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OF THE

GEOLOGICAL SURVEY

OF

INDIA.

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GEOLOGICAL SURVEY OF INDIA.

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ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA AND OF THE MUSEUM OF GEOLOGY, CALCUTTA, FOR THE YEAR 1869.

The close of another year (1869) calls for a brief summary of the progress of the Geological Survey since our last report.

The area, which it is possible to examine geologically within a year, depending essentially on the number and ability of the officers employed, it is necessary, first, to premise that during ten months of the twelve just passed, Mr. W. T. Blanford, Deputy Superintendent, was absent, being engaged in the elaboration of his report on the Geology and Natural History of Abyssinia, the result of observations made while attached as Naturalist to the Abyssinian Field Force, and during a brief visit, subsequently to the return of this force from Abyssinia, to the adjoining territory of Bogos. Mr. Blanford was, at the beginning of the year (1869), ordered to proceed to Europe, where alone he could have facilities for the comparison and identification of his collections and of reference to all previously published accounts. After an absence from India, on this duty, of about six months, Mr. Blanford rejoined the Geological Survey at the beginning of November, and immediately took the field. Mr. Ormsby, who (as reported last year) had been obliged to proceed to Europe, suffering from sunstroke, returned just before the working season commenced in November. During the most important and largest portion of the year, therefore, the survey was without the aid of these two gentlemen. Mr. W. King and Mr. F. Mallet obtained 12 months' furlough each, and left in September for Europe, having completed their maps and reports of the previous season; and their services will, of course, be wanting during the present season. Last year I had to report that Mr. Charles Oldham had proceeded on furlough in November, and with deep regret I was called on to report his decease in April last. In him the Government of India lost a trained and able servant, distinguished for his conscientious devotion to duty, and for the care and skill with which he, as Deputy Superintendent for Madras, conducted the labours of the party working there. In him also the officers of the Survey regret the loss of an esteemed colleague. This death, resulting from the effects of an attack contracted during his active service in India, adds another to the long list of those who have succumbed to the very trying exposure in the worst and most unhealthy parts of the country which the pursuit of Geology in India necessarily entails. The remaining officers of the Survey have all been actively engaged during the year.

Soon after the commencement of the year (1869), having then just returned from the Punjab, I proceeded to Cachar and Sylhet, to examine, on the spot, the evidence connected with the serious earthquake of the 10th of January, which had caused such extensive damage. I was unfortunate in visiting the localities just at the time when all the available carriage of the district was needed for the Military expedition then just leaving Silchar; so that I found it impracticable to see quite as much of the country as I could have wished. I succeeded, however, in obtaining some accurate and valuable observations. And in returning I crossed the Khasi Hills, noting the results of the same earthquake at Sylhet, Cherra Poonjee, Shillong, and Gowhatty. A brief notice of these results was given at a meeting of the Asiatic Society of Bengal in March (*vide* Proceedings of the Society for April 1869, p. 113). While working out these observations, I was led to notice how little of any accurate record existed in this country regarding the earthquake shocks to which many parts of it are

frequently subject. And I have, therefore, given some time to the preparation of as perfect a catalogue of Indian earthquakes as I had means of obtaining. This will, I believe, prove an useful addition to Indian seismo-statistics, and I trust may at the same time be the means of eliciting further information on the subject. Many private records of such phenomena doubtless exist, full of interesting and often valuable information, which has never been given to the public. I would solicit the contribution of any such facts as may tend to prove the occurrence of shocks not hitherto noticed, or to indicate the extent of area over which, and the relative violence or intensity with which, shocks already recorded may have been felt in different parts of the country. The very nature of such a catalogue precludes the possibility of successful compilation by any unaided individual; the co-operation of many is essential. A report of the effects of the earthquake of 10th January, 1869, is in progress.

At the beginning of November, I proceeded to the Central Provinces to control the operations there in progress for the exploration of the coal in Chanda and Berar. I found that the late rains of the year had caused a good deal of fever in many places, and the taking of the field by the Survey Party was a little delayed in consequence. Proceeding from Nagpore in company with Mr. C. Bernard, Commissioner of Nagpore, in whose jurisdiction the Chanda district is, I first took a general review of the field as far south as Ballarpur. And then returning fixed upon positions for future borings, with a view to test not only the continuity of the beds of coal which the river Wurdah had exposed in one or two places, but also to prove the nature, thickness, and contents of the coal-bearing formation generally. I have seldom seen a country less favorable for detailed Geological research, as a thick covering of clays conceals the rocks entirely, excepting at distant intervals. Any detailed examination, therefore, necessarily takes much time, and cannot in the end be very satisfactory. But, with the aid of borings, we hope to be able to trace out the rocks with tolerable accuracy.

