water-level in this region. In confirmation of this observation, we find these deposits continuous with those of the great Gangetic plains, in which the remains of extinct varieties of large mammals have been found. The best known locality for these fossils is near Etáwá in the bed of the Jamuná, close to the north-east limit of Scindia's territory. It is very likely that similar remains might be found within the boundary in the Chambal and other large streams.

Superficial deposits.

4. The trap-rock of Málwá is the next in order of age to the valley-deposits, the break in time between them being enormous, embracing nearly the whole of the geological period known as TERTIARY. The formation is known as the Deccan trap, this rock in Málwá being in unbroken connection across the valleys of the Narbadá and the Tapti, with that forming the great plateau of the Deccan. The upper limit of age for the formation is given by the occurrence of NUMMULITIC strata resting upon a denuded surface of the trap along the western base of the highlands near Broach. The lower limit of age is FIXED by the occurrence of CRETACEOUS rocks, supposed to be middle cretaceous, beneath the trap at Bágh in one of Scindia's outlying districts in the Narbadá valley, and also on the plateau near Jábná. Within the formation itself there occur local intertrappean beds, patches of sedimentary rock, earthy and calcareous, frequently containing fresh water fossils. The independent evidence of these has been thought to connect the trap more with the tertiary than with the secondary epoch. The trap belongs to the basaltic family, but presenting many varieties from greenish black, dense, columnar basalt, to porous amygdaloids with agates and zeolites, and to earthy ash-like beds. Within the district under notice no dykes have been observed, showing that it is beyond the immediate region of eruption. The present northern limit of the trap is an irregular line between Nímach and Badráwás. It is purely a boundary of denudation, and it would be impossible to say how much farther to the north the eruptive rock may originally have extended. The laterite band which is so generally associated with the trap may give a clue to this question. There are many kinds of laterite of different ages and modes of origin. The variety here spoken of is a purely earthy ferruginous rock free from sandy detritus, its upper part, to a depth of ten to twenty feet, being intensely hardened by the segregation of the iron. It appears as a capping to the highest plateau of the trap, thus having the apparent relation of an original

The Deccan trap.

top-rock to the formation. If it could be legitimately taken as thus related to the trap, we could assert that this rock had never covered the whole surface in the neighbourhood of Gwalior, for laterite of this type caps the high hill eight miles south-west of the city resting on the Morar rocks, without any intervening trap. A full half of Scindia's territory is on the trap formation. The laterite is finely developed about Guná and Augar.

Cretaceous rocks.

5. Mention has already been made of the small patches of rocks of middle(?) cretaceous age in the Narbadá valley about Bágh and on the plateau near Jábná, both places in or near the Chujerrá district. The most important rock of the group is a limestone holding marine fossils, and underlaid by sandstone, or resting upon the basal crystalline rocks. The infratrappean or Lámèta limestone and sandstone of the districts to the east (Ságar and Jábalpúr) are thought to represent the Bágh beds; but as yet only vertebrate remains, some of great size, but unidentified, have been found in them. This information is given because the ground under description has been only partially examined, so that representations of either group might be looked for anywhere at the base of the trap.

The Vindhyan formation.

6. There is an immense geological gap between the cretaceous beds and the Vindhyans, which are the next oldest rocks in this region. In other parts of India this gap is partly filled up by the great rock series of which the Indian coal measures form a part. Geologically, the Vindhyan plateau is a basin. The lower strata of the formation only appear along the boundary of the field, with a greater or less slope towards the centre in which direction younger beds succeed. The whole series has been divided into the following groups :—

Bhanrér ...	Upper Bhanrér ...	Upper Bhanrér sandstone.
	Lower Bhanrér ...	Sirbu shales. Lower Bhanrér sandstone. Bhanrér limestone. Ganúrgarh shales.
Riwa ...	Upper Riwa ...	Upper Riwa sandstone.
	Lower Riwa ...	Jhiri shales. Lower Riwa sandstone. Panná shales.
Kaimúr ...	Upper Kaimúr ...	Upper Kaimúr sandstone. Kaimúr conglomerate.
	Lower Kaimúr ...	Bijigarh shales. Lower Kaimúr sandstone.

7. Most of these groups are represented in Scindia's territories north of Badrawás. The Kaimúr conglomerate and its overlying sandstone are admirably exposed about Gwalior. In the fort-hill and the adjoining scarp they rest upon one of the trappean bands of the Morar group. In the hills to the south they rest upon other beds of the same series. Passing north-westward the Panná shales are found in the low ground along the base of the next scarp, which is formed of the Lower Riwa sandstone. Beyond this again there is a third scarp formed of the Upper Riwa sandstone with the Jhíri shales at its base. Still further to the west we find the Ganúrgarh shales and Bhanrér limestone well exposed in the valley of the Chambul, the Lower Bhanrér sandstone forming the Dholpur ridge on the left bank of the river. In the Nimach district the same series is well developed ascending from the west. The Bhanrér limestone is well exposed between Nimach and Chittorgarh. The age of the Vindhyan series is still quite undetermined. All that can be said is that it is greatly more ancient than the base of the coal measure series. Although so undisturbed and unaltered, and apparently so adapted by their varied composition and the conditions of deposition (as indicated by the variety and prevalence of water-marking), for the existence

and preservation of organic forms, the Vindhyan strata have as yet yielded no fossils. Fine building material is procurable from all the sandstones of this formation. Its most famous product is the diamond, the occurrence of which seems to be limited to the shales near Panna.

The Gwalior Series.

8. The most varied and instructive geological sections in all Scindia's territories are in the immediate neighbourhood of Gwalior itself, where the Vindhyans are in contact with the rocks next to them in age occurring within our area. It would be impossible to find a better example of unconformity of strata. The lower rocks have not undergone any great disturbance, little more than the Vindhyans themselves, being still in approximate horizontality; but scarped valleys of erosion are found in them filled with thick masses of (Kymore) Kaimur conglomerate and sandstone, the former being principally made up of angular debris of the subjacent strata. These rocks have been called the Gwalior series. The boundary of the Vindhyans passes close to the west of Gwalior, with a general north-easterly direction; and the Gwalior series occupies a comparatively small area between the Vindhyan scarp and the river Sind, forming low east and west ranges of hills. The southern range is fifty miles long, and unbroken, being formed of a strong quartzite-sandstone, the bottom rock of the series, and known as the Par sandstone. This group has the same relation to the gneissic area of Bandelkand as have the Kaimur strata. Both present scarps towards the low ground of crystalline rocks, out of which the under-cliff is formed; the irregular surface of junction between the Par sandstone and the gneiss slopes northwards, disappearing up the gorges at a few score yards from the line of the scarp, and so vanishing altogether towards the end of the range, where the Sind forms small cataracts over the Par sandstone at Seonrha. The same northerly slope prevails throughout the series, bringing in higher strata in that direction. The Par sandstone is thus succeeded by a great thickness of very different strata, known as the Morar group. These have some decided characters common throughout—finely laminated shales and flags, often highly ferruginous and very commonly banded with layers and nodules of jasper and hornstone. Two very marked breaks occur in the uniformity of this group, owing to the intercalation of great sheets of eruptive rock, apparently of contemporaneous origin; and this has resulted in a corresponding break in the form of the ground. The lower part of the Morar group is found along the north side of the main range of hills. In the irregular valley between this and the broken middle range, the rocks are concealed by alluvium; but at the head of the valley, near the villages of Chaora and Buda, two strong flows of trap are finely exposed. There is just enough evidence to show that the valley is excavated along the outcrop of this trap, it is seen in the stream close to Barori village, and again at the east end two miles west of Behat. This is a very ancient valley; for in the middle of it, near Bastori, there stands a small plateau of Vindhyan sandstone. The plain of Morar, separating the middle range from the very broken chain of flat hills to the north extending eastward from the old Residency, is undoubtedly laid upon the denuded outcrop of the great sheet of trap exposed continuously all round the base of the fort-hill and of the adjoining scarp where it is overlaid by Kaimur sandstone, and which is equally well seen along the south face of the northern hills to be overlaid by the jaspideous shales of the Morar group. There are several scattered hillocks of this same trap over the plain to the east of Morar. Besides the trap, the Morar group contains local bands of cherty limestone. One of these occurs in the hills about the old Residency; another is traceable in many points in the middle range of hills. A very rich earthy iron ore has been extensively extracted from near the base of the Morar group in the southern hills. In the Sind, at the eastern end of the southern range, at a mile and a half above the village of Nardha, there is a vein in the Par sandstone said to contain lead ore (galena).

There is but one other formation to be noticed. Scindiah's territories include a small portion of the crystalline rock area of Bandelkhand. The relation of this rock to the Gwalior and the Vindhyan series has been noticed. The GNEISS is often highly granitoid, but no intrusive granite has been detected. Bands of schists, sometimes hornblendic, occur occasionally, having an east-west strike. The most remarkable feature of this area is the number of great reefs of vein-quartz, forming narrow regular precipitous ridges, with a prevailing north-easterly direction. No trace of gold has ever been noticed about them. The gneiss is also much traversed by trap-dykes; in these a north-westerly direction prevails. They have been found in some cases to traverse the quartz-reefs, and are, therefore, younger than these. But both reefs and dykes are older than any of the sedimentary formations in contact with this gneiss. At the western edge of the trap and Vindhyan plateau, there may be patches of crystalline rocks within the Amjhera and Jawad Nimuch districts of Scindia's territories.

Gneiss.

April 1873.

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Specimen (cast) of *Eophrynus Prestvicii*, H. Woodward, *Curculioides id.* Buckland, from the coal measures, Dudley, England. Presented by H. WOODWARD, ESQ.

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14*th April*, 1875.

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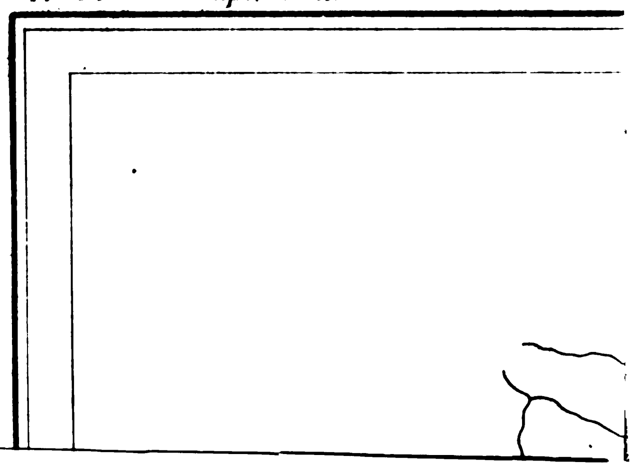
April 14th, 1875.

Medlicott *Shapur Coal-Field.*



RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1875. [August.

THE SHAPUR COAL-FIELD, WITH NOTICE OF COAL-EXPLORATIONS IN THE NARBADA REGION, *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

I.—NOTICE OF RECENT EXPLORATION.

The question of the coal-supply in the Narbada valley has now been for long before the public, and is still unsettled. Mohpani is still the only locality where workable coal is known to occur; and the extension of the coal here is as yet unproved. Since December 1872, explorations have been carried on in several places under the orders of Government, but so far without result. The region to which these remarks apply is the northern portion of the great Satpura basin of the coal-bearing rocks, within comparatively easy reach of the Great Indian Peninsula Railway. It has long been known that there are numerous outcrops of coal along the south margin of the field; but the distance would greatly add to the cost of exploitation. To that ground, however, we must have recourse if our endeavours to find coal in a more favorable position prove unavailing. With this in view, a survey was made during the past season of the western and more accessible portion of the southern region, known as the Betul or the Shápur coal-field.

Before proceeding to describe this field, with the aid of the annexed outline-map, I would give a sketch of the explorations up to date. It cannot be said that any of the experiments has proved a failure, because no one of them has attained the full limit contemplated for the search. No success, however, can be reported as yet; and in one case some disappointment has to be recorded. Having had the entire responsibility of choosing the positions for the trial borings, I am, of course, anxious, for the satisfaction of Government, that a right understanding should exist of the grounds upon which I decided: it is so easy after the fact to condemn a project as hopeless; and there are always people ready to take the credit of wisdom on such occasions. The data available were never more than could warrant a fair possibility of success, as was duly explained at the first.

The regular mode of proceeding in this investigation would have been to explore the measures at Mohpani—to see how the coal-seams behave on this side of the basin to the deep of their only outcrop. Information might thus have been gained giving some grounds for a definite opinion as to the position and depth of the coal elsewhere along this region. This course was not available, the ground being in the possession of the Narbada Coal Company. The interests of this colliery depend largely upon the conditions in question; but as yet little or no light has been thrown upon them—no coal has up to date (June 1875) been found beyond the limits of the faults against which the original working stopped.

Thus the attempt that had to be made was not that of exploring a known coal-field, but to look for the coal-measures in a great series of formations where it was known they might occur. The explorations proposed were of two kinds: one depending upon the unknown limits of the rock-basin itself; the other upon the unknown lie of the coal-measures within the known area of the basin.

Exploration in the open valley of the Narbada.

So far as appears on a geological map, the northern limit of the rocks with which the coal-measures are associated would approximately correspond with the slightly irregular line indicating the southern edge of the alluvial plains. Along certain portions of that line narrow outcrops are seen of metamorphic rocks; and where these appear, the continuity of the younger rock-basin is, of course, cut off. There are, however, wide gaps where no older rocks appear, where the valley-deposits rest against the coal-bearing formations. It was for a time supposed that the junction of the sandstones with the metamorphic rocks occurred along a great fault, by which the newer rocks were thrown up to the north and removed. Were this so, we should be entitled to draw a fixed fault-boundary to the possible coal-bearing ground across those gaps between the existing outcrops of the metamorphics. From a careful study of the rock-junction where seen, I came to the conclusion that no great line of dislocation could be proved: the actual contact of the two rock-series was almost everywhere found to be the original one. I even got remnants of the younger strata on the north flanks at the same level as on the south of the narrow ridges of metamorphics. It thus becomes apparent that the gaps in the present boundary, where the alluvium laps against the sandstones, may only represent bays in the original edge of the basin of deposition of the coal-bearing formations. A full discussion of this question is given in my last report upon this ground; it can only be by a revision of that discussion that the exploration for coal in these blank areas can be shown to be unwarranted.

The Mohpani colliery, on the Sitariva, lies in the centre of one of the longest of these blank portions of the boundary. Almost the last rock seen in the river is the coal, in full strength, underlying steeply towards the plain. An attempt was made to work the coal here, but it was found to be too much broken and crushed to be worth extracting. It was to the north of this position that I recommended borings to be made in the alluvium, close to the branch railway, where coal, if found, would be very favorably situated. There were of course, other doubtful conditions besides the principal one already indicated: the bay may have been there, and yet the coal deposits have found small place in it: or whatever had found place there may have been to a great extent cleared out by the excavation of the hollow in which the alluvium now lies. The probability, such as it is, of coal existing under any considerable portion of the immense area covered by the alluvium seemed sufficient to warrant some outlay upon the search. Boring was attempted at Gadarwara station and at Sukakheri, at ten and four miles from the boundary. The former trial broke down at a depth of 251 feet. The hole at Sukakheri was carried to a depth of 491 feet, yet without piercing through the valley deposits. Both these trials were started when boring implements were deficient; and although I gave 500 feet as a possible thickness for the alluvium, I certainly expected rock to be struck at a less depth; thus the borings were not begun on a sufficient scale for such a depth where piping had to be used throughout.

There was nothing whatever for a positive opinion that the superficial deposits would be so deep. The Narbada flows on the north side of this broad plain; and within comparatively short distances throughout its course it touches rock, leaving the valley through a narrow rocky gorge 100 miles to west of, and at a level about 200 feet below, the surface at Gadarwara. This gorge is the lowest lip of the rock-basin of the actual valley; for the watershed on all sides is on rock. We have thus at least learned from this Sukakheri boring an interesting geological fact regarding the depth of the pleistocene valley.

A complete prognosis of the case would involve also the consideration of yet another, great valley of excavation in the same area, but regarding which our information is still more obscure. The valley occupied by the pleistocene deposits was to a great extent cut out of the great trappean formation, which had filled up a previous valley to the full level of the highlands on the north and south. Both to east and west of the Sitariva bedded trap is, at several places, the last rock seen passing under the alluvium at the south side of the valley. Locally, too, it is underlaid by thin fresh-water deposits supposed to be of upper cretaceous age. That pre-tertiary valley to some extent corresponded with the existing feature, being principally bounded by the Vindhyans on the north and the Mahadeva hills on the south; but it is improbable that its line of discharge was the same as that of the present Narbada. Regarding its possible relative depth there is no certain clue; but there is nothing to suggest its having been great in the Sitariva region, older rocks being seen at many places to east and west. There were some symptoms that the boring at Sukakheri was approaching a bottom of this kind; the last samples of clay brought up were much charged with granules of iron oxide as if from a lateritic layer which is frequently found coating the trap.

The discovery of the great depth of the surface-deposits at Sukakheri is, no doubt, a check to our hopes of finding the coal-measures within easy reach in this neighbourhood, and may therefore divert the press of exploration to other points; but, of course, the question of the existence or not of the coal-bearing rocks in this position is quite untouched. The argument on this point stands just as at the beginning; and unless before long coal is found under more favorable conditions elsewhere in this Satpura region, I would certainly recommend the prosecution of the search here. The actual position might be shifted to Gagarola, a village a mile and a half south of Sukakheri. I went clear to the north in first choosing a site, to avoid coarse gravels in the covering deposits near the hills, and to get well beyond a known region of disturbance in the coal rocks, should they be found.

Exploration in the hill-region.

The other class of exploration is directed to find the coal-measures within the known rock basin. On the south side of the basin the outcrop of the measures is nearly continuous from east to west. The hope of finding them on the north side is based upon the single outcrop on the Sitariva, and upon the fact that very generally they are closely associated with the Talchirs, and these are found at several places along the north boundary. The reasonable conjecture is, that the coal may be more or less continuous throughout the whole basin, beneath the covering Mahadeva rocks. For a short distance west of the Sitariva the Talchir rocks, and even the coal-measures, are traceable; their manner of disappearance in this direction is not seen; the nearest section is very obscure and greatly affected by trap dikes.

In the first complete section exposed, in the Dudhi and east of it, younger rocks occupy the whole ground up to the boundary with the metamorphics. When next the lower members of the series come to the surface along the boundary, the Talchir group alone is found, overlaid by younger rocks than the coal-measures, the latter being completely cut out, or 'overlapped.'

In explorations of this nature it is commonly the case that some approximation can be made towards computing the depth at which the object should be attained. The simple general rule is — from the proposed point of experiment to follow the descending section directly across the strata to the outcrop of the bed sought for; and then, from the surface distance and the mean dip of the rocks, to calculate the depth from the surface at the required point. Were this rule to hold good in the present case, the coal would be hopelessly out of reach where we are now seeking for it. Throughout this whole central area of the rock basin, the strata have a very constant northerly slope to within a short distance of the north boundary, where, according to the above rule, the depth to the measures would be enormous. The rule, however, works upon the assumption that the beds continue to the deep as they appear at the surface; and it is quite certain that this is not the case with the rocks we have to deal with here. They are for the most part massive, irregular sandstones; and it is demonstrated that not only individual beds, but whole groups of beds, die out to the deep and are overlapped before reaching the north side of the basin. There is no *law* known, or in the nature of the case possible, for such a mode of extinction and succession of stratified deposits. Their distribution depends upon the local physical conditions at the time of their formation, the only evidence for which conditions is to be found in the deposits themselves. Thus, there can be no reason assigned why the coal-measures themselves should not also die out to the north, they being composed of thick sandstones not unlike those above them. The hope that such is not the case rests upon the features along the north boundary, as already noticed.

The facts bearing upon this class of explorations have also been given and discussed in some detail in my last report on this ground; but from the foregoing brief remarks it can be seen that these trials, though under such very different conditions, are of a scarcely less precarious nature than are those in the open valley. It may also here be understood that any offhand opinion on the point can be of no value, unless in so far as it may be based upon reasons such as those indicated.

In selecting sites for these borings, I gave, as for the others, a wide berth to the known difficulties close to the general boundary of the field; such as, firstly, the greater disturbance of the strata, often with trappean intrusion; secondly, the coarsely conglomeritic character of the Mahadevas in this zone, which has proved so obstructive to borings at Mohpani; and thirdly, to give a better chance of getting below the known overlap. To these considerations the surface features added other inducements. On the east and west of the basin, two wide open areas are presented in the valleys of the Dudhi and the Tawa, separated from the plains of the Narbada valley by a narrow belt of low hills. If the Satpura coal-basin ever fulfils our reasonable hopes as regards coal, it is in these areas that the industry would be established, and here that it should be started. Whether or no coal should be found somewhat nearer the surface towards the edge of the basin, it would be a duty to ascertain if it lay within reach of these central areas where mining must be located if it is ever to expand; but to fulfil this purpose the borings here should be carried to the full depth at which there would be any prospect of mining being profitably carried out. Upon this point my knowledge and experience scarcely entitle me to an opinion: I should say conjecturally, that supposing coal to be present, it would pay better in the long run to work it at 150 fathoms in the centre of the field than at 50 fathoms near the margin.