The results of the trials up to November last were published in the last part of the Records of the Survey (Part 4, 1869), and it is not necessary to repeat them here. Since that time, up to date, additional information has been gained, which is all satisfactory. One of the great sources of doubt as to the extent of the coal deposits arose from the widely established fact, that the beds in the group of rocks in which the coal here occurs (that known to Indian Geologists as the Barakar group) had invariably a tendency to exhibit very great variation both in thickness and quality within short distances. They are often of great thickness locally, but thin out and nearly disappear within short distances: this variation also being not only in the thickness, but also in the quality of the beds, so that what shows as a bed of good coal in one place may, within a few yards or a few hundreds of yards, pass into a shale without coal, or even into a sandstone. It was, therefore, important to test this, and the first new boring which was fixed on was put down near the village of Telwasa, some ten miles to the north of where the coal had been found in the river. No coal was visible, nor had any been ever known to be there; but the position in which it ought to be found, if the beds continued, was, as appeared to me, well marked. After some delays, the rods were put down here, and passing through the beds of sandstone, seen on the surface, they entered a group of beds of coal and shale, in the proper position exactly as anticipated. Up to the close of the year, 19 feet of this coal, with a few shale partings, had been cut into and the beds still continued.* Near the village of Nokora also, to the extreme south end of the small area of coal-bearing rocks which occurs on the Chanda side of the Wurdah river, near Ghúgús, the limits of which had been approximately fixed by Mr. Blanford in 1866, a bore-hole was put down by Mr. Fryar to test the character of the beds there. This has cut the same group of beds with coal found to the north of Ghùgùs village. There are representatives of the two upper beds, and then of the thicker group of shale and coal below. But, as expected, there is a large amount of variation in the actual section. The thick beds of so-called coal and shale noticed in the borings at the north of Ghúgús (see Records, Geological Survey, 1869, p. 97), as being there altogether some 33 feet in thickness, have increased to more than 50 feet at Nokora; but this increase in aggregate thickness is chiefly in the greater development of the earthy or shale beds. The details of measurements need not be given here.

The results, so far as the explorations have been carried, seem to me to point to the *general* continuity of the coals on a fixed horizon in the lower sandstones, and if this be confirmed by further examination, these coals may be sought for with considerable certainty within

* Forty-one feet, seven inches, of coal have been cut altogether here, in a total depth of 138 feet.

the very limited area which these rocks occupy. Until the recent trials, I regret to say that no principle seems to have guided the selections of the several points at which bore-holes were put down. They were apparently put down completely at hap-hazard, and were of course, in most cases, without any definite result. Localities have now been absolutely fixed upon for a number of additional borings, where, at comparatively small depths, the presence or absence of the coal may be determined.

A steam-boring machine has also been delivered at Chanda, but it is not yet in operation. It will in reality be of very trifling use in this field. The country is to an immense extent either covered with jungle or with deep beds of clay, through which every little stream cuts a deep channel or gully, and in either case there are no roads excepting of the most primitive character. There are not, therefore, more than half a dozen spots in the district to which this steam-boring machine can be conveyed, excepting at great loss of time and expense. And even in those localities, the required information can be obtained with ordinary boring tools more cheaply and expeditiously if only a systematic system of choice of position be acted upon. It is, however, hoped that a trial will soon be made with this steam-boring machine when the services of some one competent to undertake the management of it can be obtained.

To Major C. B. Lucie-Smith, Deputy Commissioner of Chanda, I am indebted for the most hearty and effective assistance in all things. The Geological Survey is also indebted to Mr. S. H. Hennessy, Extra Assistant Commissioner, for the earnest and friendly way in which he has ever met their wishes.

It is hoped that as soon as the Chanda district is examined, the investigations of the Geological Survey may be continued down the valley of the Godavery, at detached points in which we know of the existence of small basins of the coal measure rocks, in which coal may exist in good workable quantity. Such a basin, for example, occurs about 15 miles north of Dumagudiam, from which, at the place indicated by Mr. W. Blanford in 1866 near the junction of the Tal river, in the left bank close to the village of Lingala, a considerable quantity of coal was raised last year from the bed of the river. This coal worked effectively in the low pressure stationary engines, but was not sufficient to keep up steam for the high pressure engines of some of the steamers. I am also indebted to Colonel Haig, R. E., for the information that coal has been again found exposed in the scarped face of the rocks on the right bank of the river, about 34 miles below Dumagudiam. 'About two feet are seen above water level, and it extends under the water as far as a man can reach with his arm.' All these facts point to the necessity of an early and careful examination of this country. And it is my purpose next working season to work up from the Madras side, the party of the survey there engaged bringing up with them the extended knowledge they have obtained of the older groups of rocks in the Madras Presidency and the officers of the survey from Bengal working downwards, and bringing with them their widely acquired intimacy with the structure, character, and sub-divisions of the coal measures of India. The extent of country to be visited is, however, wide, and the detailed examination of so large an area will unavoidably occupy much time. The result of a systematic examination of this kind will, however, be more satisfactory and more trustworthy than if taken up at detached points.