Dudhi Valley.

In commencing operations, preference was given to the Dudhi area, for the reason that the strongest natural outcrops of the coal both to north and south were on the east side of the basin. The borings at Khapa and Manegaon were commenced in the middle of February 1874. Both start in the Denwa horizon of the Mahadeva series. At the close of the season, on the 1st June, they had reached the depths of 260 and 242 feet. After the stoppage of the Sukakheri boring, work was resumed at Khapa and Manegaon on the 15th January 1875. On the 23rd of April work was suspended at the Manegaon boring (at 419 feet), the depth now attained necessitating the constant attention of the European foreman at one boring. At the close of the season (15th May) the hole at Khapa was down to 472 feet. The sections of these borings give as yet no hint as to the prospect of finding coal: the rocks are throughout the same as at the surface, purple and greenish clays, alternating with sandstones, either white or tinted by admixture of the coloured clays. In the Khapa hole the proportion of clays to sandstones is 193 to 279, at Manegaon it is 219 to 200. There is nothing discouraging so far. I have shown elsewhere that the Pachmari sandstone (lower Mahadeva) passes into clay to the deep; and the change to the coal-measures would probably be abrupt.

Tawa Valley.

On the representation by the Railway Department of the importance of a supply of coal as far as to the west as possible, the trials in the Tawa valley were commenced on the 25th December 1874 at Kesla, and on the 1st January 1875 at the Suktawa, under the management of Mr. A. Gardiner, M. E. The latter is entirely in strata of the Damuda formation, on the horizon of the Bijori beds as described in this region, and nine miles south of the Shapur coal-field. The Kesla boring starts in the lower beds of the Mahadevas, somewhere in the Pachmari horizon, so far as can at present be determined, four miles due north of the Suktawa boring; yet, if the structure upon which all these trials depend is favorable, if the Barakar coal-measures rise again towards the north edge of the basin, they may be nearer the surface at Kesla, which is only three miles from boundary of the metamorphics. When closed for the season (30th April) the Kesla hole had reached to 302′ 6″, that at the Suktawa to 241′. Clay greatly preponderates in the Kesla boring, a hard sandy rock variegated brown and red. The Suktawa rock also maintains the same characters as at the surface, alternations of strong sandstone with slightly carbonaceous shales. I do not find in them any grounds for a change of opinion regarding the original project; the depths as yet attained are no greater than might occur at a short distance from the outcrop.

Other trials recommended.

There is, however, already the surety from these borings that mining in this central region will have to be deeper than has yet been attempted in India. For this reason, and to provide against the by no means improbable event of failure to reach the coal-measures at all in this position, it is certainly advisable to commence trials in other ground. Two projects are open to us: to try for the measures close to the north boundary of the basin, in a position analogous to that of the outcrop at Mohpani; and, to commence the exploration of the Shapur coal-field. With this view I have selected four sites for trial borings along the north boundary: one on the road into the Dudhi valley, about seven miles west of Mohpani; one on each of the roads to Pachmari, close to patches of Talchir rocks; and one at Lokartalai. For the southern region I have selected a site near the village of Sonada. One or more of these trials can be carried on at the same time and under the same management as one of the deeper borings in each of the river valleys, say at Khapa and the Suktawa.

II.—The western extension of the Satpura basin.

The occasional mention of the probable extension of the coal-bearing series beneath the trap to the west of the known Satpura basin, and the fresh demand for coal for the new State Railway starting northwards from Khandwa, led to the request for an examination of the line of ground most likely to throw light on the possibility of finding coal in that direction. At the end of the season I made a tour to the west of Lokartalai along the direction of the north boundary of the basin. There cannot be said to be any immediate practical result, but observations have been made confirming and greatly extending the conjecture upon which the hope was based: direct evidence has been found of the underground continuation of this important series of rocks for some distance beyond the limits hitherto known; and an identification of Mahadeva rocks has been made far to the west on the Narbada near Barwai, which opens the question whether some of the so-called cretaceous sandstones along the valley of this river to near the coast may not belong to the same much older series, and thus be indicators of western coal-fields corresponding with those of the Damuda valley on the east.

No observation has hitherto been made (or at least published) of any appearance to the west of Lokartalai of rocks closely connected with the coal-bearing series. At page 43 of my last report (1872) on the Satpura basin (Mem. Geol. Sur., Vol. X) a brief notice is given of the western part of the northern boundary of the basin. The following remarks are in continuation of those there given. It was said that east of Sali the metamorphics are in force along the boundary. This was hazarded on the strength of a small outcrop at Sali, and of their forming the principal part of the range twelve miles to the east on the high road north of Kesla. I find, however, that intermediately there is an important section in which the Mahadevas are continuous to the plains. It is south of Zumáni in the Narbada valley, and north of Lálpáni in the Táwa valley. Along the base of the hills north-west of Kesla and Táko the Bágra limestone is in force, with a dip of 30° to north-north-west. The overlying sandstone and conglomerate with a low dip in the same direction form the scarp above. From the large and numerous blocks of trap at the foot of the waterfall there is probably an outlying cap of this rock on the hill. The crest of the pass north of Lálpáni is on the southern ridge of the range, on the run of the high dip, 30° to north-north-westerly, in conglomeritic sandstone overlying limestone. There is probably some slip or sudden twist along the north of this ridge, for on the sloping high ground in that direction the strong limestone is again in force, with a low north-north-westerly dip. On the rise to the outer crest of the pass the overlying sandstone and conglomerates come in again. These breccia-conglomerates are splendidly exposed in the steep gorge to east of the road. In a spur near the mouth of this gorge there is a small Mahadeo rock-temple in the conglomeritic sandstone, having a dip of 3° to north-north-west. A little below this the dip rises rapidly to 40°, in hardened sandstone distinctly overlying the conglomerates; there is then a band of crushed rock and a trap dike, but within about eighty yards apparently the same sandstones are again 30° to north-north-west, rapidly falling to 5°. The beds that come in here are peculiar: a whitish sandstone (which has been a good deal quarried), with partings of white shale and a layer of pyritous coaly shale. The character of these beds and their stratigraphical position at the top of a long ascending section of the Bágra group make it highly probable that they belong to the Jabalpur horizon, the nearest known position of which is capping Chátar hill sixty miles to eastward. When last seen in the stream under Jalpa the beds are quite flat, and end abruptly, with some crushing, trap being the next rock seen. This is, perhaps, the most important section we have of the north boundary, as it marks so clearly the upheaval of the Satpura area, or the depression of the Narbada valley, along it. It illustrates and explains some of the sections to the east, especially that on the Anjan (op. cit., p. 37).

The Zumáni section.

About six miles east of Lokartalai there is a fine section of the boundary under the scarp of Budimai ridge. South of Batki the Bágra limestone appears in force in the low ground at the base of the scarp, dipping at 30° to north-north-west, under the trap of the valley. Along the strike to the south-west of those outcrops the limestone disappears, but there is a much fuller section of this fringing zone of rocks. They form quite a flanking range outside the scarp, separated from it by a chain of small longitudinal valleys excavated along the broken uniclinal flexure,

Budimai section.

between the nearly horizontal beds of the scarp, and the same beds tilting down under the plains. Before these beds disappear the dip flattens very much, or even slightly turns up to the north, while near the axis of the flexure it is nearly vertical. I did not here detect any characteristic Jabalpur rock, but unless faulting interferes with the sequence they ought to be represented. The fine Dandiwara sandstone, so much prized on the Great Indian Peninsula Railway, comes from the top beds of these inclined strata. Structurally this section corresponds with that of Zumáni, only the flexure is more marked. It is important to remark that in both cases the sandstones reach well to the front of the run of the nearest metamorphic rock. The strike of the latter into the anticlinal axis rather suggests that they acted as a fulcrum upon which the overlying strata were bent and broken.

The western inliers.

No special disturbance was noticed in the trap on the Moran. In passing to the west-south-west on the strike of the little rib of metamorphic limestone south of Lokartalai, at about a mile distance, there is a low ridge. A clear section of it is seen in the stream, showing it to be formed of trap, with a central band of gray and reddish clay, all having a dip of 60° to south-south-east. In the next stream there is a still better section of this continuous little ridge, just under Sálei village. The clay band here is calcareous, and is locally full of *Physa Prinsepii*, the common fossil of the intertrappean formation. The dip is the same as before. The ridge passes just to south of the village, and immediately north of it there is a strong outcrop of hard conglomeritic sandstone, about 30 yards wide, the dip being 60° to 70° to south-south-east. The trap occurs again immediately north of it. This rib lasts for about a mile, the intertrappean band being traceable much further. In the Ganjál at Uskali, and exactly on the same strike, there is a stronger outcrop of the same sandstone. It has been extensively quarried in the little hill east of the village. The dip here is 45° to south south-east, and in front of it the trap is well seen, although the beds are massive, to have the same dip, gradually lowering to 5° at half a mile up stream. The intertrappean band is absent in this section. Immediately below the sandstone there is a small obscure section of trap. Two miles further, on the same exact strike, at Kupási and Jinwáni, the rib of sandstone appears again, still at 60° to south-south-east, and just under it at Kupási there is a small crop of metamorphic limestone. This is the last appearance of the sandstone, at eleven miles from Lokartalai. The structural feature, however, is well marked for a much greater distance, and exactly on the same strike: south of Padarmati there is an outcrop of intertrappeans still at 50° to south-south-east; in the streams at Káthmákhera and Singanpur, and better still in the Máchak above Magardha, the zone of high dip in the trap is well seen. Beyond this it seems to die out, being scarcely noticeable in the Siáni below Makrai. Magardha is twenty-five miles from Lokartalai.

Interpretation of them.

The feature just described is a very remarkable one. The sandstone of these inliers would seem to belong to the Bágra rocks; it is quite like the rock found near the metamorphics all along the boundary. It is the structural feature that exhibits such a change. Even this might have been anticipated in kind: the steady south-westerly dip of the sandstones on the Moran indicates a depression of the formations in that direction; but it was not there detected that the trap participated in that disturbance. This fact comes out very forcibly from these western sections; and they give one, too, an idea of the magnitude of the event. For a thickness of quite 1,000 feet the trap affects the same steep dip as the sandstones, which must, one would think, carry the latter to at least that depth in the ground to the south. This, of course, would put the chance of coal indefinitely out of reach in this immediate region; the horizontal extent of the feature being quite in proportion to the vertical magnitude. The geological reading of it is very puzzling, especially when it has to be taken from such scattered observations as can be made during a single march across the ground. I can only state the puzzle as it stands. The extraordinary straightness of the feature compels one to consider it as possibly connected with faulting. In this connection especially these western outcrops must be taken as solidary with the rest of the boundary to the east; for the disappearance of the sandstones on the Budimai and Zumáni sections is exactly on the same line. The great contrast, however, in the features of the cross-sections to east and west makes it especially difficult to connect both with one and the same master-dislocation.

Whether faulted.

Apart from the fact of remarkable continuity and straightness, the *primâ facie* suggestion of faulting is the same in the east as in the west of the line. The abrupt termination, with especial crushing, of the flat sandstones at the north end of the Zumáni section, with trap at a lower level close-by in front, is strongly suggestive of faulting with northern downthrow; the only other explanation being the pre-trappean origin of the edge of sandstone. Similar close vertical juxtaposition of formations occurs to the west: trap is found close to the north of the sandstone outcrops, and at a lower level, at Sálei and Uskali, suggesting the same northern downthrow, or else pretrappean exposure. The rock itself of the western outcrop does not suggest any difference of throw east and west. Nor is there any excuse for placing the fault (if there is one) between the sandstone and the metamorphic limestone at Kupási: the sandstone seems to be of the same horizon as that occurring at the same level east of the Moran,—a breccia conglomerate, such as is found in natural contact with the metamorphics all along the boundary; and at the Moran this ridge of supporting rock strikes into the axis of the Budimai flexure, well to the south of the supposed fault-line. Thus from this more direct portion of the evidence, one must, I think, conclude that if there is a fault it is post-trappean, and has a southern upthrow throughout. The collateral evidence, with reference to faulting, presents, on the contrary, a great difference between the eastern and the western areas. The proof of a great post-trappean southern depression by flexure at the edge of the stratigraphical basin to the west of the Moran is now beyond question. This, though perhaps not incompatible with a southern upthrow by faulting along the north boundary of the same area, certainly does not seem to agree with that supposition. The evidence of elevation, by flexure along the same line of disturbance, of the area to the east of the Moran seems equally clear, and this would remove the necessity for upthrow by faulting along the northern boundary, though not incompatible with the co-operation of such a feature. The certainty of the post-trappean age of the western depression might afford presumption that the elevation to the east was of the same age, opposite effects in adjoining areas being rather the rule than otherwise in crust movements; but I shall presently in this paper call attention to the evidence of extensive disturbance and denudation of the Mahadeva and underlying series prior to the outflow of the trap. The fact, as I said, is a very important one; and if it is established at one point on a geological horizon, it must be taken some account of throughout.

III.—Possible coal-fields on the Lower Narbada.

The Barwai area.

Finding myself at Khandwa, after a vain attempt to discover any further sign of the infra-trappean formations along the Satpuras, I devoted a few days to visiting Barwai, where so many different rock-series are represented within a small area. A combination of favorable circumstances, due to the works of the Holkar State Railway now in active progress, put it in my way to add another to the list of geological attractions of this ground.

The Mahadeva horizon.

When the general description of the western Narbada region was published in 1869 (Memoirs, Geological Survey, Vol. VI, pt. 3), the original conception of the Mahadeva formation—that it was quite unconformable to, and independent of, the coal-bearing rocks of the Damuda series, and superior even to the

Rajmahals—had not been rectified. Mr. Blanford accordingly, in correlating the groups of the lower with those of the upper Narbada valley (which he had not seen), affiliated the Lameta, and with it the Mahadeva beds of the latter, to the cretaceous horizon of the former area. This view has been so far upheld as regards the Lameta group; but in November 1872 (Records, Geological Survey, Vol. V, p. 115), the correction was pointed out as regards the Mahadevas. In making so important a change it might have been thought better to adopt a new name, but if that were done the correction would not have been so apparent—the old name would have held on in its false connection. Besides, the correction was made in the typical area: the Pachmari (Mahadeva) sandstone is now known to hold a middle horizon in a continuously superposed series, of which the Jabalpur (Rajmahal) group is the uppermost, and the Talchirs the lowest member. The original Mahadeva ground contains four well marked groups (Jabalpur, Bágra, Denwa, Pachmari) forming the present Mahadeva series.

True Mahadevas at Barwai.

The correction just quoted led, of course, to the view that there were no Mahadevas in the lower Narbada area; that all the infra-trappean strata there either belonged to, or were closely connected with, the much younger cretaceous group of Bágh. The observation I have now to bring to notice is that there are true Mahadevas at Barwai, unconformable to the cretaceous beds of that place. The proof of this discovery is due to Mr. Moore, one of the engineers at the railway viaduct on the Narbada. Mr. Moore has charge of the great quarries opened at Gatta, on the upland east of Barwai, on the banks of the Choral, and to which a temporary railway is laid from the viaduct. In the bottom of a small valley, about a quarter of a mile north of his bungalow, Mr. Moore discovered a number of fossil oyster shells in a shallow water-course. The ground being quite flat there was no section; so at my request Mr. Moore had a shallow pit sunk, and has sent me the following description:—

"1'	6"	entirely of oyster shells.
	9"	Thin bed of conglomerate with fossils imbedded.
3'	3"	Bed of soft white sandstone; first foot excavated with a pick; the rest harder and distinctly stratified with perfectly level beds.
4'	6"	Thick bed (bottom not reached) of water-worn pebbles and small boulders imbedded in stiff yellowish-brown clay or loam."

From this spot, by sinking shallow pits, Mr. Moore traced the fossil-bed (without getting to the end of it) to within 400 feet of the scarped upland, about 80 feet high, formed of the massive sandstone in which quarries are opened over a very large area. It is a hard white rock with red streaks and mottling. Pebbles (chiefly of Vindhyan quartzite) are scattered through it locally so as to form a conglomerate; but even in the clearest sections in the quarries no regular bedding is visible, the strings of pebbles, however, indicating that the mass is undisturbed. Well marked joint-planes traverse it in various directions. It is a thoroughly consolidated rock, though portions of it are much harder than others through infiltration of silica from the once superincumbent trap. No earthy layer is found in it; and along the Choral it is seen resting directly on the nearly vertical Bijawar limestone and breccias.

One could scarcely desire a more distinct case of a wide geological break than is presented in this section: the petrographical contrast is evident enough from the foregoing description, suggesting in the strongest manner the necessary distinction of the formations. The case for unconformity may not be considered conclusive: a small fault between the oyster bed and the scarp to east of it would account for the actual relative positions; a concealed sharp curve in the bedding would have the same effect; or even it might be an original great bank of sand with the muddy oyster bed alongside of it. Nothing short of an artificial cut across the rocks could finally dispose of all these objections; but certainly the first and most probable explanation is that of original denudation-unconformity. The incompatibility of the even approximate contemporaneity of such rocks as these now are, indefinitely increases this probability.

The oyster bed and its associates are characteristic representatives of the Bagh beds of this region. All the petrographical characters of the Gatta rock point to its being a representative of some member of the Mahadeva series of Central India. I failed, owing to the Huli festival, to get to the larger area of similar rocks about Kátkot. I suspect the great quarries opened there for the works on the ghât are in the same rock as at Gatta.

Inference as to coal.

The observation I have just explained has a very direct bearing upon the object of my trip westward—the possible extension of the coal-fields. It has not been sufficiently noted that the resemblance of the massive sandstones of the lower Narbada valley, especially in the Deva valley close to the alluvial plains of Broach, as repeatedly observed by Mr. Blanford, is a permanent character, and would hold true whatever geological rearrangement the original Mahadeva group might undergo; also, that the connecting of those rocks with the overlying cretaceous beds is given with great doubt by Mr. Blanford, more because he had not detected any break between them, than from any dependence upon their apparent conformability. This missing link of evidence has now been found, and Mr. Blanford's original conjecture confirmed. It is certain that at least some of the rocks in the Western Narbada area provisionally placed with the cretaceous formation are not only lithologically like the Mahadevas, but are stratigraphically related to the cretaceous beds just as the Mahadevas of the eastern area are to the Lametas. There is scarcely much risk in supposing that the sandstones of the Deva valley are the same as the Gatta rock; and if so, the position of the Mahadevas as now understood would give a new significance to the fact, suggesting very directly the possible or even probable occurrence of the coal-measures. It is not for a moment supposed that there are outcrops of the Damudas in the Deva valley; and no probable guess can be made as to the depth at which they are likely to lie; 2,000 is as likely as 500 feet.

The prospect would include the neighbourhood of Burwai. No doubt the rock at Gatta rests immediately on metamorphics; but there are like overlaps of the Mahadevas in their typical area. The Kátkot outlier is also very likely to be shallow. I saw, however, at the viaduct a quantity of cut stone of the same description from a place near Akhund, to the south-east. It is possible this may be the lip of the basin from which Gatta is an overlap, and that coal may be within reach. Of its great value in such a position I need not remark. I had sent my camp by forced marches to Bankeri railway station, and had no means of going about, having already overtaxed the hospitality of the local officers.

A general consideration of the case does not discourage these suggestions. The great Satpura basin almost certainly had its outlet to the west. Its uppermost strata spread out to the east over the gneiss at the watershed of the peninsula. It is not unreasonable to suppose that to the west as to the east of India an expansion of the lower coal-bearing groups took place towards the sea-board, and that the Bengal fields may have underground equivalents in the region of the lower Narbada.

IV.—The Shapur Coal-field.

Position.

In the event of failure to find coal, and in sufficient quantity, on the north side of the Satpura basin, the alternative will be to take up the most accessible position on the southern outcrop of the measures. In anticipation of this necessity, a survey has been made of that portion of the ground where such trials should be commenced. Throughout the whole length of the basin from east to west, the Barakars are exposed in a more or less continuous outcrop. On the east, where unfortunately the coal is in much greater force, the position is quite out of reach of present demand in an upland valley of the Pench river, which is a tributary of the Wein Gunga, which, as the Prenhíta, is an affluent of the Godavery. The head waters of the Tawa adjoin those of the Pench; but they fall rapidly to a much lower level, flowing at first in deep gorges, which soon open out into broad undulating plains. This broad valley of the Tawa, though containing some large patches of flat alluvial land, is for the most part barren, rocky, and uneven. The high road between Hosungabad and Betul crossing it from north to south is decidedly a rough one.

Map.

The annexed map represents a portion, about twenty miles long, on the southern and western borders of this valley. It is taken from sheets 6, 7, 12, and 13 of the Topographical Survey. The topography is very far from being as accurate as is required for close geological work, but for present purposes it will suffice in the hands of any one in the least fitted to look after coal. The boundaries of the coal-measures are about as close as the transitional character of the formations admits of. The other geological features are accurate so far as given, but a good deal remains to be done in the way of following out trap dikes, quartz reefs, and like details.

General characters of groups.

The first thing to be done is to indicate what rocks constitute the coal-measures, or in a wider meaning, the Barakar group. Coal and carbonaceous shale are seen to be confined to a special line of country; but it soon becomes apparent that the rocks containing them are not constantly separated from the adjoining rocks by any sharply defined features, that in fact, the measures only form a zone, horizon, or group, in a closely connected stratigraphical series. The demarcation of fixed boundaries thus becomes a matter of much difficulty, and must be accepted subject to correction. In the absence, or very rare occurrence, of fossils, the problem has to be worked out conditionally from lithological and stratigraphical data.

The whole rock-series is composed exclusively of sandstone and clays, the former greatly preponderating, except at the base. The character of the bedding throughout is massive, and, as is then generally the case, irregular. It is only in the most general way that either rock can be said to prevail in any particular zone. There are, however, some types of composition and of texture more or less characteristic of different portions of the series, and it is upon these that the discrimination of the several groups in a great measure depends. Throughout a great thickness of strata at the base the sandstones are very fine-grained and of a pale greenish-yellow tint; the clays are hard, splintery, and silicious; both often enclose large erratic blocks and other débris, forming coarse conglomerate, generally with a large preponderance of matrix. These beds form the Talchir group. Above this comes the coal-bearing zone, the Barakars; in which the sandstone is generally white, somewhat coarse and gritty; the clays being shaly and carbonaceous. The sandstone of the next overlying band of the Motur horizon is softer than that of the coal-measures, more earthy and of mixed composition, and having corresponding gray, brown, and greenish tints; the clays are lumpy, sandy, and ochrey. The distribution and the relations of these groups will appear from the description of the local sections.

Conditions of disturbance.

The difficulty of demarcating the several formations is much increased by the disturbances that have affected the whole series, producing intricacies in the boundaries very troublesome to make out where the primary characters of the groups are so undecided. The dips are not often high, but they vary much; and faults are numerous, some having a great throw. There are also many trap dikes and quartz veins or reefs. These are seldom connected with actual dislocations of the strata, but they often disguise the mineral characters of the rock, and thus obstruct the identification of isolated outcrops.

The southern boundary.

The south boundary of the area under notice is the base of the sedimentary series,—the junction of the Talchir group with the gneissic and schistose rocks forming the highland of Betul. For the most part the contact occurs in the low ground along the base of the hills of crystalline rocks. It forms an exceedingly indented outline, being in fact the intersection of two very irregular surfaces—the present ground surface with that of the original floor of deposition of the Talchirs. The actual contact is frequently exposed; nowhere better than in the Phopás (at the south-east corner of the map): the gneissose schists are denuded in the bed of the river, and for several score yards along the left bank the Talchir boulder clay is seen resting flatly on a rough, sharply weathered, ancient surface. At some points this boundary seems to be a faulted one, as in the section of the Amdhana stream at the south base of the Bhaorgarh ridge; the contact here is very steep and crushed, and is moreover on the run of the Machna, north-east to south-west, fault. In the west, at the head of the Bhoura and Súki valleys, the Talchirs rise to a considerable height, forming the upland about Kota, between the Bhaorgarh crystalline ridge on the south and the basalt-capped ridges on the north. The formation is splendidly exposed in the scarps of this small plateau, west of Mura village. The exact position of the south boundary has only been fixed at a few points of our area, the intermediate portions being left uncoloured in the present map.

Northern limit of map.

The northern limit of the area to be described is an arbitrary line in the great sandstone deposit overlying the coal-measures. These beds belong to that middle portion of the Damuda series of the Satpura basin indicated in my former paper as the Motur horizon, in which carbonaceous matter seems to be altogether wanting (but reappearing in the overlying beds of the Bijori horizon). The clays of the Motur group are often slightly ferruginous.

Motur-Barakar boundary.

The Motur-Barakar boundary line is, on the whole, well defined. At several distant places, as Dolari and Kosmeri on the Tawa and below Sonada on the Bhoura stream, the contrast is very well marked between the hard white sandstones of the coal-measures and the softer earthy tinted rocks above. On the Tawa below its confluence with the Machna the distinction is not so marked. Some other parts of the boundary are only approximately accurate on account of the covered condition of the ground.

Barakar-Talchir boundary.

The base of the Barakar group is very vaguely definable as a strict geological horizon. The characters of the two deposits are not only blended vertically by interstratification, but it would appear as if this also occurred horizontally—beds of decided Barakar type in one place being represented by as decided Talchir rock elsewhere. Thus it may be that the line given is not truly equivalent in different parts of the field. This feature will be indicated in the descriptions of the different sections.

Four separate areas.

The physical features suggest the division of the area into four portions: on the east a great fault quite detaches the Dolári outcrops from those lower down the Tawa; the great Machna fault cuts off this second area from that traversed by the Súki, and this again is separated from the Sonada outcrops in the valley of the Bhoura by a steep ridge of indurated sandstone along a vein of quartz infiltration.

The Dolari area.

In the Tawa under Dolári village there is the fullest section of characteristically Barakar rocks within this whole district. The steep narrow Lodadeo-Baramdeo ridge has a back-bone of vein quartz, and the sandstone is disguised beyond recognition. In the small stream close under the north base of the ridge, thick, soft sandstone and red and green clay have a northerly dip of 20°. It would seem, therefore, that the main part of the ridge must be formed of these Motur rocks. In the Tawa, to the north, these same rocks have a low south-westerly dip. Below the Karia stream, the dip is 3° to south on both banks of river for half a mile, and then turns up sharply to a south-easterly dip of 20°, lowering to 10° near the quartz vein which crosses the river obliquely to east-30°-south in the direction of Lodadeo. The same rocks, with a more easterly dip, appear below the quartz reef up to the trap dike which crosses the river to south-35°-west, immediately under the eastern village of Dolári. The dike does not disturb the strata, the same strong bed of mixed earthy sandstone appearing on its west side, where it rests directly on a bed of coal.

Motur beds.

The change of formations is thus lithologically as abrupt at this spot as it could be; but the parallelism of stratification is unbroken. The coal is only seen just under the sandstone, the rest of the outcrop being covered up; but there is room for a large seam. From beneath it there rises a strong bed of white felspathic sandstone. Immediately under this again coal is seen for a small thickness, the rest of the outcrop, full twenty yards wide, being concealed. Below this, for 130 yards, there is white sandstone; then again coal. The covered outcrop of this seam is 40 yards wide, in which some layers of dark shale can be traced under water, but there is room for much coal in the unseen portions. There is then 50 yards of sandstones, and below it 20 yards of covered outcrop with coal at top. This fourth seam is also underlaid by strong white sandstone. These 350 yards of section, with an average easterly dip of 12°, represent about 200 feet of strata, containing what may be four strong seams of coal. I saw nothing to suggest that any of the outcrops are due to repetition by faulting.

Coal-measures: upper beds.

There is a marked change in the character of the underlying measures. The thick rough white sandstones are replaced by sharply defined hard flaggy beds, very fine in texture and of dull greenish-yellow shades, more of the Talchir than the Barakar type of rock; but the alternating shales are copiously carbonaceous, and with some strings and thin beds of bright coal. There is more disturbance in these beds, the dip being sometimes as high as 30°, but in the same easterly direction. The thickness is about 100 to 150 feet.

Middle beds.

Below these thin measures there is still a descending section for over half a mile to where a run of quartz crosses the river from north to south. The only rocks seen in this reach are thick sandstones, in composition and texture mostly of the Barakar type, though some would pass as Talchir, especially the lowest bed adjoining the quartz vein. The intervening earthy beds are completely covered; I conjecture that they are of Talchir type, not carbonaceous. I have, however, coloured the whole as Barakar, not to complicate this small area with boundaries of doubtful nature and position, as undoubted coal-measures occur again close by. The thickness of these lower beds may be 600 to 700 feet.

Lower beds.

The quartz vein just mentioned occurs on a broken anticlinal axis; the silica simply filling the many cracks in the fractured sandstone, some central ones being much stronger than the rest. The reverse dip is seen in the indurated rock forming the reef, below which there is a blank of some 300 yards to where sandstone appears in force in the left bank at the con-

The Phopás: section and fault.

fluence with the Phopás. It is a typical Barakar sandstone, and dips south-westerly at 15°. This rock forms the left bank of the Tawa for a quarter of a mile. It becomes much crushed and silicified, and is finally cut out by a run of broken Talchir rock agglomerated by silica. Up the Phopás, there is an ascending section for some 200 yards, the upper beds having somewhat the aspect of Motur sandstone; and they abut at a moderate angle directly against the same crushed mass of Talchirs. There is clearly here a fault of very considerable throw. The ridge of crushed and indurated Talchir rock is about 40 yards wide; and immediately on its south-west side the boulder-clay is quite undisturbed.

The Lodadeo stream.

In the small stream running parallel to the Phopás under the Lodadeo ridge, and at 100 yards from the Tawa, there is a two-feet seam of bright coal, covered by strong sandstone and resting on thick carbonaceous shale. The dip is 23° to west-south-west. For more than a mile in a direct line typical Barakar rocks are exposed at intervals up this stream; the dip is very variable in amount and direction. The last outcrop, at west-6°-north from Lodadeo, is a white sandstone, dipping north-easterly at 15°; Talchir clay occurring close behind it at the same level. The fault here is unaccompanied by any crushing or vein rock.

The Dolári fault.

The above indicate all the outcrops in the Dolári area. The continuation of the measures along the south base of Lodadeo has not been followed out. In the stream north of Dolári, I fully expected to find the repetition of the main section in the Tawa, the ground between being quite flat, with nothing to suggest a great break in the rocks. At the nearest point, however, just to north of the village, typical Motur beds occur, having a low southerly inclination, and continue so to westwards. In proceeding down the westerly reach, there is a run of fracture with quartz veining; and the dip increases, through an ascending section of the same sandstones, to within 300 yards of the Tawa, where it is 30° to south-south-west. The actual rock against which these sandstones abut is not exposed in the banks of the stream; but a little below its confluence with the Tawa, there is a good section of one of the reefs of broken rock cemented by quartz infiltration, so frequent in this region. I believe the rock it includes to be Talchir; but owing to the small scale of the map, I have not complicated it by attempting to represent these small and obscure outcrops. Talchir clay is seen at several points with a low northerly dip on both banks throughout the Baspur reach of the Tawa. There can be no doubt of the presence of a great east-west fault, having a northern downthrow of several hundred feet, bounding the Dolári coal-field on the north. Two miles east of Dolári, at the angle of the stream south-east of Siwanpát, there is an outcrop of broken and silicified rock on the exact run of the Dolári fault. The whole country here north of the Tawa is deeply covered by soil.

Site for a boring.

A boring in the gully between the two villages of Dolári ought to cut all the coal within 250 feet from the surface.

The Machna Area.

The Golai reach.

The Dolári fault is well seen in the Tawa at the bend below Baspur. A mass of crushed Talchir rocks indurated by silicious infiltration projects into the river from the west. Close under it on the left bank, massive white Barakar sandstone is seen dipping at a moderate angle from the fault; but within a few yards it turns up to a low southerly inclination which lasts throughout this north-east reach of the river, and as far as a pair of strong trap dikes cutting very obliquely in a nearly east-west direction, across the Tawa, under Golai. The sandstones throughout this length are decided Barakar, and unless repeated by faulting (of which there is no appearance) they represent a thickness of 700 to 800 feet. The outcrop is very little interrupted, but no coal is seen; and such earthy beds as are exposed are only slightly carbonaceous, yet nearly the whole group must be here exposed.

The Silapti reach.

The two great trap dikes south of Golai about correspond with an anticlinal flexure. At the mouth of the Gonapur stream they are beautifully exposed, cutting sharply through a strong bed of fine pale greenish-yellow sandstone of decided Talchir character. It contains, however, small strings of bright coal; and the gray sandy clay under it, as seen up stream in the Tawa, is slightly carbonaceous. The low northerly dip of the sandstone is not in the least disturbed by the dikes, each about 20 yards wide. The sandstone is continuous down the left bank of the Tawa, gradually rising to the west and then to north, where the gray clay rises with it. Under this another strong bed of fine sandstone crops up in force, ending at a line of broken and crushed ground. As in the Dolári area, I have coloured these doubtful beds with the Barakar group. Beyond the crush, which may also include a small fault, a very typical Talchir rock appears, massive greenish-gray splintery clay with thin bands of hard compact limestone; it is overlaid by thick sandstone like the preceding. All have a low northerly inclination, soon becoming quite flat, and then turning up to the north. These beds are very well seen in the stream between Silapti and the Tawa, and threads of coaly matter are observable in the sandstone. They end along a marked line of fracture crossing the river to west-30°-north; some Barakar-like sandstone occurring immediately to the north of it, and then there is a blank of fifty yards in the section.

It would be impossible to follow closely the lines of this Silapti inlier to east or west, the ground is so flat and covered with clay. In the stream north-east of Golai only Barakar beds are seen, with some crops of very poor coal. The feature north of the Golai dikes is, on the whole, a blunt wedge of lower strata exhibiting two flat synclinal folds with intervening crush, elevated with faulting, and throwing off the coal-measures to the south and north.

The Temni reach.

To the north of the blank in which the last section ends, thin-bedded measures come in with carbonaceous shales and poor coal, probably representing the middle measures of the Dolári area. The dip is at first southerly, soon turning over in a flat anticlinal, and the northerly dip lasts up to the confluence with the Machna. The outcrops are nearly continuous throughout, strong sandstones of undecided character; the few earthy partings being also uncharacteristic, and but faintly carbonaceous. The whole are, however, Barakar. A thin seam of coal occurs under the great sheet of sandstone on the left bank, at the Temni ford. I saw nothing to suggest a concealed outcrop of strong coal.

The Mardánpur outcrops.

So far, in what might be called the main section through this Machna area, there is very small appearance of useful coal deposits. It was from outcrops in the Machna itself under Mardánpur that the large quantity of coal was taken which gave such satisfactory results in a trial on the Great Indian Peninsula Railway in 1873. From the confluence of the Machna and Tawa a great sheet of strong Barakar sandstone rises gently to westwards along the bed of the former stream. Under Douri a long deep pool has been cut by the water through this rock into an underlying earthy bed, which is quite concealed, the same mass of sandstone continuing above the pool and extending on the left bank up to where the river bends to the west-south-west. For a hundred yards or so near the bend the sandstones on the right bank have a considerable north-westerly dip; and in the bed of the river is visible the crack along which, by faulting, this abutting stratification takes place. There must also be a south-westerly or some equivalent line of fracture at the back of this upheaved mass of beds. It is at the top of this little section that the coal seams occur, cutting very obliquely across the river bed. At every available point of the outcrop, along a length of some sixty yards, coal was cut on both sides of the river. The holes are now filled in, and little can be seen. There are two seams, the lower one apparently with a strong parting of shale. There did not seem to be in either seam room for more than four to five feet of coal. The dip is 30°. At a short distance up stream the dip changes to north-east, and continues so up the next, north-south, reach. I could not find that the seams are repeated on the reverse outcrop. There is thus here an oblique synclinal flexure, sloping towards the main fault, and the continuity of the coal at this spot is therefore closely limited. The place seems, on the whole, very unpropitious for mining operations.

The Kotmi section.

The next north-westerly sweep takes the river for about half a mile across the main fault into most typical Talchir rocks, the massive fine clay with thin bands of dense, nearly black, limestone. Above this there are again Barakar beds, showing an east-west flat synclinal, south of which a very massive bed of sandstone rises to the next bend of the river. Beneath this rock, along the east-west reach, a band of flaggy sandstones and coaly shales is very well exposed, and the same are traceable for some distance up the gully draining from across the fault to the west. All have a moderate northerly dip, and at the head of the island, at the southerly bend of the river, they are regularly underlaid by the fine Talchir sandstone. These flaggy measures may correspond with those already noticed twice on the Tawa.

The Talchirs on the Machna.

Hitherto we have only seen broken sections between the Barakars and the Talchirs. In the Machna the sequence is quite continuous; and if the conjecture regarding the identity of the flaggy coal-measures here and at Dolári be correct, the contrast between the underlying beds in the two sections is striking: at Dolári the Barakar type of sandstone prevails, while in the Machna, from below the flaggy coaly beds a mile north of Shápur, we meet only rocks of Talchir character. There is another feature in these beds on the Machna different from what is found to the west—the sandstones are in force down to a low horizon in the series, alternating with the boulder clay and even containing large erratic blocks itself. From the Machna the section was followed to the south boundary up the stream flowing near the high road. The moderate northerly dip is remarkably steady throughout, and unless there are repetitions by faulting the thickness would be over 2,000 feet. From the top of the section there are broad intervals between the successive crops of thick fine sandstone. The clays which no doubt occur in these spaces being quite concealed, an important aid was missed in fixing a fair boundary for the groups; the presence of carbonaceous matter was thus also not ascertainable. I did not hit upon the clay with limestone which is peculiar to the Talchirs, though not confined to a particular horizon. The boundary I have given is certainly higher than that taken elsewhere. Locally it is the best marked line in the series, and for coal-searching purposes the most suitable. I had not time to work the question out more minutely.

The Machna Fault.

The Machna fault is quite as well marked as those in the Dolári area, and has nearly as great a throw. The upland to the north-west of it is almost entirely formed of Talchir clay, except the hills north-west and north of Shápur, which are mostly sandstone, perhaps partly Barakar. The Barakars occupy the low ground along the river. The run of the fault is very steady; the bulge appearing in it on the map may be due to incorrect plotting of the river course. At both points where it cuts the Machna there is much confusion of the stratification, with infiltration of silica; but at the only point where I got a view of the actual plane of contact, the feature is very sharply defined. This occurs in a small gully, within fifty yards of the river at the north-westerly elbow above the Murdánpur coal crops. The exact line is not traceable in the covered ground north of Douri, nor can it be fixed on the Tawa. It has probably died out in that direction, as all these features are clearly connected with the special disturbance of the stratification along the margin of the basin. To the south-west the fault is seen at the base of the range of gneissic rocks at the mouth of the Amdhana gorge. Its continuation up the valley has not been followed out.

Site for a boring.

For reasons already indicated, I should not advise any outlay upon an attempt to mine the seams in the detached block of measures south of Murdánpur. If there is any continuity in the measures, the seams should be found in a favorable position away from the fault-ground. A good site for a boring would be on the left bank of the Tawa, a little below the confluence of the Machna. A depth of 400 feet here would probably prove the whole of the measures.

THE SUKI AREA.

Kosmeri.

The east end of this portion of the field, about Bhumkadhána and Kosmeri, is hopelessly concealed and obscure. From isolated outcrops and the frequent occurrence of vein quartz, it is plain that the stratification is much disturbed. On the left bank of the Tawa at Kosmeri there is typical Barakar sandstone, and on the right bank as typical Motur rock. At a few feet from the base of this latter group there is all along this portion of the boundary an extensive exhibition of trap rock, appearing generally as a sheet-dike along the outcrop of a massive bed of rusty clay. This character is well displayed in the Lohár river, where there is a wide spread of the sandstone covering the trap at a low angle, and broken and altered by it.

The Súki section.

In the Súki itself there is an unbroken section, including apparently the whole Barakar group; and if it is so, the promise of coal is very poor indeed, there being no seam of workable thickness or quality. At the very mouth of the river the strong white Barakar sandstone is in force; typical Motur beds appearing a little to north of it on the left bank of the Tawa; all with a steady northerly dip. At top of an irregular earthy parting in this band of massive sandstone, there are three inches of platy coal. Up stream, in a short west-south-west reach, under the top sandstone there is a flat section of very irregular flaggy sandstone showing already some Talchir characters. Above this there is a long north-south reach with no strong crop, but on right bank the section is almost continuous; a low northerly dip in soft sandstone and sandy micaceous shale. Two of these beds are carbonaceous, with mere strings of coaly matter, the associated sandstone being persistently fine, earthy, greenish. From the upper end of this reach to the causeway at the road-crossing there are continuous crops of strong fine sandstone with a few thick irregular partings of sandy micaceous shale, faintly carbonaceous in strings. The flat reach above the road is along the top of a lower band of softer, finer sandstones, below which the Talchir clays come in with scarcely any associated sandstones. In this section the characters of the two groups are run together in a very puzzling manner: the Talchir-Barakar sandstones are clubbed in force with interspersed carbonaceous matter. The boundary adopted is a very marked one, but manifestly on a lower horizon than that taken on the Machna. If the section on the Machna were to be interpreted by the analogy of that on the Súki, the base of the Barakars should be taken well to the south of Shápur.

Doubtful prospect of coal here.

The question of coal in this locality turns upon whether the shales observed become coal to the deep, and whether some of the top measures may not be suppressed by faulting. I noticed no direct evidence for the latter supposition: there is no doubt much quartz-veining along the boundary at this spot, but I do not think it is connected with faulting; such is rarely and indirectly the case with the many runs of vein-quartz observed throughout the district. The conformable succession of strata here seems unbroken. There is also little encouragement to adopt the other supposition. I would rather connect the want of coal here with the other peculiarities noticed in the original characters of this formation in this position.

West of the Súki.

In the left bank of the Tawa, on the strike of the ridge of indurated rocks separating the Bhoura and Súki streams, there is an excellent section of the bottom Motur beds. There are two strong bands of mottled sandy clays overlaid by thick sandstones. These latter pass up to form the crest of the ridge along the quartz vein. The extension of the Barakars along the base of this steep ridge is quite covered up by débris.

THE SONÁDA AREA.

The north boundary.

The point at which the Motur-Barakar boundary crosses the ridge of induration is put in inferentially, from the apparent structure, the rocks of the ridge being too much disguised for close identification. The position of the boundary on the Bhoura Nadi is well defined. In the reach to south-east of Bandábir the massive greenish-brown and mottled purple clays of the Motur are in force. A lower band of the same appears near the bend of the river to east-by-south of Sonáda. To the west, along the flanks of Jámgarh, these bands, if present, are concealed by talus. But I rather think they die out to the rise: the sandstone forming the east flanks of the hill are seen to pass down into the low ground to the north; at the high level they are porous and conglomeritic, while low down they become earthy and fine grained.

The coal-measures.

The Barakar beds are fairly exposed for several miles along the Bhoura stream, the course of which is very oblique to the strike of the formations. For this reason and the doubtful accuracy of the map, it is impossible to be certain whether two or more of the outcrops may not belong to the same seam, or to assign an approximate thickness for this group. It is certain, however, that the coal-measure characters are more pronounced than on the Súki. The top rock is as usual a very strong white sandstone. Under Sonáda, near the top of the long west-by-north reach of the river, two poor strings of coal occur in local partings of this rock. Above Sonáda there is a succession of south-westerly reaches, across the measures, and west-north-westerly reaches more or less along the strike. At the northerly elbows between the four first pairs of these reaches coal is seen on the left bank under strong sandstone. The first two are, I think, the same seam, and also the third and fourth, at a lower horizon. From one to two feet of coal is seen in each case; but there is room for more in the concealed part of the outcrop. There are besides several bands of covered ground in these sections that may contain coal. To the west the whole group passes into the base of the Jámgarh range, and is obliquely overlapped by the covering trap which passes across it to rest on the Talchirs west of Teter. The first scarp north of Teter is of coarse Barakar sandstone, locally altered by the overlying basalt.

The Talchirs.

Here again we find an instance of the mutual accommodation that occurs between these two groups: as the Barakar type of sandstone, and with it true coal deposits, increases, the Talchir stamp of sandstone decreases. I have still left a considerable band of these latter within the coal-measures boundary, so as to let it correspond with the continuous line in the Súki area; taking as top of the Talchirs the first appearance of the massive, fine, silicious clays with thin bands of hard compact limestone north of Kupa. Beneath this there are still some strong beds of the fine yellowish sandstone. The very massive Talchir clay is deeply weathered out in the broken ridge south of Teter, showing the quartz veins passing vertically through it. Lower still the boulder deposits are splendidly exposed in the eastern scarp of the Kota plateau.

The high road (it only deserves the title from the causeways and culverts constructed across the watercourses) passes through the Súki area, which, as has been shown, offers the least promise of coal. For any really effective roadway from the north, Sonáda is much the nearest and most accessible point of the coal-measures. There is no serious obstruction to overcome between it and Dhár on the present road. For this reason it is here that a first attempt should be made to prove the ground for a workable coal, although the apparent prospect of success may be less promising than in the Machna or Dolári area. In choosing an actual site for boring one might at first be inclined to avoid the visibly barren ground at the top of the measures at the bend of the river just above the village. Yet, as none of the outcrops are very tempting, the object should be to test the whole measures a little to the deep of the outcrop. With this in view I should take up a position immediately to the north of Sonáda village. When there is such uncertainty as to the thickness of the measures it is difficult to assign a depth for a boring. If 400 feet at Sonáda did not clear all the measures, the remainder could be tested by another shallow boring half a mile to the south.

Site for boring.

TRAP.

The few trap dikes that occur are not likely to prove very troublesome. The only one seen in the Sonáda area is close to the Talchir boundary. There are none in or near the Súki section. None is seen either in the Machna. A ten-yard dike stops just short of its left bank, at the mouth of the little stream south-south-west of Douri. It is very remarkable for its finely developed prismoidal structure. Two small dikes cut across the Tawa, just below the mouth of the Machna. A boring here might be placed between the two, or below the lower one. Several fine dikes cross the Tawa within this area to south. In the Dolári area a strong dike crosses the river immediately above the outcrop of the coal seams.

The general habit of the trap dikes is to coincide approximately with the lines of flexure, and therefore with the local strike of the strata. The great dike at Kámti and that north of the Tawa at Kosmeri cut across the strike and parallel to the Machna fault. There are some good instances in this field of the tendency of intrusive trap to run out in sheets at the contact of thick clay bands with strong overlying sandstone. The broad run of trap along the north bank of the Tawa in the Kosmeri reach is a good case of this, as already mentioned. There is also a very good example of it in the Talchirs on the Phopás: a band of hard sandstone is seen broken or tossed about upon an underflow of trap. I am disposed to think that the cotemporaneous trap said to occur in the Talchirs elsewhere is only an exhibition of this phenomenon.

I have seen nothing to disturb the opinion I have already expressed that all the trap in these formations is of the age of the Deccan rock. There is excellent evidence within the range of our map of the advanced denudation of these formations at the time of its outflow. The trap forming the summit of Jámgarh is fully 800 feet thick, the top scarp of Motur rocks having an elevation of about 2,000 feet. At a distance of little over two miles, in the gorge west of Teter, the trap is at the lowest level. The fact of there being no infratrappean deposits in such a position only shows that even then this must have been an upland gorge. There is one mode of occurrence of the trap that suggests at first sight an opposite conclusion regarding the periods of denudation. The best case in point I noticed this season, about twelve miles to the east-north-east of Dolári: a very strong dike, traced for several miles along the low ground, cuts straight up the west face of Kilandeo hill and forms a ridge on the summit. It is certain that when this occurred the whole of the present low ground was filled with rock; but it is quite open to supposition that the filling rock was in great part trap. The unquestionable fact, that the main Narbada valley itself, formed on the south by scarps of Mahadeva strata, is re-excavated out of the covering trap-formation—the floor of the valley being still of this rock at many places in front of the Mahadeva scarp—removes any apparent improbability in such a conjecture as that here made regarding the inner vallies of the basin and the pretrappean denudation of the Mahadeva formation. A just estimate of this feature is an important factor in our judgment upon the time-relations of the Mahadeva series, the top member of which is the Jabalpur (Rajmahal) group, in comparison with the Bagh series (cretaceous) in this region; and also upon the distinction of the Deccan and Rajmahal trappean formations.

QUARTZ-VEINS AND FAULTS.

Quartz-veins: composition.

The frequent occurrence of strong and continuous quartz-veins is perhaps the most peculiar feature of the southern zone of this rock-basin. Along the northern margin, where the contortion of the strata is locally greater than here, I have not observed a single case of quartz-veining; and in other basins of these formations the thing is almost unknown. There is, however, one marked feature of these veins that has long been familiar to us in many parts of India in metamorphic and transition rocks—a peculiar pseudomorphic structure, thin shining plates of pearly white quartz, either in parallel arrangement or confusedly entangled, with empty interstices. I do not recollect noticing this form in vein-stones of other countries; but in India it seems to be nearly universal. The fine lines on these shining plates have suggested that they may be after micaceous iron. Stains of iron are common, but there are no signs of any other metal in these veins. There is often associated brecciated quartz.

Not fault-rock.

The whole rock was for long currently designated amongst us as 'fault-rock.' In highly contorted and altered strata, where this stone was most familiarly known, it is generally difficult to establish the fact of faulting; but in these little disturbed and unaltered deposits the evidence is often complete. From many observations made in this field I can say that this rock seems rather to shun a connection with faults, as if they were related to opposite results of disturbing action—such as if faults occurred along lines of maximum compression and these veins along lines of tension. The vein forming the core of the ridge between the Súki and Bhoura streams is at least eight miles long, varying from one foot wide in the Talchir clays to six feet in the sandstones. In the masive unstratified clays vertical dislocation might not be detected, but there is little or no sign of crushing or rubbing alongside the vein, clear sections of which are abundantly exposed in the broken ridge south of Teter. In the sandstone it is quite surprising how this fissuring of the rock and introduction of foreign matter does not even locally derange the moderate dip of the bed: an indurated shell of sandstone of variable width commonly adheres to the south face of the vein, to the rise of the dip; and in this, as well as in the strips of rock enclosed by the ramifications of the veinstone, the low northerly dip is uniformly undisturbed. The best defined and most continuous of the quartz-runs correspond with this description. The few cases where the quartz appears locally near the Dolári and Machua faults might be quoted on the other side; but besides that these spots are quite local as compared with the length of those faults, it can generally be seen, as in the Tawa and the Phopás, that the quartz is located in broken flexures adjoining the fault, where no vertical displacement has occurred, and does not represent what is properly designated by the term fault-rock; it is simply veinstone. One of the veins which have given rise to the group of sandstone ridges north-west of Shápur is seen on the path descending the Amdhána gorge to the south, to run continuously into the gneiss as a comb-vein one foot wide.

The structure of some of these runs of vein quartz is peculiar: the small veins of which the reef is made up are not always coincident with the general direction. In the hill north-west of Bhoura the component veins are nearly normal to the direction of the aggregate. In the Tawa above Temni the run of the quartz rib is east-west, while the veins composing it lie north-east, south-west. It is perhaps conceivable that 'colliding' earthquake waves might shatter the rock in this manner.

Peculiar local structure.

The induration and metamorphism of the sandstone that occurs in connection with this infusion of quartz is sometimes remarkable, as it takes the form of felspathisation, the development of innate crystalline felspar. I noticed this at the contact of the Lodadeo reef in the Tawa. It is important to find it in this connection, because the most marked case I found of this form of induration is not visibly connected with any veining. It is in the small hills on the Bhoura stream south-west of Bandábir. They are formed of sandstone having quite a granite-like hardness; the porosity of the sandstone is not destroyed, nor is the earthy matrix quite obliterated; but bright glassy facets of a felspar are disseminated, manifestly innate; and it must hold the whole in an invisible bond to account for the peculiar hardness of the rock.

Peculiar induration.

The well-marked faults within the stratified series form another peculiar feature of this region. We are familiar enough with the word 'fault' in the northern region, about Mohpani; but they would be correctly termed slips in comparison with the principal faults in the Shápur field, where top Barakars or even high Motur strata are brought into contact with middle or lower Talchirs; in which cases the throw must be from 500 to 1,000 feet.

Faults: dimensions.

Notwithstanding the dimensions of these faults, I cannot look upon them as anything but local features, not merely in the literal and obvious sense, but as connected with and determined by pre-existing local conditions. The Machna, north-east-south-west, fault runs with the crystalline range of Bhaorgarh; but I cannot regard them as concomitant effects of elevating action. I rather connect the fault with a pre-existing feature of the basin of deposition, of which there seems to be coincident evidence in the marked change in the character of the Talchir strata along that line.

Local relations.

The only noteworthy instance in India of Barakar deposits occurring at a high elevation is on the continuation of these outcrops to the east, in the Pench valley. The case has been appealed to as a sufficient refutation of the general remark that the areas of Barakar deposition correspond in a recognisable manner with the existing depressions of the peninsula. The objection, however, will not hold if it is shown that the apparent exception is due to local elevation; and there seems every probability that such was the case. But for the great faults which set on to the eastward from Shápur, the coal-measures here would correspond in position with those in the Pench. The fault which brings up the coal on the Pench river west of Chendia has, on the contrary, its upthrow to the north: here, too, the quartz veins keep clear of the faults.

Different throw in east and west.

The structural features of this region offer a most tempting subject for study. I believe it will appear that the limitation of the sedimentary basin here is not in any important degree due to elevation from the south; but rather that this present local stratigraphy is connected immediately with pre-existing surface features.

SUMMARY.

Although the foregoing details are reduced to the minimum required for any one who would carry on the investigations described, or even as evidence for any one who would study the questions discussed, each of which is marginally noted, it may be well briefly to point out what conclusions or opinions have been arrived at.

As to coal: the only tangible and immediate prospect is, of course, where we are certain of the coal-measures; I think there is a good prospect of coal in the Shápur field; if not in the Sonáda area, then further east, on the Tawa.

Regarding those places where we are searching for the measures themselves, I can only say that there is a reasonable hope of finding them. In the central area, where the deep borings are being made, the chief risk is that the measures are out of reach. In the trials along the border of the basin the extra hope is that the measures, if there, have partaken in the extension and rise of the Talchir beds towards the northern outcrop; the extra risk, that the boring may be outside the overlap.

The prospect held out of coal on the lower Narbada is in some ways more precarious, the ground being so very far from any known occurrence of the coal-measures; yet the countervailing suggestion of a probable original expansion of the measures towards the sea-board is not without weight; and the presence of a rock that is known to overlie most of the important coal-basins in India is no small encouragement. Considering the importance of a local supply in Western India, the chance ought not to be left untried.

NOTE ON COALS RECENTLY FOUND NEAR MOFLONG, KHASI HILLS, *by* F. R. MALLET, ESQ., *Geological Survey of India.*

On the 19th April 1875, I visited the coal recently discovered near Umsaomát and at Dédúm Hill.

Two spots were pointed out to me near Umsaomát, one about half a mile, and the other a mile south-east of the village. The coal at both these places is worthless, being shaly, and the seams only a foot thick.

The following assays have been made of the Dédúm coal, and for comparison of that at Máobeláka, the latter seam is that which for some time past has been worked for the supply of Shillong with fuel:—

	Dédúm Hill.	Máobeláka.
Hygroscopic water	6·0	3·4
Volatile matter, exclusive of water	24·6	39·6
Fixed carbon	37·8	55·2
Ash	31·6	1·8
	100·0	100·0

The Máobeláka coal was taken from the fresh working face of the quarry, while that from Dédúm was from the surface of the weathered outcrop. The latter coal would probably be found considerably better a few feet in. The seam is three feet thick (the Máobeláka coal being 3′ 6″ to 4′ 0″), but the outcrop is at the foot of a perpendicular sandstone cliff 15 feet high, from the top of which the hill slopes back steeply for 30 or 40 feet more. The hill near the top of which the seam is situated appears to be equally steep all along the southern side, so that the coal could not be quarried. If sufficiently good in the interior, however, and no better seams should be found in the neighbourhood, it might be worth mining on a small scale, as when the projected new road is completed, the facilities for carriage from Dédum to Shillong will be considerably greater than those from Máobeláka. The roof is good and the seam horizontal, and a few miners could raise sufficient coal to supply Shillong. The chief difficulty in the way of opening such a mine under native supervision would be the risk of explosions if it were not properly ventilated.

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DURING APRIL, MAY AND JUNE.

Laterite from Pigeon Island. Limestone from Bittrapar one of the Laccadives, and Rock specimens from the Vingorla rocks. Presented by A. O. HUME, ESQ. ,*Secretary to Government of India.*

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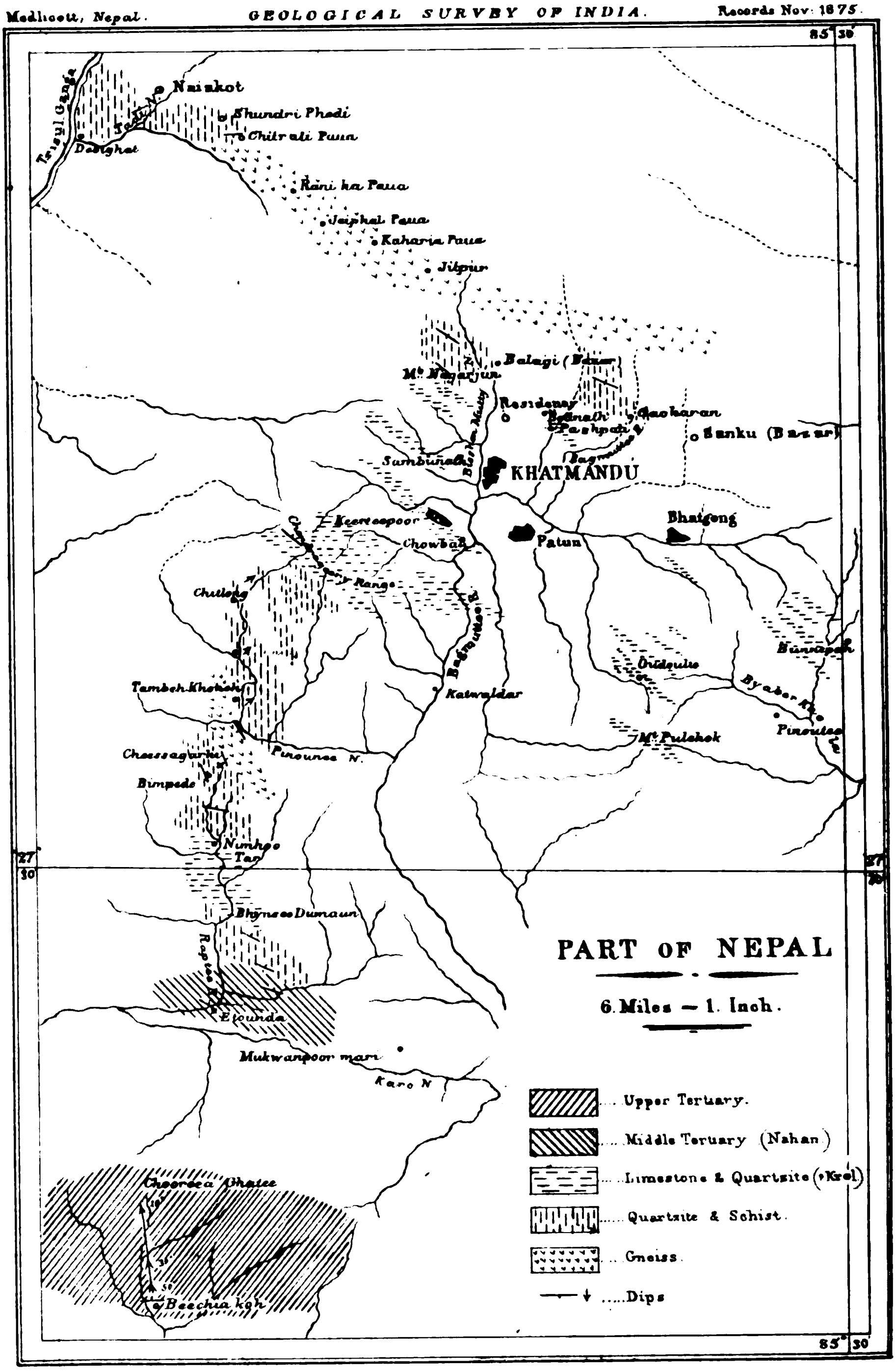
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Residency
Pashpati
Gaokaran
Sankhu (Bazar)
Sambunath
KHATMANDU
Keerteepoor
Chowbar
Patun
Bhatgong
Range
Chitlong
Tambeh Khanah
Katwaldar
Pinounee N.
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Karo N.
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27° 30'
PART OF NEPAL
6 Miles — 1 Inch.
Upper Tertiary.
Middle Tertiary (Nahan)
Limestone & Quartzite (Krol)
Quartzite & Schist.
Gneiss.
Dips

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1875. [November.

NOTE ON THE GEOLOGY OF NEPAL,* *by* H. B. MEDLICOTT, M. A., F. G. S., *Deputy Superintendent, Geological Survey of India.*

Through the kindness of Mr. Girdlestone, the Resident of Nepal, I had an opportunity in May last of visiting that very secluded country. It will surprise many to hear that although the marches of Nepal run for more than 500 miles along some of the most fertile and populous districts of British India, that country is still rigorously tabooed to all outsiders, Englishmen included. With the exception of the track to Katmandu, no part of that extensive area has been traversed by civilized man. Even the route to the capital is only open to political envoys, and by special favor to invited guests; and any digression from the actual road-way is suspiciously watched. The permitted range of exploration from Katmandu is correspondingly restricted: one may go as far as the Trisal-ganga, on the north-west, about sixteen miles (direct), and to about an equal distance on the south-east, in both cases a short way beyond the precincts of the actual valley. The following observations are therefore most scanty, there being no opportunity to follow up and examine features of special importance in the general section. They may, however, have some interest as a term of comparison between the known ground on the east and on the west, about midway between which this section occurs.

It is necessary briefly to state what the features are with which this comparison is to be made. From the Sutlej to the western frontier of Nepal there is continuously traceable along the margin of the mountains a zone of variable width formed of slates and thin silicious beds surmounted by sandstone and strong limestone. The latter have been described as the Krol group; the lower horizons being distinguished as infra-Krol, Blini (a thin limestone) and infra-Blini. They usually form a broad, crushed synclinal ridge at the edge of the mountain-area, as at Mussooree and Naini Tal. In the Simla region they extend far beyond this ridge into the interior of the mountains, where they become obscured by metamorphism, their relation to the gneiss rocks not being as yet satisfactorily determined. In Kumaon, at least north of Naini Tal, there is an abrupt change, along a line of trappean intrusion, between the range of semi-metamorphic strata and the gneiss rocks to the north. It has been conjectured that the Krol limestone is triassic, and the underlying groups palæozoic.

* Within the territories the name Nepal is only applied to the valley of Katmandu.

The section in Sikhim, to the east of the Nepal territories, is petrographically very different from that in the Simla region. The schists and gneiss come close to the edge of the mountains, in some places quite up to it. But in many parts there is a narrow band of partially altered strata, which have been fully identified as belonging to the Damuda formation, the coal-measures of India, thought to be of upper palæozoic age. But the curious point is that these beds are the lowest and oldest member of the rock-series, conformably underlying the schists, and these again passing regularly beneath the gneiss, which forms the greater part of the mountains in the Darjiling district. In Sikhim the usual outer ranges of the sub-Himalayan hills, enclosing long valleys at the base of the mountains, are not represented. The inner zone of sandstone at the very base of the mountains is, however, in force.

In the Nepal section we find a very complete exhibition of the sub-Himalayan hills, as known to the north-west. The Churia Ghati range, in size, structure and appearance is a *fac simile* of the original Sivaliks. Inside it the *dún* or *mari* of Etoundah is an excellent example of these characteristic sub-Himalayan valleys. And to the north of this, along the base of the mountains, there is a flanking range of sandstone, harder, and apparently older, than that of the outer hills, just as occurs in the western region. There is still so much uncertainty about the grouping and distribution of these sub-Himalayan rocks, that I cannot speak confidently as to those in the section under notice. It is quite recognised that there are two strong and stratigraphically well separated groups—the Sivalik and the Nahan—in the trans-Jumna region; but considerable doubt has been thrown upon the view I at first adopted, that the cis-Jumna Sivalik hills belong to the upper group of rocks. Lithologically, the resemblance is more with the Nahun than with the Sivalik group. Thus it would appear that structural position, even in the case of what is physically a single range, is no criterion of the geological horizon of the rocks; and we are unable on these grounds to assume that the Churia Ghati strata are true Sivaliks. Lithologically too, they have small resemblance to the typical Sivaliks of the trans-Jumna range. In mere composition they are much more like rocks of the cis-Jumna hills, consisting as they do in the lower half, of massive gray sandstone, and above of great beds of conglomeritic gravel. There are, however, some points of difference: in the west the change from the sandstones to the conglomerates is gradual and alternating; here it is rapid and complete, from an almost unbroken mass of fine grey sand to an equally uniform mass of pale yellowish-brown conglomerate. This character can have no significance; but I was much struck with the very fresh aspect of these Churia Ghati deposits as compared with those of the range south of the Dehra-Dún. The sand, in solidity as well as in appearance, is scarcely different from that forming the *chars* (temporary islands) in the great river beds. I should, perhaps, mention that it is several years since I have seen the Sivalik sections, and have since then been occupied with much more ancient formations. On one point, however, I will speak firmly: I must at present refuse to believe that the Churia Ghati strata can be of the same horizon as the sandstone forming the hills north of Etoundah; and so, these being presumably Nahans, the former may for the present be set down as Sivalik.

At the outer base of the range, at Bichiakoh, there are some rusty earthy beds; and all are greatly crushed, locally quite vertical. The dip soon settles down to 30°, to north-north-west, maintaining it steadily to the top of the pass. This is the type structure of these detached sub-Himalayan ranges, of whatever group composed: the flat half of a normal anticlinal flexure. The range is about four miles wide, which would give an aggregate thickness of about 10,000 feet of rock.* The pass, as is universal in these ranges,

* It is still necessary to note that this does not imply vertical sequenc .

follows the broad bed of a torrent, to near the very summit, where it turns up a steep gully, partly artificial. Here I noticed a strong bed of ochreous clay. A similar rock is very common in a like position in the passes south of the Dehra-Dún. Boulders of from 12 to 20 inches cube are common in the bed of the torrent, though it is rare to see stones of this size in the conglomerate forming the cliffs on each side, from which, it would be assumed, all must be derived. Near the foot of the steep rise I observed a huge block of quartzite, measuring 10′ × 7′ × 6′. Reference to it will be made further on.

In the Rapti, immediately under Etoundah, there are outcrops of the rusty sandy clays and greenish-gray sandstone at the base of the section north of the dún. They dip at 60° to north-by-east. Wherever observed along the road, this dip (with slight variation in amount) was found constant, and there is but little change in the character of the rock. It is clearly an ascending section: clays occur, but very subordinately; the sandstone becomes somewhat softer in the higher beds, and there are here several layers of thin conglomerate. In no single feature is there any precise resemblance to the series in the outer range. The strata closely correspond with the Nahan group of the north-west, and with that described by Mr. Mallet at the base of the Sikhim Himalaya. At Etoundah the formation is about a mile wide, which would give an accumulated thickness of about 10,000 feet, there being nothing to suggest repetition by faulting or flexure. A blank covered space of fully 100 yards, between the last outcrop of the sandstone seen on the road section and the first outcrop of the slates, conceals the contact. It is probably, as usual, very steep, if not overhanging. Mr. Mallet has adopted for the Sikhim ground the view I put forward regarding this main feature of the mountain-structure in the north-west, that it is not primarily a faulted rock-junction. There is no sign at the base of the section, nor as a remnant along the junction, of any older tertiary rocks that might represent the eocene group of Subathu. The inner limit of these sandstone hills is well marked by narrow longitudinal valleys of denudation.

The first rocks seen north of the tertiary sandstone are some earthy schists, with a crushed dip of 50° to north-by-east, quite parallel in strike to the sandstone. A thin band of blue limestone occurs in these beds, and further on a strong band of black schistose slate, in which are some irregular vein-like nests of impure carbonaceous matter. All these beds within a few hundred feet of the boundary, though decidedly subfoliated, are less altered than any rocks to the north of them, and also less highly inclined. They are overlaid by more silicious rocks, flaggy schistose quartzite, nearly vertical, or folded in zigzag contortions. There is again a small appearance of more earthy schist, or possibly a reappearance of the former band, for the beds are greatly contorted, although the northerly underlie seems constant. A trappoid rock occurs here; but its intrusive character is not well marked. It is the only rock of this kind that I observed in Nepal. The thin quartzites come in again and pass up into stronger beds of the same rock, which are overlaid by massive white crystalline limestone, all dipping at 70° to 80° to north-by-east. This limestone must be several hundred feet thick. The sample I brought with me is not dolomitic. At Bhainsi Daman, where the river takes a bend, and above it for some miles, the rocks are much broken and confused. Great masses of the white limestone form irregular cliffs on both sides, the underlying rocks being concealed by vegetation and valley-deposits.

It would seem as if the ascending section from the boundary to Bhainsi Daman here passed into a broad, broken and contorted synclinal basin. The east-by-south general strike is maintained throughout; it was observed in some quartzites a mile below Bimphedi, which stands at the head of the valley close under the steep ridge of Chessa-garhi. This glen of Nimbua-Tanr on the upper course of the Rapti is one of the most picturesque I have ever seen.

Although this Chessa-garhi range has a nearly east-west direction, parallel to the strike of the rocks to the south of it, it is formed, at least at this point, of rocks having a widely different direction. Even at Bimphedi, at the south base of the ridge, the strata strike to north 35° west. They are again thin quartzites, greatly folded and shattered, but maintaining a dominant high underlie to north-east-by-east. A little below the crest of the ridge on the northern descent, the quartzose schists are associated with strong bands of prophyritic gneiss, which is the dominant rock towards the base. The strike would take it into the ridge well within the basin of the Rapti. At the north base of the range the Pinouni river flows from the north against this mass of gneiss, and turns away to the east. Just above the bend of the river there is a cliff-section showing the crushed condition of the gneissic strata, contrasting well with the steady high underlie of the sharply bedded quartzites through which the river cuts its way obliquely. The general strike in both rocks is the same; and the whole feature suggests that the gneiss has been formed, and perhaps faulted up, along a broken anticlinal axis of flexure. It is near this line of disturbance that the copper mines of this locality occur. I was, of course, unable to visit and inspect them; but by a curious coincidence I passed at this very place a number of coolies laden with foreign copper for Katmandu, which suggests that the native resources in this metal cannot be very great. Here, and at several other places where I saw abundant refuse of old copper smeltings, the work seems to be now abandoned.

From the Sango bridge at Tamba Khoneh, along the Pinouni nearly due north to Marku, and then up the Chitlong valley to the north-east, there is an ascending section (obliquely) through the sharply bedded quartzites underlying steeply to east-35°-north. Wherever their composition is more earthy, foliation is well marked; but I did not see any gneissic band. Towards the head of the Chitlong valley the strike of the rocks becomes more easterly, up to the Chendragiri ridge, where it is east-15°-south; and the rocks are freely calcareous.

The Chendragiri ridge overlooks the Nepal valley, which is enclosed, except on the north, by rocks of the same description as those found here. There is, however, nothing like a circular arrangement of the ridges or of the rocks; the strike of both is most constant, between 15° and 25° to south-of-east; and the form of the valley is consequently most irregular—a number of longitudinal valleys, united in a central area by the suppression of the ridges, which are in some cases mere spurs running a short distance into the open; others, again, as that of Kirthipur, are nearly continuous across the valley: sometimes, as at Pashpati, the rock appears isolated in the alluvial deposits. The south-west corner of the valley divides the Chendragiri from the Phulchok range, on the same strike. Here at Kátwaldár, the Baghmati leaves the valley through rocky gorge across vertical quartzites. It is a moderately sized torrent, the watershed being confined to the ridges immediately surrounding the valley, which is only about sixteen miles long from west-north-west to east-south-east, and about twelve miles transversely, from Katawldár to the base of the Sheopuri range on the north. The alluvial area may be about 125 square miles. The elevation of Kátmandu is given as 4,500 feet. Phulchok on the south-east is the highest summit of the surrounding hills, rising to 9,720 feet.

Excluding the Sheopuri range on the north, all the ridges skirting or abutting into the Nepal valley are formed of steeply folded repetitions of one set of rocks, in which, as already noticed, a calcareous ingredient is very general. It often appears as limestone, in some force and of various degrees of purity. The summit of Phulchok is of thick white crystalline limestones. Strong beds are also found on Chendragiri and Nagarjan, both of which are synclinal ridges. The pure rock would thus seem to occur chiefly near the top of the series, but some single beds are found low down. The schistose limestone of which the monoliths of Katmandu and Patun are made is quarried low down on the Kirthipur ridge at Choubal, where it is well seen at the gorge of the Baghmati. There are some thin bands of limestone also in the gorge at Pashpati. The prevailing rock is a peculiar massive, very fine schistose quartzite with a trifling percentage of carbonate of lime, yet to this minimum ingredient is, I believe, largely due the physical condition of this mountain zone—its deep erosion, as chiefly exhibited in the basin of the Nepal valley. This rock is very prone to decompose, by the abstraction of the small calcareous element in it, and is therefore seldom found in clear out-crops. It is well exposed in the little stream at the north-west side of Sambunath. For the most part it forms at the surface an ochrey sandy clay. When only partially decomposed it forms what might be called a sandstone (freestone). In this state it is quarried at the base of Nagarjan for building.

From the frequent reappearance of similar rocks across a broad zone of more or less vertical strata, one might of course presume that there is repetition by folding; but this condition is independently established: both Chendragiri and Nagarjan ridges, and those flanking Phulchok, are on synclinals. There would thus seem to be from the Pinouni into Nepal a repetition of the structural feature observed in the outer zone along the Rapti valley—an ascending section, only affected by minor foldings, through thinly bedded quartzose schists into a broad many-folded synclinal, in which an upper group of calcareous strata is frequently repeated at the surface. There is also sufficient likeness in the two series to suggest that they belong to the same formations, the most marked difference being the concentration of the calcareous element at the top of the southern section and its dispersion in the upper part of the northern one.

I would further venture to suggest that this series may be the continuation of the Krol and underlying formations of the Simla region. The flaggy quartzites of the lower horizons in the Nepal sections would very fairly represent the thin silicious beds that form so large a part of the Simla slates, or infra-Blini zone. Cases have, moreover, been recorded of the Krol limestone being represented elsewhere by more or less calcareous sandstone: a relation quite analogous to that now suggested between the strong quartzite and limestone of Bhainsi Daman and the calcareous quartzites of Nepal. Katmandu is in about the same zone of the mountains as Simla and Almora, being only thirty miles in a direct line from the plains. There are two points of contrast between the section here and in the Simla region, supposing the rocks representative: the contortion and the metamorphism of the strata in the latter position are local and partial, whereas in Nepal they are general and more or less complete. The limestone on the crest of the Chendragiri pass between Chitlong and Nepal is somewhat less altered than usual; in it I noticed some small facets of spar having a central puncture, and which I took to be crinoidal; but Dr. Waagen could not say positively that they were so.

On the north-north-east side of the valley the alluvial deposits rest against gneiss at the base of the Sheopuri range. The white patches so conspicuous along this edge of the valley are slip-faces in this rock where it is deeply decomposed. It is a coarse felspathic gneiss with much silvery mica and schorl. Its débris is a prominent ingredient of the valley deposits at Katmandu. On the spur north of Bodhnath and that connecting Sheopuri with Nagarjan, one finds very fine mica schists, first alternating with, and then succeeding to, the gneiss. The compression of the whole is so excessive and the underlie so variable, that it would be impossible to conjecture, without very detailed study, what the normal order of the strata may be. On nearing Nagarjan the underlie sets towards it; but the flaggy quartzites of Chitlong, which certainly underlie the calcareous zone, are not specifically recognisable in the short section between the limestone and the gneiss. In crossing the range northwards, schists are frequently observed with the gneiss, always intensely crushed; but the general strike of the Nepal rocks is maintained. At Chitrali Powah, some height above the north base of the range, the gneiss is permanently replaced by schists, which here have a decided southerly underlie towards the gneiss. The valley of the Tadi and that of the Trisal-ganga between Debighat and the Nyakot sango are in these rocks, variously inclined at high angles, but with an east-north-easterly strike.

There seems to be scarcely any specific resemblance between the Nepal section and that in Sikhim, beyond the undoubted equivalence of the tertiary sandstones at the foot of the range. The slightly carbonaceous band at the base of the section in the Rapti valley cannot be directly identified with the coal-measure zone to the east, the associated rocks being quite unlike the Damuda sandstone, in which the crushed coal occurs at the base of the Darjiling section. Bearing in mind the great distance (more than 200 miles) between the two, it is, of course, quite possible that true equivalence may exist, but from simple petrographical comparisons, the carbonaceous schists of the Rapti would be more like the similar rock in Mr. Mallet's Daling series, over the coal band. The chief discrepancy occurs, however, in the ascending sections: in one case we find massive limestone, in the other massive gneiss. It would be idle to speculate upon the possible reconcilement of those features from such very scanty evidence. One may only notice that although the degree of metamorphism has increased from Nepal to Sikhim (if, indeed, the prevalence of gneiss does require this assumption), the degree of disturbance is far less marked in the latter area, judging from published descriptions.

It is truly vexatious to think that the settlement of questions of such wide scientific interest should be held in abeyance to gratify antiquated and barbarous official prejudices or customs. I met with the greatest civility from the few country-people with whom I chanced to come in contact. The obstructiveness is entirely on the part of those in power, who think their own dignity enhanced by exclusiveness. The officials at Katmandu were most anxious to obtain from me some useful information regarding a sulphur mine recently discovered at the base of Gosain Than mountain, in the upper valley of the Trisal-ganga, or rather in the main branch of that river that does not flow from the sacred lake; but nothing could persuade them to allow me to visit the locality. Their state of enlightenment in such matters may be judged from the fact that they imported from England a number of Davy lamps to counteract the effects of the noxious gases or vapours pervading the mine, but which I could not make out from their description to be of the nature of fire-damp. For much formal courtesy received I would offer my thanks to Sir Jung Bahadoor.

To the foregoing sketch of the older rock formations I would add a few words regarding more recent deposits. I have said that the Nepal valley contains some 125 square miles of alluvial land, but in precise language I am not prepared to say to what extent those deposits are alluvial or lacustrine. They are, on the whole, analogous to the Karewah deposits of Kashmir, as partially described by Major Godwin-Austen; but there is here no present lake, however small, to suggest a formerly more extensive water basin. The sacred myths, of course, record that the valley was once a lake, and even account in the usual miraculous way for its mode of origin; so far as I could observe, however, the oldest temples were founded during the existing phase of the surface, which is one of arrested erosion of a once continuous deposit. The feature all over the valley is flat uplands separated by broad flat valleys, locally called *Tánr* and *Khola*, and corresponding exactly to the *Bhángar* and *Khádir* of the upper gangetic plains. There is much artificial terracing where the upland flats pass into the rain-wash slopes from the mountains; but I observed only one regular river terrace, that made by the actual course of the streams. Although, wherever a bend of the channel touches the edge of the upland, the side-erosion is still in progress, enlarging the area of the khola land, the rivers are not now lowering their bed. If any change is in progress, it is the reverse; the channels are very wide and shallow, and in some places at or above the level of adjoining cultivation. Such at least is the case above the gorge at Choubal; below it the channel is more confined, as occurs when a river is deepening its channel, in this position the upper surface of the valley deposits must be 500 feet above the stream, which gives a minimum thickness for the formation.

There are within the valley three remarkable instances of the rivers having cut deep narrow clefts through rock-barriers. The one just referred to at Choubal is the largest, where the united drainage of the main area crosses the point of the Kirthipur ridge. There is another much higher up on the Baghmati at Gaokaran, through the point of a ridge flanking Sheopuri; and a third at Pashpati, where the Bishenmati passes through a low isolated outcrop of rocks on the strike of the Nagarjan ridge. They are mere clefts, narrower than are at all usual in the most confined gorges. One must suppose that the bygone conditions which produced them were in some manner special, and connected with the production of the alluvial basin; *i. e.*, they can hardly be accepted as remnants of the primitive channel of the Baghmati valley, before that simple feature of denudation had been converted in its upper area into a basin of deposition.

It may be presumed that the valley of Nepal is a true rock basin—that the rock-surface beneath some considerable portion of the covering deposits is below the level of the outcrop at the head of the gorge of outlet. It would seem indeed to comprise a series of such basins: if the clefts through the several ridges, as described in the last paragraph, were filled up, this would certainly be the case now; and that such has been the case there can be no doubt, for the beds now forming the adjoining terrace-land above those gorges could not have been formed had these outlets been then available. Thus the excavation of these rock-gorges by the existing rivers accounts for the present features of the valley deposits, and gives some measure of the antiquity of those features.

The fact of a rock-basin, even of considerable depth, does not involve a water-basin. This would depend upon the relative activity of the production of the barrier and of the accumulation of deposits above it, which cannot be independently determined. The question must be settled by observation as to whether the deposits are alluvial or lacustrine, and of this the evidence is not very fixed or easy of application. The degree of horizontality is one of the best tests, but needs much caution and accuracy in applying it; the slope at which true alluvial deposition may take place being so small, and there being always a chance of a very slight movement giving a tilt to originally horizontal layers. There is, indeed, sufficient evidence that some such disturbance has affected these deposits in Nepal: at several points, south of Bhatgaon and in the Kátwaldár area, along the south side of the valley, near the base of the hills, I observed dips as high as 15° in fine deposits, directed from the mountain. I could find no such occurrence in exactly similar deposits along the north edge of the basin. It would seem as if the action which originally formed the rock basin had been again, or still, at work after the formation of some of the highest beds. Major Godwin-Austen records a similar feature in the deposits of the Kashmir valley: a dip of 20° and upwards on the south and none on the north (Quarterly Journal, Geological Society, London, 1864, p. 383).

There is, however, one observation showing that at many different levels the surface at the time of formation was not a submerged one. Beds of an impure peat are of frequent occurrence. I noticed them at the lowest levels exposed in the gullies close above the Kátwaldár gorge, and near the surface of the uplands north of Katmandu, and not confined to the edges of the valley. Thin layers of the same kind occur in Kashmir; but in Nepal they are thick, and pure enough to be much used for burning bricks. Such deposits are only compatible with swamping, such as is an ordinary concomitant of alluvial conditions. There is another deposit of extensive occurrence in Nepal, and of which I find no mention elsewhere. It is a fine stiff blue-gray clay, which is very extensively used all over the valley as a manure. Although it commonly contains particles of carbonized vegetable fibre, the little organic matter in it can hardly account for its fertilizing properties. This would seem to be due to the presence of phosphate: I noticed that blue specks of vivianite are freely scattered through the clay.

It will hardly be believed that I obtained no fossils from such deposits as these. I never was near a section without having a look out for shells, and I examined several spots carefully, without any success. This may be another argument for the alluvial mode of formation of the deposits, for certainly this process is not propitious to the preservation of organic remains. In extenuation of my failure I would mention that one of our best known Indian naturalists (Brian Hodgson) was for many years Resident of Nepal; he certainly would have at least noticed and recorded the fact had he observed any in the sections that confront one in every direction. The case is the more remarkable, since Major Godwin-Austen (in 1864) describes land and fresh-water shells as abundant in the Kashmir deposits. So at least it is in the south-east side of the valley; but in his first paper on the subject (in 1858), derived from observations on the north-west side, he remarks—"in all my wanderings amongst the Karewah Hills I never was able to find the slightest trace of a land or fresh-water shell in any of the many sections I have examined." I would urge the matter upon the attention of future dwellers in Nepal. The remains of mammalia or of plants would be specially interesting; and both might be expected to turn up occasionally in such beds as the peat and the phosphatic clay.

There is no temptation to attribute the rock-basins of the Nepal valley to glaciers. Even if it were proven that glaciers had extended to a much lower level, the form and conditions here are not such as would result from or account for the existing features through that agency. The valley is not in the course of any main drainage line; on the contrary, the watershed is closely restricted to the hills immediately surrounding, none of which are of great elevation. The valley is only a local exaggeration of what has occurred generally along this mountain zone. I have said that along the strike in both directions special denudation has taken place, which I have attempted to account for by the nature of the rocks; and in both directions we find the valleys more or less filled with deposits exactly like those of Nepal. The phenomenon is longitudinal with respect to the mountain system; and can be rationally understood as the effect of compression. The local yielding might be induced by the special excavation along this zone; and the effect would be a relative elevation of the ridges on the down side, producing rock-basins. It is an illustration of a process I appealed to last year in explanation of the cretaceous rock-basins in the Garo Hills (Rec. Geol. Surv. Ind., vol. VII, p. 62).

Although rejecting the intervention of glaciers in connection with the Nepal valley, I have been much puzzled with what I took to be glacial evidence elsewhere. Etoundah stands in the Dún exactly facing the gorge of the Rapti. The ground all about is strewn with great boulders, up to 10 feet cube, principally of coarse gneiss, high and dry above the present bed of the river, in which no such blocks are now to be seen. I came to the opinion that they must be glacial erratics; although the elevation of the locality is probably well under

1,500 feet. Proceeding up the valley I did not notice any such blocks up to Nimbuatanr, where the bottom of the valley is quite choked with an accumulation of similar blocks. These I took to be a later moraine deposit. Above this they become gradually concealed, as it seems, beneath lighter detritus, over which the stream runs for some way, and which passes into a great fan-deposit stretching across the valley from a lateral gorge on the east just below Bimphedi. Here the main branch of the stream runs upon rock at a much lower level, passing by a steeply cut channel along the west side of the valley. No great blocks appear in or upon this diluvial fan.

The case was not a little complicated at first by the fact that, along the whole valley of the Rapti and up to the crest of the Chessa-garhi ridge in which it rises, no gneissic rock was observed in place. The first rock of this kind crossed on the road is some way down the northern side of the ridge. The strike of the rocks, however, would take this gneiss into the ridge east of the road well within the head-waters of the Rapti; and from this source, it must be presumed, all the aforesaid erratics were derived. The highest point of the watershed of the Rapti must be under 7,000 feet.

It would hardly have occurred to me to question the glacial origin of those immense boulders had I succeeded in finding any confirmatory evidence of glacial conditions in the higher mountain region. If the Rapti valley were ever occupied by ice, the whole country to the north must have been in a similar state. Yet I have to record that throughout the rest of my trip I failed to find any symptom of such conditions. Thinking that the valley deposits of Nepal would be younger than the glacial period, and might cover its most characteristic remains, I searched for such at the deepest point of erosion, about Kátwaldár, but without success. I was more surprised, and should have been so independently of the suggestion in the Rapti, to find no signs of glacial action in the Trisal-ganga valley at Nyakot. This is one of the great rivers, draining from the Gosain Than, a peak of over 26,000 feet in elevation, and it must now be fed by immense glaciers: yet in a length of six miles, from Nyakot to Debi ghât, I could find nothing to suggest glacial action. It is true the same excuse would apply here as in Nepal; this portion of the Trisal-ganga valley is occupied by deposits, well stratified and with peaty layers very similar to those about Katmandu, the river only touching rock at a few points; still it were marvellous that no trace should be seen of such a glacier as must have lain here had the ice ever advanced to Etoundah.

Despite all this want of confirmation, I cannot declare finally against the glacial origin of the Etoundah erratics. I know that torrents can do wonders in the way of moving large masses. But it does not appear that the Rapti can now stir such blocks as these, much less pile them together as they are at Etoundah. The great block noticed in the Churiaghati pass may be a straggler from the Etoundah rocks, though I could not see any like it on the northern slope of the range.

I trust that these crude notes will be of some service in guiding future visitors to Nepal Even incorrect suggestions may lead to observations that would otherwise have remained unnoticed.

H. B. MEDLICOTT.

August 1875.

THE RÁIGARH AND HINGIR COAL-FIELD, *by* V. BALL, M. A., F. G. S., *Geological Survey of India.*

(*Second notice.*)

INTRODUCTION.

The following account refers to the south-eastern extension of a very considerable tract of coal-measure and associated sedimentary rocks which is situated in the south-west frontier districts of Bengal, and some of the north-eastern districts of the Central Provinces. The limits and consequently the contained area of this tract are at present imperfectly known, but not improbably the latter exceeds 5,000 square miles. To the whole the name south-west frontier coal-field might be given; but for convenience in the description of certain portions which admit of separate treatment, such names as Bisrampur and Ráigarh—Hingir have been employed in previous accounts.

The name Ráigarh—Hingir was first adopted in 1871 as being less likely to mislead than the old name Gángpur,* no portion of the field being in Gangpur proper. The extension of the coal-field, as ascertained during the past season, has not rendered any further change of name desirable, the States of Ráigarh and Hingir being sufficiently centrically situated in the now known area to furnish a suitable local name; but the fact that the area so indicated is not an isolated coal-field should not be lost sight of. To the west, through Udipúr, the coal-measures or their associated rocks spread continuously to Korba in Bilaspur, while to the north, through Sirguja, the connection is unbroken up to Rewa and the borders of Mirzapur.

The Talchir coal-field,† though quite detached, is only a few miles distant from the most eastern points of our field, and may not improbably have been at one time connected with it.

The area occupied by that portion of the coal-field to be described in the following pages has a very irregular outline. Save for two narrow prolongations which extend to the east of the Ebe, it may be said roughly to commence in the angle enclosed between the Ebe and Mahanadi rivers a few miles to the north-west of Sambalpur. Thence it spreads in a north-westerly direction, the southern and south-western limit being defined by a well marked and in part faulted boundary. On the north-east, for about twenty miles, the boundary has only been partially examined, but sufficient is known of it to show that it is of an unusually complicated and obscure character. Originally it is not improbable that the extension of the Barákars was limited by the tolerably regular cliff of a low plateau of metamorphic rocks; but at the present time a considerable thickness of a newer series of rocks laps over this boundary and forms the hilly and difficult country of northern Raígarh and Hingir, thus concealing the edges of the Barákár rocks.

The reasons for supposing the Barákars not to have extended much further north are, that in a line with the bounding, uncovered metamorphics of the north-eastern corner of the field, exposures of the same rocks are found at intervals, as we proceed westwards, paving the deep-cut valleys between the ranges of upper sandstones.

How far these upper sandstones stretch northwards through Serapgarh is not known. It is possible that they conceal some small detached basins of Barákars. Thus far for twenty miles of the northern and north-eastern boundary, but for thirty miles further, until Rabkob on the Mand in Udipúr is reached, no northern limiting metamorphic rocks have been met with as yet.

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* Records No. 4, 1871, p. 101. All previous notices of the field will be found mentioned in that paper.

† Described in Mem. G. S. I., vol. I.

In the present account the coal-measure rocks which occupy the valley of the Mand and stretch thence to Korba are not described, as they have not been fully examined. They extend over a considerable area and contain many seams of coal.

I.—General Geology.

The rocks which occur within and in the vicinity of the coal-field belong to the following series and groups:—

Metamorphic Series.
Vindhyan „
Talchir „
Damuda „
Barákar Group.
Upper sandstones or Hingir Group.
Laterite.

The rocks of the metamorphic and Vindhyan series, which surround and underlie the coal-field, are not described at present, as the examination of them has been limited to the immediate vicinity of the field, and no general exploration of them has been yet attempted.

The Talchir series does not in this area attain any great thickness. Probably 250 feet is its maximum, but this estimate, in the absence of reliable *data*, is, it must be admitted, purely conjectural.

The rocks constituting the Barákar group are, I believe, of much less thickness than in the Damuda valley coal-fields; but there are no sections which would justify any definite statement.

The upper sandstones, for which the temporary and local name of Hingir group is used without prejudice to their future relegation under one of the titles used for similar rock elsewhere, may in places exceed 1,000 feet, but that is, I believe, a fair average. It has been arrived at from the measurement of horizontal beds from the level of the Barákars to the tops of the highest hills.

The thickness of the laterite seldom exceeds 60 feet. Generally it is much less.

II.—Talchir Series.

Within the area under description, the rocks which belong to the Talchir series do not anywhere attain any very great importance either as regards their thickness or the area occupied. As to the amount of the former, only an approximate and very rough estimate has been offered, no measurable section being exposed. Of evidence of faulting along the boundaries, except in the case to be hereafter mentioned, there is none. On the whole, it would appear that the representatives of this series merely occupy originally shallow and more or less detached depressions in the metamorphic rocks, and before any marked disturbance or denudation took place, were covered up and overlapped in most instances by the Barákars. One well marked case, at least, occurs, however, where Talchirs are immediately superposed by the upper sandstones, no trace of intervening Barákars being found.

In their lithological characters the Talchirs of this area conform closely to the well-known types, as will be seen from the following detailed descriptions.

For purposes of reference it will be convenient to refer to the several areas of Talchir rocks which occur along the margin of the coal-field by the names of the principal villages or rivers within their limits. Thus denominated they would stand under the following heads:—

Sasun—Remra. This area occupies an irregular strip of country which stretches from a few miles east of Sasun* westwards to beyond Remra, in all for a distance of about twenty miles, and with a breadth of from three to six miles.

* Sasun is about eight miles north of Sambalpur.

In the neighbourhood of Sasun the rocks are much concealed by alluvium and laterite, and the exact position of the eastern boundary is from this cause somewhat uncertain. Both to the north and south of Sasun short sections of sandstones and shales are seen. Some of the beds of the former are tolerably thick, and one, a bluish-grey fine-grained rock, has furnished both building stone and material for vats used in lac manufacture. So far as it is seen, the boundary appears to be quite natural, following the irregular edges of the basin of deposit. West from Sasun, and on both sides of the Ebe, laterite conceals the Talchirs to a very considerable extent; though in this particular section of the country it is not abundant on the older rocks. There is sometimes, for several miles together, a most remarkable coincidence between the Talchir-gneiss boundary and the edge of the terrace-like spreads of laterite. So much is this in some places the case, that one can follow the boundary with the eye from a distance by means of the raised banks of laterite which terminate abruptly at the junction of Talchirs and gneiss. Of the cause of this I am at present unable to offer even a plausible explanation, and must therefore confine myself to the simple record of the fact.

The greater part of the bed of the Ebe, where it traverses these rocks, is one unbroken waste of sand; but there is a short section of sandstones and shales, with a dip of 8° —15° to north-north-east, at the bend near Mangalpur. Here, too, in the bed of the channel, there is a boulder bed, the boulders in which are not very numerous nor of large size, but they can be seen sticking out of the silt here and there underneath the clear waters of the river.

In the country to the west of the Ebe so complete is the covering of laterite, that exposed outcrops of Talchir rocks are only very occasionally met with. In the eastern branch of the Kadam river at Gorgoda and Bodopali, and in the western at Binki and Bolunda, there are short sections, and the existence of a spur of metamorphic rocks running into the main Talchir area is rendered apparent. Half a mile north of Binki there are seen, in the high ground, shales and thin sandstones with a dip of 30° to north-east which has been caused by some very local disturbance.

At Remra (Remda of map) there is an inlier of metamorphic rocks whose boundaries are much concealed by laterite. From this westwards, the Barákars, which first appear overlying the Talchirs at Telunpali, gradually lap over, and before Borkhol is reached all traces of Talchirs at the southern boundary have disappeared. This total disappearance is, however, probably not exclusively attributable to overlap, as the boundary appears to be a faulted one, and a portion of the originally existing Talchirs may have been cut off. In the stream west of Dagarmunda the Talchirs for a short distance dip away from the gneiss at an angle of 60°.

A small outlier from this area of Talchirs exists in the valley of the Ebe near the villages of Taldi and Terda. The rocks seen are shales and sandstone.

This area covers something under one square mile, and was in all probability, judging by the character of the surrounding country, originally, as it is now, quite detached from the main mass.

KIRARAMA—PUTRAPALI.—Some eight miles to the north of the strip of Talchirs mentioned above, a second spur-like eastern prolongation of the field crosses the bed of the Ebe. Although Barákars are the principal rocks seen, indications of underlying Talchirs are not wanting at the margins. The first of these is at Kirarama. The principal rock is a boulder bed which is exposed at the foot of some small laterite hills to the east of the village. The boulders consist of jasper-conglomerate, quartzite, &c., all of quite foreign origin. The boundary here is not improbably natural, the beds appearing to rest against hornblendic gneiss, a section of which is seen in the bed of the river. To the south and west the boundary is much concealed by laterite.

Apparently disconnected from this patch, Talchirs again crop out from beneath the Barákars in the bed of the Ebe below Ramesur, where there are green sandy shales with a low dip to north-east. Further east, in the village of Putrapali, sandstones come to the surface. To the north-east of that village, in heavy jungle, there is a ridge of pseudomorphic quartz which is not improbably connected with some faulting, but I failed to discover its character owing to the laterite covering. South-east from Putrapali, along the boundary, small outcrops of shales are seen at various points; and beyond Burimal, in the high ground, there are some considerable lenticular masses of limestone included in the beds of silt. Further east from this, detailed examination was not continued, but Talchir rocks were observed at Bursipali and Rurimoul.

RAJPUR.—On the northern boundary of the above mentioned spur, Talchir rocks appear in the vicinity of Rajpur, especially in the Godadia near its junction with the Baisunder, where there is a short section of shales and boulder bed, the latter resting naturally on gneiss. In the Baisunder, too, close to the junction, there are some sandstones with a dip of 5° to the south-west. In the bed of the Ebe the rocks are for the most part concealed by sand; but at Degam, on the western bank, there are short outcrops of shales and sandstones.

To the south-east, at Singaboga, some fine sandstones and shales are exposed, otherwise there are no other outcrops, and it would appear that at Chaltikra the Talchirs are completely overlapped by Barákars.

GARGANBAL.—Further north a narrow strip of Talchirs occurs on the boundary near Garganbal. The lowest bed is generally formed of arkose, as I found to be the case a little further north at Kosira on the Baisunder.* It rests naturally on the gneiss.

SAMBULPURI.—Passing now to the southern boundary of the field, a narrow strip of Talchirs is met with between the villages of Jamga and Laka. In some places, as to the south-west of Badpali, they dip away from the gneiss at a high angle. Sambalpuri is situated at about the centre of the area, and in its vicinity are the best sections. In some the beds dip at a high angle from the boundary.

A little beyond Laka these rocks are overlapped by Barákars, which are again, themselves, covered up by the upper sandstones.

Still further west is the area which may be conveniently indicated by the name of the river.

KURKET.—On the east and north the Talchirs of this area are bounded by the upper sandstones. Possibly the eastern junction may be faulted, but it has not yet been fully examined. On the west they are bounded by Barákars and on the south by gneiss. Close to Lotan there is a fine boulder bed.

III.—DAMUDA SERIES— BARÁKAR GROUP.

In describing the Barákar rocks of this field, we have to deal with a number of detached or semi-detached areas. Those on the north have been partially or fully described in the already published report on the Baisunder and other river sections, and the area in the Mand valley, and thence westwards, has only been partially examined. As neither it nor the Baisunder section were visited during the past season, they will not be alluded to further here.

VALLEY OF THE EBE AREA.—Commencing on the extreme east of the known extension of this area, a narrow strip or spur of Barákar rocks is found in the vicinity of Lupunga, where they are horizontal and much concealed by superficial deposits. Towards the north, the junction with metamorphics, as seen at Bomali, is quite natural, the Talchirs being com-

* *Vide* Records Geological Survey, India, 1871, p. 102.

pletely overlapped. On the south, however, there are indications all along the boundary, from Bursipali to the Ebe, of underlying Talchirs.

Proceeding westwards, the northern boundary is found to strike obliquely across a great loop bend of the Bonum river at Chalitikra, but the lowest seen sandstones there seem to be Talchirs. Between this loop and the Ebe, the country is very hilly and uneven. The rocks are coarse sandstones and conglomerates, some of the beds being of considerable thickness. As seen in the neighbourhood of the old fort of Rampur, in the Ebe section and in the country further west, some of these rocks resemble the upper sandstones of the Hingir group; but after full examination I am inclined to refer them to the Barákars. Brown hæmatite iron ore is very abundant, and especially so to the east of Ramesur. It does not appear there, however, to constitute any definite continuous bed, but to occur rather in concretionary nests and bands in the sandstones. Fragments of ore from this source spread over a considerable surface, and give the appearance of an abundant supply, especially in the valleys where they have accumulated for ages. Iron is manufactured at Chalitikra, and was formerly at Rampur, where there are still considerable heaps of slag to be seen.

Some of the conglomerates seen here consist of pebbles in a matrix which is barely sufficient to bind them together. As this matrix is often removed at the surface, the hills of conglomerate look simply like piles of loose stones, not a sign of consolidated rock being apparent. The bed of the Ebe affords no continuous section of these rocks, the few outcrops being for the most part separated by long stretches of sand. As, moreover, the beds are here horizontal, or nearly so, nothing of importance regarding their thickness can be made out. Opposite the mouth of the Bonum river, a cliff of sandstones covered by conglomerate rises to a height of from 50 to 60 feet. These rocks, though not exactly like the usual types of Barákars, from their position and physical relations, should, I think, be referred to that group. The rocks of this horizon can be traced north and south over about ten miles, from the neighbourhood of Cherla to Bograchaka; they form long low ridges with a very slight dip to the west, which carries them under the more typical Barákars containing coal and some ironstones which are about to be noticed. Between the Ebe and the boundaries of the upper sandstones underneath which the Barákars disappear, rivers and streams occur in abundance, but in two only have any traces of coal been met with.

THE LILLARI RIVER.—This river, like many others, takes its rise close to Hingir, and joins the Ebe, after a course of about twenty-five miles, near the village of Balput. Following it up from its junction, in the first two miles or so, metamorphic rocks only are seen, but beyond them Barákar sandstones are exposed, and appear at intervals up to Durlipali, where there is a seam of carbonaceous shale and coal, of which the following is the section, *descending*:—

Top denuded.

		Ft.	Inc.
1.	Slightly coaly blue and black shales	9	0
2.	Black carbonaceous shale with flaky coal	6	6
3.	Concretionary blue shales	1	3
4.	COAL (*Vide* Assay, p. 120) contains much iron	2	6
5.	Blue concretionary shale with coaly layers towards top and bottom	5	6
6.	Slaty carbonaceous shales, portions coaly	3	0
7.	Ditto ditto the coaly portion confined to thin layers of 1-3 inches thick	12	0
8.	Blue concretionary shales	1	6
9.	COAL fair (*Vide* Assay)	1	0
10.	Blue concretionary shales	2	0

Base concealed.

Coal from No. 4, brought to camp, burnt indifferently, leaving a considerable ash. From No. 9, the coal is much better; a *garah* full when roasted gave out a luminous flame 18 inches long (with a 1-inch diameter burner) which lasted for an hour. Most of the residue was partially caked. Higher in the section there is a bed of tesselated ironstone which seems to be continuous at that horizon, being seen again at Choakani, five miles to the north, and also in the intervening country. North of Kodaloi there appears to be a second ironstone zone which includes a better quality of stone. This zone is also seen further south, one mile to the west of Rugonathdera. The rocks throughout this region are much concealed by laterite.

Seam.

Two miles further up the stream, near Khairkoni, the top 2 feet of a coal seam are exposed. For four miles further, up to Chamri-mahal, the bed of the river discloses a much broken section of sandstones and carbonaceous shales, which in places roll slightly, but are otherwise horizontal. Beyond this the sandstones of the Hingir group are alone found.

Seam.

BAGDIA RIVER.—About half a mile from Ailepur (Lakenpur) the top of a seam is seen in the river. Owing to water and shifting sand I could do no more than prove the existence of at least a foot of fair coal which burns freely, leaving a flaky ash. What the total thickness of the seam may be it is impossible to say at present. In the country to the east there are some ridges of ferruginous sandstones which may, perhaps, be in part prolongations from the main area of upper sandstones, but I was unable to separate them from the underlying Barákars with any degree of certainty. Leaving for the present the description of the strip of Barákars which extends from this neighbourhood through Borkhol along the south of the field, that which occurs along the north-eastern boundary may be most conveniently disposed of. Close to Ratakand, a small village on the Godadia, the Barákars, which further south are covered up by the sandstones of the Bilpahari range reappear, and form an irregular strip which is continuous up to the Baisunder, where the coal-measures, described in the previously published notice of this field, occur. On its eastern side, the Barákars occupying this strip rest naturally upon the metamorphic rocks, an arkose bed being not unfrequently found at the base. On the western side the irregular outline formed by the foot of the upper sandstone highlands of Hingir constitutes the limit of exposure. In the river at Dúlúnga, to the south-south-west of the village, there is a coal seam of which the following is a section of the portion seen, *descending*:—

Seam.

		Ft.	Inc.
1.	Black and grey shales		10
2.	Hard stony COAL		6
3.	Flaky COAL		2
4.	Grey and black shales		4
5.	Flaky shales, coaly in parts	1	10
6.	Blue and grey shales	1	0
7.	Stony COAL and black shales	1	4
8.	COAL		4
9.	Stony COAL and black shale		7
10.	COAL		7
11.	Shale	1	4
		8	10

Further down the stream some higher layers of carbonaceous and coaly shale belonging to the same seam are imperfectly exposed.

To the north of the village there is a seam seen, at the road crossing, which contains about six feet of coaly shale and coal, the dip being 5° to south. In the section of rocks below this, that is to say, further up the stream, the boundary is seen to be perfectly natural; gneiss being exposed in the bed and sandstone in the overhanging banks. From this northwards the relations of the rocks are for the most part obscure and the western boundary is very intricate. In the Barákars to the south of Kiripsira, black shales and ironstones occur. On the Garganbal and Bagbura road, east of the boundary, in the first stream crossed, there is a bed of arkose which seems to be detached from the field. Beyond it for the next mile or so, the granitic gneiss rocks which occasionally appear are much covered by loose boulders which in their miscellaneous and foreign character resemble those found in the Talchirs. In all probability they were derived from a Talchir boulder bed of which no other trace is left now.

SOUTHERN BOUNDARY.—Passing now again to the south boundary at Borkhol. In speaking of the Talchirs it has been pointed out that they disappear on the boundary at this point, being much overlapped, and having probably been in part cut out by a fault which appears to have formed the present southern boundary and limit of the field. At Singapur the area occupied by the Barákars does not exceed about half a mile in width, and as they rest nearly horizontally on Talchirs, the evidence of extensive overlap by the upper sandstones is complete. West from Borkhol, where the Talchirs are not found on the boundary, their apparently diminished thickness might be attributed to the fault having cut out lower beds, but here it is quite clear that, unless there has been great natural and original thinning out of the upper beds of the Barákars which are seen in the Ebe valley, their edges must be completely overlapped by the upper sandstones.

From Borkhol the faulted boundary runs in a steady north-westerly direction for nearly forty miles, and with it for thirty miles, a valley which presents a wonderful degree of uniformity throughout. On the one side, outside the fault, are ranges and sometimes low ridges of metamorphic or other old rocks, on the other the scarp of the sandstones forming the Hingir plateau. The bed of this valley being coincident, or nearly so, with the base of the upper sandstones, the Barákars, and sometimes the Talchirs, form the floor. Although many rivers and streams cross the valley at right angles, there is such an accumulation of superficial deposits, that sections, showing the character and relations of the rocks are of extreme rarity. The bottom of the valley, almost throughout, may be described as one succession of *paddy* fields. The origin of this state of things is quite obvious. The valley, in the first instance, scooped out by lateral streams along the faulted junction, has subsequently served as the repository of the solid substances brought down by the rivers, which, coming from the highlands of comparatively soft sandstones, find themselves suddenly arrested by the metamorphic rocks through which they have only been able to cut narrow gorges.

At Borkhol itself no rocks are exposed in the valley; but further west, south of the village of Durga, sandstones and gneiss are seen in close proximity to one another, though no actual contact is exposed. To the west of Kutrapali there are some ferruginous Barákar sandstones with ironstones, which also extend northwards up into a bay to the north of the village. Proceeding in the same direction the same rocks are met up to Dibdorah, with the addition, at that place, of coal which crops out underneath the waters of the Hingir river. An excavation which I had made in this seam proved a thickness of at least 6 feet 6 inches down from the denuded surface. Of this thickness, all, except the lowest foot, consists of very fair-looking coal. So far as appearance goes, it is certainly the best which I met with in the field. The dip is about 5° to north-20°-east, or from the boundary. What the total thickness may be I had no means of ascertaining.

Seam.

Higher up the river, close to the foot of the falls over the upper sandstones which are described on a following page, the Dewan of Kodibuga pointed out to me some fragments of carbonaceous shale which he said had been there for several years. Whence they came I am quite uncertain. There may possibly be a seam at the foot of the falls covered up by water and fallen blocks. Certainly in its higher reaches the river does not cross any Barákar rocks, and I found no trace of carbonaceous matter in the stream above.

Between Jhargaon and Dibdorah, the sandstones, wherever seen near the boundary, as also the coal at the latter place, exhibit no trace of great disturbance at their edges, having, apparently, when faulted, gently subsided into their present position. Neither at Dibdorah nor Jogidhipa are junctions disclosed by the rivers. Between Dibdorah and Jogidhipa the Barákars are of the same character as those between the former and Jhargaon.

At Jogidhipa, the scarped hills, which further east marked the limits of the upper beds, locally die away, and physically it seems possible that the rocks exposed for some distance to the north might be Barákars, but lithologically they appear to belong to the upper group.

Continuing along the valley we find at Lipuspali, north of the village, dark colored sandstones which appear here to form the base of the upper series. No Barákars are seen, though they doubtless exist under the alluvium. Before reaching Manwapali, Talchirs are found to come in again, forming a narrow strip along the boundary and leaving but very little room for the Barákars to occupy.

In the Supnai west of Bhogra (Basunpali of map*), at the base of the section, there is a short thickness of sandstones, apparently Barákars, which dip from the boundary at an angle of 30° to north; the overlying rocks, too, are also locally disturbed. Between Bhogra and Sumbulpuri the position of the Barákars is marked by ironstones, which are seen near the village of Badpali. At Sumbulpuri, if the coarse grits seen in the river section dipping at angles of from 30° to 45° from the boundary be not referable, as seems probable, to the Barákars, then that group must be here reduced to very narrow limits. At Danot the upper rocks come close to the north of the village, while Talchirs crop out on the south; but there is room for a small thickness of Barákars. In the Kelú section between the gneiss on the one hand and brownish-red upper sandstones on the other, a concealed interval affords room for both Talchirs and Barákars. One short outcrop of Talchirs is seen close to the road crossing.

Had I not known something of the upper reaches of the Kelú, the occurrence of fragments of coal in the bed of the river, as it issues from the upper sandstone hills, would have been a puzzle involving much fruitless search. It is evident that these fragments have travelled from the seams which the Kelú traverses far to the north near Tamar and Jhargaon.

Between Laka and Cheripani, an interval of only about 150 yards exists between these upper sandstones and the Vindhyan quartzites. In this interval laterite and a recent conglomerate are the only rocks seen. Further west from this I did not meet with the slightest trace of Talchirs, and the lowest sandstones seen are not, I think, Barákars, so that both series are again most probably cut out by the fault which hence westwards runs between quartzites of Vindhyan age and the sandstones of the Hingir group.

GARJAN AREA.—To the north, under the Garjan hill in Hingir, some carbonaceous rocks, probably Barákars, are exposed in the streams. This area has not been examined as yet in detail.

NORTHERN RAIGARH AREA.—This is an area of Barákar rocks of which upwards of 200 square miles have been examined. It is situated in the north-eastern corner of

* The names of all the villages in this part of the valley are misplaced on the map.—(Atlas Sheet).

Ráigarh. On the east, south and west it is surrounded by hills formed of the upper sandstones, under which the coal measures pass.

To the north the limits have not yet been ascertained, but from the sections which have been examined, and from the general physical structure of the country, it is probable that, with a few exceptions in the valleys, where contacts of the Barákars with the underlying metamorphics are exposed, the edges of the former are overlapped by the upper sandstones.

In this central area, the Barákar rocks, which from their position are probably the top measures of the group, differ materially from those met with in the Ebe valley to the east. Instead of coarse sandstones and conglomerates, there are fine sandstones with much carbonaceous shale and some coal. In all probability the coarser rocks occur below, and indeed to the north some of them are seen cropping out towards the boundary. In the Baisunder section†, on the other hand, it would appear that the coarser rocks never were deposited, as only a small thickness of sandstone and arkose intervenes between the carbonaceous shales and gneiss.

In the western part of our area the Karket river collects the drainage and affords tolerable, though much interrupted, sections.

KARKET RIVER SECTION.—That portion of the Karket which traverses the upper sandstones will be found described on a following page. In so far as the Barákars are concerned, it is only necessary to describe the descending section which is exposed between Báiámundá and Karamakel.

The highest rocks seen are some sandstones with three bands of carbonaceous shale, which measure respectively 2'., 3'. and 3'. 6.", the dip being 5° to south-west, which carries them under the horizontal upper sandstones. Some ironstones seen to the south of Báiámunda, but not exposed in the river section, not improbably constitute the top beds.

Not far from the mouth of the Katang stream the top of a coal seam is exposed which measures about one foot. For about half a mile north of the Katang there are massive sandstones, the relations of which to the more typical Barákars are somewhat obscure: at first it appeared probable that they might be upper beds resting in a flat synclinal, but subsequently seen cases of similarly situated and similar rocks, suggested that they were only locally interpolated beds.

Seam.

Beyond these again there are thin bedded sandstones with shales more or less carbonaceous, having a low dip to south. Less than half a mile to the south of Suadera there is a coal seam which contains only eight inches of good coal with a dip of 5° south-west.

From this up to the mouth of the stream which rises in the Duldulla H. S., the only rocks seen are thin bedded sandstones and carbonaceons shales, which vary a good deal in the direction of their dips on either side of south, but not much in the amount, never ranging above 10.° There is nothing that can be called coal exposed in this portion.

At the stream, however, there is a seam of which the following is a section :—

	Ft.	Inc.	
Massive sandstone, about	25	0	
Shale		?	
COAL	1	7	
Shaly parting	0	9	
COAL...	0	5	
Carbonaceous shale with coaly layers	4	8	
COAL	3	0	seen.
Base hidden; dip 3° S. S. E.			

† Records, Vol. IV, pt. 4, p. 105.

The overlying bed of sandstone is seen lower down the river to break up into several smaller ones in consequence of the interpolation of carbonaceous shales; thus bearing out the view taken above of the bed seen near the mouth of the Katang.

Further north from this I did not continue detailed examination, but fragments of coal are abundant from the higher reaches, and the Barákars extend at least as far north as the valley surrounding Kurmukel (sheet 59 *a*, old series).

In the Katang stream, from Kassia to its junction with the Karket, there are carbonaceous shales with sandstones, and the massive bed previously mentioned. Some fragments of coal were seen, but no exposed seam could be found.

Throughout the country between the Karket and Pazar the rocks are much covered, and there is nothing of particular interest to be noticed.

PAZAR RIVER SECTION.—At the junction of the Barákars and upper sandstones, where this river enters a gorge through the hills to the south-west of Kasdol, the former show signs of local disturbance, and the bed, which is a few feet from the junction, dips away from under the overlying horizontal sandstone in a manner which is suggestive of unconformity. There being no actual superposition, this section cannot perhaps be considered conclusive, and causes other than original unconformity may have produced the present appearance. Taken in conjunction, however, with other evidence of unconformity to be given further on, this section assumes some importance. A short distance up the stream there is a seam of which the following is a section:—

	Ft.	Inc.
Sandstone	0	6
Shales	7	0
COAL	1	5
Black shale	0	5
COAL	1	0
Shales, portions coaly.		

For the remainder of this section up to Pondripani there are fine sandstones and carbonaceous shales, the latter with occasional layers of coal, as at Putrapali (8″) and at Pondripani (2″). There is much false bedding and interpolation in this section. In the Digi stream the section is similar. A seam of 6″ of coal is exposed at Deogur. The Kelu river section up to Tamnar also exposes the same kind of rocks with no coal of workable thickness.

The Kelu section beyond this up to Khara was described in my previous report. Resuming, therefore, at that place, we find that for nearly two miles hardly any rocks are seen, but beyond that there is a tolerably continuous section of sandstones and carbonaceous shales The first seam measures, descending, dip 5° south-west:—

	Ft.	Inc.
COAL	6	0
Shales	3	6
COAL	1	0

The coal is probably of rather inferior quality, but in its weathered and water-logged condition it is not possible to form a conclusive opinion. The next seam of any importance measures about 17′. The coal is in thin layers of less than a foot, alternating with shale, dip south-south-west. Beyond this there appear to be some other seams; but they are not well exposed. North-west of Pelma two flat seams are exposed. Their thicknesses seem to be about 6′ and 4′ respectively. The coal may be of fair quality. These seams are also seen in the broken ground east of the river, where the thickness may be somewhat more. For three miles further I followed this section (into Sheet 52), the Barákars continuing steadily in the bed of the river, while the hills on either side were of the upper sandstones. Fragments of coal were still to be seen at the furthest point reached; but from the abundance of gneiss and jasper-conglomerate pebbles, the metamorphic rocks cannot be very far distant. The jasper may not very improbably be derived from Talchir beds.

The Pelma-Milupara valley is one of several along this frontier where denudation has removed the upper sandstones, thus forming a vast amphitheatre in which Barákars form the floor. A considerable accumulation of alluvium occurs in this valley; it is much cut up by ravines, and consequently difficult to traverse. As it was impossible to take the camp beyond Milupara, much time was wasted in going to and fro. To draw a satisfactory boundary at the foot of the hills would require close and very detailed examination.

BENDIA RIVER SECTION.—In the portion of this river not previously examined,* between Kornkel and Janjghir, for the first three miles the rocks are much covered, after which there are coarse sandstones with a succession of seams containing coal in bands of from 2′ to 3′. None of these seams are well exposed, as they are for the most part flat, and it is impossible to speak decidedly of their value. It is not, however, at all improbable that good coal in workable quantity may exist. At Janjghir the Barákars abut against gneiss, and are in places covered by upper sandstones which cross the boundary. In some cases the bottom beds resting on the gneiss in the Janjghir valley may be Barákars; but the cases are doubtful. To the west of the village a pebble conglomerate bed can be traced from off the metamorphics on to undoubted Barákars upon which it appears to rest unconformably, but the section is not quite clear. In one place in the river it is seen distinctly overlying a coal seam with associated Barákar sandstones. This seam measures—

	Ft.	Ins.
COAL, about	0	8
Parting	0	3
COAL	1	0

I think the conglomerate must be referred to the upper series.

In the bed of the stream on the hill side, at the head of this valley, I found some fragments of black shale, which appear to have come from the upper beds. As will be noticed further on, a similar case occurs to the east, in the valley of the Bendia.

From the preceding it will be seen that there are no *data* sufficient for forming an opinion as to the total thickness of the Barákars, but that there is strong evidence of great irregularity of deposit.

On the prospects of coal being found in useful amount, I shall speak in the section on economic resources.

IV.—UPPER SANDSTONES, OR HINGIR GROUP.

Resting upon the Barákar rocks is a group of beds differing from them in their lithological characters, and containing certain fossil plants which have in no part of the country been found to occur in rocks of the Barákar horizon.

With rare, and perhaps even somewhat doubtful exceptions, this group does not include any carbonaceous deposits. In the fossil plants the carbon has been all removed and replaced by iron.

In some of the sections described on previous pages evidence is given of the extensive scale in which the Barákars have been overlapped by these younger rocks, At many places along the southern boundary of the field, as, for instance, at Singapur and Borkhol (*vide* p. 108) the area occupied by the Barákars is reduced to very narrow limits. Again, near the Kurket

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* Vide Records, 1871, pp. 105-6.

these upper rocks rest immediately on Talchirs, and along the northern boundary not unfrequently upon gneiss.

Unconformity.

Although the junctions between these rocks and the Barákars often appear to be quite conformable, certain observations seem to indicate that some unconformity between the two does exist. No actual section exhibiting unconformable superposition can be adduced, however. The nearest approach to it is perhaps the case above mentioned, where, close to Janjghir, a pebble conglomerate was traced off the gneiss on to Barákars upon which it appears to rest unconformably, but owing to some false bedding, the section is not quite clear, and should not, perhaps, be regarded as crucial. In the Pazar river section (page 111) there is the already noticed case of disturbed Barákars occurring close to the junction with the massive horizontal upper sandstones.

Passing from these individual cases, which afford evidence of only doubtful value, to the more general relations existing between the upper sandstones and the Barákars, we find that, taken as a whole, the latter exhibit an amount of rolling and disturbance of which the upper beds show no trace whatever.

The great amount of false bedding in the Barákars, noted both in this and the previous report, and the overlap, are quite sufficient to account for the fact that the beds of Barákars appearing from underneath the sandstones vary much in character in different parts of the field. At Lipuspali, for instance, there is a coal seam only a few feet below the red shales. Yet no sign of this coal seam appears in any other section. But when the facts observed in the tract of country indicated as the northern Ràigarh area (p. 109) come to be examined, it is difficult to imagine any cause other than unconformity as being able to produce the relations which exist there. Denudation has in that part of the country cleared away the upper rocks and formed an extensive basin where upwards of 200 square miles of Barákars are exposed. Numerous more or less continuous sections of these rocks are afforded by the rivers which run from north to south; but the best is that in the Kurket. In that river from south to north there is a steadily descending section, which is sometimes complicated by local rolls, but which must represent several hundred feet in thickness. The crumpling and rolling and the dips,—the latter in places attaining as much as 10°—are incompatible with the idea that these beds are merely in their original position of deposit on a sloping surface. Several of the coal seams dip at angles of 5,° which, small though it be, can scarcely have existed at the time of deposit. From its very nature and generally accepted origin the coal must have been at first horizontal, or nearly so.

In the surrounding rocks which form the ranges limiting the basin, and in three inlying hills or groups of hills known as Gid, Duldulli, and Kolam, no evidence of similar rolling and crumpling is apparent, while the sections, so far as they go, induce the belief that these outliers rest on the edges of different portions of the Barákar succession. From the interpolation and false bedding, which, as has been alluded to, characterise these Barákar rocks, no actual conclusion could be drawn from observations on the difference in charactar of individual beds which are immediately covered by the upper sandstones. Indeed, the overlap alone would be sufficient to account for such differences as have been observed. It is therefore necessary to confine the evidence for the unconformity to the more general characteristics of the two series, all small sections being, for the above given reasons, unreliable.

Examined closely, the upper sandstones exhibit no signs of disturbance and appear to be quite horizontal. On some of the scarped ranges where the view takes in several miles, a slight southernly trend can, however, be made out, but no rolling corresponding to that in the Barákars at the base. Whether the rolling and crumpling in the thin beds is in any degree due to the pressure of the great mass of hills—which would in that case have been produced subsequently to the denudation—may perhaps be a subject for speculation; but even supposing that a certain amount of disturbance may have been due to this cause, the general steady succession of beds from south to north, and the fact that the sandstones rest upon different members of that succession in different places, must, I think, be regarded as indicating a period of disturbance and denudation between the deposition of the two series of rock. It may be added that whereas we find in the case of the Janjghir section, already alluded to, the upper sandstones passing from Barákars (at the base of the group) on to gneiss, the same rocks cover up the highest members of the Barákar succession which are exposed on the southern limits of the Barákar area between Bijana and Deogaon.

In their lithological characters these beds differ in a marked degree from the Barákars. The first thing which strikes one about them is that they almost invariably present a reddish aspect from the freely disseminated iron. Be they conglomerates, sandstones, or clay shale, the presence of iron is generally prominently apparent. The soil, too, which is derived from their decomposition, is nearly always red and sandy. Notwithstanding this, ironstones of good quality are very much less frequently met with in this group than in the Barákars.

I have been unable to see that the beds of different lithological characters occupy any definite succession. The red clay beds particularly seem to have a very capricious distribution. Though not always present, they are generally found among the bottom beds of the group. Towards the top, too, they not unfrequently occur. In the centre they appear seldom. Often where one would expect to see them, they do not show the slightest indication of their presence. Conglomerates and sandstones alternate with one another without showing any regular sequence so far as I was able to make out.

The conglomerates consist chiefly of small rounded quartz pebbles, bound together in a sandy ferruginous matrix with a varying amount of felspar. The pebbles rarely exceed 6 inches in their greatest diameter, and sometimes they are uniformly, throughout particular beds, not larger than small marbles. Occasionally the pebbles are of gneiss. This is, of course, most frequently the case when the underlying rocks belong to the metamorphic series.

The sandstones vary much in texture and color, but really fine-grained sandstones are rare, and white, or even grey looking, rocks are of unusual occurrence. Sometimes beds occur, both in the case of conglomerates and sandstones, which it is not easy to distinguish from Barákars. In such cases traces of associated carbonaceous beds are anxiously looked for as affording an almost infallible test of the age. The beds of sandstones, as may be seen in the scarped sides of the hills, occasionally attain very considerable thicknesses, narrow partings of shale occurring at distances of from 20 to 40 feet. The most common form of sandstone is a rough brownish grit, which, even when under the constant action of running water, seldom shows a clean or smooth surface. Carbonate of lime is not often present in sufficient quantity to give rise to any marked form of chemical weathering. Mechanically formed pot-holes are, for some reason which I cannot explain, less common than in the Barákars.

Shales or clays, generally red and sometimes passing into ironstones, include all the remaining forms of rock found in this group. In one direction these beds show a tendency to pass into sandstones, but as I have said, fine grained sandstones, properly so called, seldom occur. Mica occurs in abundance in certain layers. With the exception of some white beds which are occasionally met with, all are ferruginous, some highly so; the latter are dense and heavy, but are seldom used as an ore of iron by the natives.

The only beds of this group which have so far proved fossiliferous are the shales which have just been mentioned, and they are by no means universally so. The place where I found fossils most numerous as regards individuals was in the Garjan hill in Hingir. Here, too, the number of species was the greatest, but it does not altogether exceed eight.

The following is a preliminary list by Dr. Feistmantel:—

EQUISETACEÆ.

Schizoneura ? = Damuda sp.
„ ? sp.
Vertebraria Indica, *Bunb.*

FILICES.

Glossopteris Indica, *Schimp.*
„ Browniana, Brogn. Var. Australasica.
„ Sp.?
Pecopteris Sp. = Bunbury's drawing.
„ Lindleyana, *Royle.*

The specimens of Vertebraria were met with at Girundla, Kodaloi, and on the Bilpahari.

The question of the correlation of these rocks with the groups elsewhere known in India is for the present reserved.

These sandstones cover by far the largest part of the area included in the field. Throughout the central portion no other rocks are met with, and to the north-east and south-west, only narrow strips of the older rocks are disclosed at the boundaries, and that for comparatively short distances. In the northern part of Ráigarh there is a considerable exposure of Barákars which is surrounded on all sides by these rocks, and so superficially separated from the Barákars of the Ebe valley on the east, and of the Mand on the west.

The eastern boundaries of these sandstones follow an irregular outline, which is in general well marked, and is more or less coincident with the limits of the hilly plateau country of Hingir. Possibly there may be some small outliers within the limits of the area colored as Barákar, but the often highly ferruginous characters of some of the pebbly beds presumably belonging to the latter, and the obscurity of the physical relations renders discrimination almost impossible.

The group of hills of which Sitaram and Bilpahari are the culminating points is situated at the northern extremity of the eastern boundary; the rocks seen there are sandstones and red shales, the latter containing *Vertebraria.* Some of the sandstones are highly ferruginous, and contain layers and plates of hardened and dense character which weather out on the surface into relief, as is commonly seen in the Pachmari sandstones.

At Girundla and Bindichua the same rocks prevail; they are generally horizontal, but at one place in the Lillari, south of the latter village, some local disturbance has given rise to a southern dip. The Bindichúa G. T. hill station well illustrates the tendency of certain beds of sandstone to weather into curious and grotesque shapes.

The rocks about Onkilbira, Komghat, and Pikol are all of the same character and call for no particular notice. The same may be said of those forming the hills to the east and south of Lakenpur.

Close to Borkhol, the Koilar river debouches from the hills; it is the first of a series which, rising in the highlands of Hingir, pursue a steady south course to the Mahanadi. As the rocks which they traverse, except near the boundary, are horizontal, the sections do not throw much light upon the general characters of the series. Ordinarily these rivers run in deeply cut channels in beds of coarse brown or red sandstones. These being water-bearing strata feed the rivers all along their course, and the moist faces of exposed rock are the favorite growing place of a species of *Drosera*; all these rivers are perennial, and their constant flow of water makes them contrast with the rivers of the gneiss and Talchir areas which soon dry up after the rains, leaving wide sandy channels.

The general characters of the valley which extends along the boundary in a north-westernly direction from Borkhol have been described on a previous page. With the rocks which bound it on the north only have we to do at present. North of Jhargaon the road to Raini ascends over the scarp of red shales and sandstones; these are still better seen further west at Dibdorah, where there is a step in the Hingir river over which the waters fall, forming a most picturesque, and in the eyes of the natives sacred, cascade. Near the foot of this fall, as has already been mentioned, some pieces of carbonaceous shale were found, but none above.

At Jogidhipa the physical features are somewhat modified, as there is no distinct ridge or scarp on the Barákar boundary, but the relative position to the main boundary of the field appears to continue the same. From this westwards the red clays cease to occur associated with the basal rocks of the upper sandstones.

In the Kur or Chota Kelú, between Berapali* and Beramunda, there are brown and yellowish sandstones which sometimes contain pebbles, but there is no trace of the red clays. Their absence may be due to overlap of that portion of the series in which they occur; but I think more probably they were never deposited here. At Jamga* the Barákars are almost completely covered up by these upper rocks.

In the Supnai section from a point east of Jhargura to Bhogra* there are coarse ferruginous sandstones which are at first slightly inclined to the south, but as the boundary is approached, they dip in the opposite direction, and the bottom beds, some of which seem to be Barákars, dip at an angle of 30° to north.

In the Somkara and Bilaijor rivers to the east and west of Sambulpuri there are similar sections; in the latter the rocks close to the boundary dip away from it at as high an angle as 45°. Close to Badpali there are some traces of a local bed of red clay.

In the Kelú there is a long interval between coarse sandstones dipping at 20° north and the gneiss. Save for a small outcrop of Talchirs at the ghât there is nothing to indicate the character of the intervening rocks. Further north, these sandstones fall to the horizontal and are deeply channelled by the river. I have on a previous page indicated the origin of the coal fragments which are seen in the bed of this river.

At Donot, the edges of the upper sandstones form a distinct and prominent ridge close to and north of the village.

In the vicinity of Cheraipani the Talchirs and Barákars are apparently finally overlapped by the sandstones on one side, and cut out by the fault on the other; at least no certain sign of them is met with further west. They may exist, however, at the bottom of the narrow alluvial valley which is bounded by on either side quartzites and sandstones. At Delari (or Derali) sandstones dip at 30° to north-east. Just north of the village the lowest bed may possibly be Barákar, but I think not. To the south-east of the village these sandstones are seen within 200 yards of the quartzites.

From this westwards to the Kurket, and also to the north in the direction of Tumardi, the rocks which are exposed all belong to the upper series.

KURKET RIVER SECTION.—At Rabo there is an interval of perhaps 300 yards between the gneiss and some beds of sandstone, which dip at an angle of 30° to 30° north-of-east.

* These names, as previously mentioned, are all misplaced on the Atlas Sheet.

What may intervene between these outcrops can only be conjectured, possibly Talchirs, but there is no trace of them to be seen. With regard to the sandstones, I think they must be referred to the upper series, though they are not unlike Barákars, which, indeed, I thought them to be when I saw them in 1871. The high dip is gradually lessened, until about a mile further north the beds become horizontal, and so continue with only local variations in dip for about five miles. In places the river runs in a deep cutting with walls twenty feet high. The sandstones are of the usual character, coarse ferruginous, sometimes with plates and layers of more highly ferruginous composition. They are often somewhat conglomeratic and not unfrequently pinkish in color. There is no sign of red clays in this section. From underneath these rocks at Baiamunda, as has already been mentioned, appear the Barákars.

To the west the boundary, leaving the river, passes along the foot of a range of hills which strikes north from Katangdi. At Nowagaon (Nowagud) these hills present a scarped face of coarse ferruginous sandstones with some red clay partings. These rocks have a general, though slight, dip to the south. Detached from this range, towards its northern extremity, is the Duldula hill which is formed of the same rocks.

The eastern boundary on leaving the Kurket, passes south of Baiamunda and then bends southwards to Jiringol. Between Balumar and Samaruma the red shales were again met with near the base of the series.

The Gid hill appears to be an outlier of these rocks, the continuity being broken on the south, but this is not quite certain, as the rocks are much hidden in the broken raviny ground. The principal rocks forming this hill are ferruginous sandstones and red shales, but at the base there is a considerable bed of white sandstone of doubtful affinities.

The character of the junction in the Kelú river section has been alluded to above; the upper sandstones, away from the boundary, are horizontal, or have a gentle dip to the south.

From this eastward as far as the Ambo hill the boundary runs along the foot of the scarp; this is well seen at Deogaon and Pariga. In the Garjan hill, I found the principal part of the fossils mentioned on page 115. The further extension of these rocks to the east has been noticed in my previous report, and it therefore only remains to describe their occurrence to the north so far as they have been examined in that direction.

At Janjghir and the valleys on either side of it, we find Barákars abutting against gneiss, the boundaries being more or less overlapped by sandstones and conglomerates which form the surrounding hills. These sandstones and conglomerates are, I think, referable to the upper group, but at the heads of two of these valleys, from 150 to 200 feet above the level of the top of the Barákars seen outside, I met with fragments of coaly shale in the beds of the hill-side torrents. At first sight this suggested the probability of Barákars occurring at the higher level, but another case, presently to be mentioned, seems to make it probable that carbonaceous shales do sometimes occur in the upper beds.

A glance at the map* will show the difficult nature of the country where these observations were made. Until the whole of the hill tract there has been examined, it will be impossible to speak with any degree of certainty on the subject. As rendering it more probable that the carbonaceous shale is from the upper sandstones, it may be mentioned that the fragments were much mixed with pieces of red shales which *may*, however, have come from a higher level.

The amphitheatrical appearance of the valley of the Kelú above Milupara has already been alluded to. Owing to the jungle and superficial deposits, the bonndaries are much obscured, but at Hingjhar there are exposed some ferruginous sandstones and red shales

* On the one inch to a mile scale. In the accompanying sketch map the hill shading has been omitted.

resting upon ironstones, which latter are presumable Barákars. On the east of the valley, in the Sukti hill, there is a good section of these rocks.

Ascending from the village of Bajarmura, which is on red clays and sandstones, the path passes over whitish grey sandstones, which might pass lithologically for Barákars; above them near a bear's cave* is a band of black shales; this is at least 300 feet above the red shales of Bajarmura, and must therefore belong to the upper series.

Above this there were coarse ferruginous sandstones which continued up to the top of the hill. On the eastern side of the hill, at Khara, the Barákars extended up the side from 100 to 150 feet.

So far as they have been examined, these upper sandstones appear to constitute one group which is not susceptible of any natural sub-division.

V.—Laterite.

In the course of the preceding pages the occurrence of laterite resting upon the older rocks has been occasionally alluded to. It is more particularly abundant on the Talchirs, and, as noticed on a previous page, its limits are curiously concurrent with the Talchir—gneiss boundary in the eastern part of the field. To the north-east it is often found on gneiss, so that its occurrence in one locality in a limited way on the Talchirs only is the more remarkable. It seems to be chiefly, if not entirely, confined to the lower levels, and I never found a trace of it on the higher hills, though in such positions it is commonly met with in Sirguja.

There is nowhere, so far as I know, a greater thickness of it than about sixty feet. In the eastern part of the field it forms wide spreads, which completely conceal the underlying rocks. In lithological characters this laterite resembles the laterite of Midnapore and elsewhere.

VI.—Faults and Dykes.

The character of the south-western boundary having been described in the previous pages, little remains to be said, and recapitulation is, perhaps, unnecessary. Although no single section can be pointed to as absolutely establishing the faulted nature of this boundary, still the general tendency of the observations which have been made is to point in that direction, while the difference in the character and age of the beds which are successively brought into conjunction, and the remarkable straightness of the boundary, are strongly corroborative of the same view.

With this exception there is no evidence of any faulting throughout the area, and most of the boundaries have been distinctly seen to be natural.

Dykes.—But one case of trap also has been met with in the field; this is at Kirarama in the Barákar area, where a dyke is exposed for a few yards. A similar rock is seen at Kondaimunda, in the gneiss, and the two may be continuous. It must be noted that there is a possibility of this being only the peak of a trap-like metamorphic rock which strikes up through the Barákars. Its lithological characters quite favor this possibility.

VII.—Economic Resources.

The economic resources of this field are—Building materials, Coal and Iron.

Building materials.—As in other coal-fields containing Damuda rocks, many varieties of sandstones occur which would be applicable to building purposes. Hitherto the only

* Note.—The cave is in a friable bed of slightly ferruginous sandstone, which I noticed was perforated in a peculiar manner. On examination each of these perforations, at least those which looked freshest, contained the nest, or rather den, of a small spider, while the older ones contained exuviæ of spiders.

It was perfectly obvious that these perforations, which were mostly ¾ of an inch deep, had been made by the spiders by patiently removing the friable rock grain by grain.

rocks which have been used in this way are the Talchir sandstones of Sasun. These furnish a suitable material for copings and similar purposes in Sambalpur. Recently they have been employed in the manufacture of washing vats for lac works. The building stone which is chiefly used in Sambalpur is a schistose quartzite which is found in the station. Limestone of limited amount, but good quality, occurs in the Talchir rocks to the south of Luponga (*vide* p. 105). Kankar is found in most of the alluvial tracts, but is not generally abundant. The Vindhyan rocks south of Padampur on the Mahanadi include an excellent limestone, which is the source of lime chiefly resorted to in the district.

COAL.—The seams which are exposed in the portion of the field at present under description are neither very numerous nor individually of promising quality; but it must be remembered that the coal-measure rocks are not only, as a whole, very slightly disturbed from their original horizontal position, but are much covered by superficial deposits, and that there is a complete want of sections which might show the succession of beds constituting the group. The true, or even approximate, value of the field, therefore, can only be ascertained by borings. In the meantime it may safely be asserted that there is a fair prospect of this field proving to be of considerable value.

Of those seams which are at present exposed I should recommend that at Dibdorah as being the one which is most likely to reward exploitation. The advantages which this seam possesses are the following:—The coal is of fair quality, much better probably than might be supposed from the assay, the sample having been taken from under water; the thickness is at least six and a half feet. The seam being at the surface, and having only a small dip, might be worked by simple undercut quarries.

Lastly, the locality is the nearest to the Mahanadi, being only about six miles distant from that means of carriage. The chief difficulty in working this seam, indeed the only one that I know of, will be caused by water which it may possibly be found not very easy to dispose of, especially during the rains. This, of course, would only be felt while the works were carried on on a small scale; with extended operations suitable provision could no doubt be made, but the narrowness of the valley in which the seam is situated must always cause some trouble.

With this in view it would obviously be best to break ground first (provided, of course, that the seam is first proved to extend so far) at the watershed between Dibdorah and Jogidhipa; this would involve somewhat longer carriage, but would secure an outlet on either side for the ejected water. The water would almost entirely be from surface sources, as the red clays which occur with the upper sandstones would, I think, prevent excessive percolation from the water-bearing rocks of the highlands.

The sections given above of the other seams in this part of the field (Ebe valley area) do not indicate any coal of workable thickness. According to the assays and my rough examination in the field, No. 9 of the Durlipali is the best coal, but of it there is only one foot. No. 4 of the same section is two feet six inches thick, but the quality is very inferior. It must be remembered, however, that the whole of this seam, as well as that of most of the others, is not exposed. As regards carriage, the Durlipali seam is much less favourably situated than that at Dibdorah; the distance from Sambalpur as the crow flies is twenty-five miles. During the rains, however, the Ebe river, which is only six miles distant, might be used as a means of carriage. The Lukanpur seam, regarding which little is known at present, is situated in an enclosed valley difficult of access, the road to which from the Mahanadi would probably be from ten to twelve miles. The Dulunga seam is about sixteen miles from the Ebe. Of the large seams in the Baisunder I have spoken in my previous report; the coal from them might, perhaps, to a small extent, be brought down that river to the Ebe also during the rains.

Some of the seams in the Kelú valley may very possibly contain good coal, but they are difficult of access, being thirty-six miles, as the crow flies, from the Mahanadi. Carts, if they could get over the ground at all, would have to travel probably not less than sixty miles. To Sambalpur the distance by any possible route would not fall far short of 100 miles.

Still more unfavorably situated as regards roads are the seams in northern Hingir to the west. The Kurket river there, however, would afford a means of transport during the rains. I saw a large boat being built at Rabo on the Kurket, so that navigation is so far possible; indeed, the river bed, thence to its junction with the Mahanadi, contains no serious obstructions of any kind.

So little is yet known of the coal of the Talchir field, that it would be impossible at present to institute a fair comparison* between the two. Unless the coal of our field is of better quality it could not compete successfully in Cuttack owing to the much greater distance it would have to travel. At the same time the Mahanadi is closer to the eastern end of the Ráigarh and Hingir field than it is to any part of the Talchir field, and the Brahmini, owing to obstructions, is not much better as a means of transport than the Ebe or Kurket would be.

The prospects of the ultimate development of this coal-field depend altogether on the future extension of a line of railway into that part of the country. If the project for connecting Calcutta with Nagpúr, by a direct line, be ever carried out, this field will attain considerable importance, should the borings, which must first be made, prove the existence of abundant and good coal, and of their doing so, there is, I think, a fair prospect.

ASSAYS OF COALS†.

	Moisture.	Carbon.	Volatile.	Ash.
Durlipali No. 4 of Sec. ...	5·3	26·4	36·5	37·1
Durlipali No. 9 of „ ...	11·8	50·2	36·8	13·
Lakanpur	9·2	33·4	34·4	32·2
Dibdorah	9·9	39·9	33·6	26·5
Dulunga	11·	45·2	33·6	21·2
Mograpali	11·2	46·1	40·	13·9

IRON.—Within the Barákar group there are, as has been indicated on a previous page, two and possibly three zones of ironstones. Assays have not been yet made, but some of the ores appear to be good. As to quantities, so far as superficial examination goes, I think at Kodaloi and some of the other localities on that horizon there is a large supply which could be easily worked. Of the abundance of ore in the hills at Rampur, east of the Ebe, I have already expressed my doubts, but on these points it is impossible, without some preliminary clearing of the ground, to speak with certainty.

The zone of ironstones which runs with the south-west boundary, at the top of the Barákars, seemed to be thin and poor.

In the upper sandstone series ironstones also occur, but are seldom used by the native *Lohars*. In several instances I found that the Lohars of villages which, owing to wood being abundant, were situated within the upper sandstone area, procured their ore from the Barákars some miles distant. Except towards the frontiers of the Hingir highlands, there are few *Lohars'* villages in that zemindari, but in no part of the country which I have visited are they so abundant as in Rampur. At many of the large villages there are furnaces, but the greater

* Selected coal from the Talchir field has been found to answer fairly well in small steamers on the Cuttack canals. Its cost, owing to expensive carriage, was, however, too high.

† By Mr. Tween.

number are worked by colonies of Lohars who form temporary villages where timber is abundant, passing to new localities when they have exhausted the supply in their vicinity. Although Sâl (*Shorea robusta*) is the wood most commonly used for making charcoal, I found the Bijasal (*Dipterocarpus marsupium*) seemed to be preferred by some. Bamboo, though abundant, never seems to be used. The wood is cut into logs about 3½ feet long, or rather more, and is burnt in holes which are about 4 feet square and 18 inches deep. Small branches are not used. The furnaces are somewhat smaller than the largest which are used in Bengal; they are furnished with a tray above, in which a quantity of mixed ore and charcoal is kept, which can be raked into the top of the furnace by the person working the bellows without other assistance. This, of course, is a great saving of labour as compared with the usual system which involves the presence of a second person to feed the furnace. Differing from the practice in Hazaribagh, the same individuals make the *giri* (bloom) and also work it up into iron for the market. The *giris* were much smaller than in Hazaribagh, in one case at Jodiboga not exceeding 6 or 7 seers, generally, perhaps, they are about 10 seers. So far as I could make out, the Mahajans get from 15 to 20 seers of iron for a rupee from the Lohars, but owing to the advance system and the transactions being chiefly in kind, this cannot be accurately ascertained.

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