In connection with these practical explorations by boring for coal, &c., I would notice the great satisfaction with which the Geological Survey have seen lately the success of that most important trial for water at Umballa. The insufficiency of the supply of water at this large station has long been a source of anxiety, and a cause of ill-health, and has led to proposals for the adoption of very costly and tedious works to increase the amount of available water and to facilitate its distribution. Mr. H. B. Medlicott, after his examination of the Sub-Himalayan rocks, urged the importance of seeking this much-needed supply of water in the water-bearing beds which must exist under all the country in that parallel along the foot of the hills.* The reasons for the confident expectation of good water being found there with a pressure at least sufficient to bring it to, or near to, the surface from very considerable depths were stated, and have, on several occasions since then, been very strongly urged. It was therefore with no small satisfaction that we saw the very first trial confirm the justice of these sanguine expectations. It is to be hoped that further trials will be now boldly

* Memoirs of Geological Survey of India, vol. III., pt. II. p. 181.

carried out, but at the same time strictly limited to those areas where the probable existence of similar conditions may be fairly anticipated after proper examination.

As stated in my last annual report Mr. Medlicott was, at the commencement of the year, engaged in the examination of the very important geological questions of the extent and stratigraphical relations of the several series of sandstones, &c., associated with the coal in Bengal as compared with those in Central India. In pursuance of this object, he traversed the entire country between Hazaribagh and Palamow on the east and Jubbulpur, on the west; and thence went southwards to Nagpore and Chanda. This extended and general survey of the vast area occupied by these rocks has brought into greater prominence and clearness, and has established the wider application of several of the views already enunciated by other officers of the Survey regarding the distribution and variation in character of the several sub-divisions of that great series of beds, in some members of which the coals of India chiefly occur, and which may, as a whole, and in a broad view of its fossil contents, be called the plant-bearing series. The vast extension and wonderful constancy in mineral character (combined with local peculiarities) of the *Talchir* rocks, which have always been treated of as the base of this great series, although forming in themselves a well marked and characteristic group, has been even more fully established than it previously had been. The dying out also in passing to the west of the distinctions so easily established in the eastern coal-fields, (Ranigunj, Jherria, &c.), where a three-fold sub-division of the true *Damuda* or coal-bearing rocks is obvious—a fact already fully indicated by Mr. Hughes, as far as the Bengal fields are concerned—has been shown by Mr. Medlicott to be entirely supported by the character of the rocks in the more western fields. And, at the same time, the co-existent fact of the considerable increase in the development of the group which occurs at the top of the series (the *Panchet* group), seems equally established. The entire group of the formations or series which in the east gives five well-marked sub-divisions *(Talchir, Barakar, Ironstone shales, Ranigunj,* and *Panchet)* becomes at only a short distance to the west only a three-fold series of the *Talchir*, the *Barakar*, and the *Panchet*. This was shown to be the case in some of the Bengal fields, and the same fact is more fully insisted on by Mr. Medlicott with reference to the country lying further west.

Although, so far as known, there seem good grounds for admitting this as giving the truest representation of the facts, it must at the same time be stated that the lithological character of each of these groups differ in the west and south from that of the typical rocks in the Ranigunj field and Talchir field. Even so near to Ranigunj as the Palamow (or Daltongunj field,) Mr. Hughes has shown that the *Barakar* rocks present a lithological character intermediate as it were between the true *Barakar* and the *Ranigunj* beds. And further, in the Bokaro field, he has pointed out the transitional passage of the *Ranigunj* beds into the *Panchets*.

With these facts, it would almost remain an open question, whether much of those upper beds, to which we are now disposed to assign the general name *Panchet*, may not represent, *in time*, the upper groups of the more eastern fields (*Ranigunj* beds, *Ironstone shale*). And the fossils contained would go to support this view. But the general mineral character very decidedly approximates more to that of the typical *Panchet* rocks, and throughout the entire area extending over many thousand square miles with well exposed sections, the absence of any deposits of coal, which are so valuable and abundant in the upper groups of the Ranigunj field, is an additional and strong reason why these rocks should be referred to the *Panchet* group rather than to the others. It might possibly solve the difficulty better in the first instance to establish an intermediate and distinct sub-division applicable only to a part of this upper group of rocks in the west, but this would perhaps only lead to greater difficulties, because this group must be localized, while all the facts point rather to a gradual passage of character over geographical areas, than to any definite sub-division. In any such large series, where the sub-divisions are not marked by material interruption, or change, of depcsit, or by any long interval of time accompanied by the destruction of pre-existing beds, there is no possibility of drawing any trenchant line of division, for such does not exist. And it can, therefore, be only on a balancing of evidence that any part is placed in correlation with one sub-division rather than with another.

Mr. Medlicott has also brought forward additional proofs to show that, on the large scale, the present limits of these coal-measure fields coincide approximately with the original limits of deposition and are not the result of faulting, or even mainly of denudation.

This limitation of original deposition has long been the view held by Mr. Hughes (and by myself) with reference to the Bengal fields which he had examined, and Mr. Medlicott now shows how he considers it applicable to those in the west also.

There appear to me, however, wider and larger views of this variation in mineral character, and in succession of beds, as well as in limitation of area occupied, which must be worked out in greater detail before any definite conclusions be possible. They may, however, be indicated. All these successive beds, (possibly with the exception of the *Talchirs*) representing an enormous lapse of time, agree in one respect, that they seem to be purely fresh water (fluviatile or fluvio-lacustrine) or estuarine deposits. This fact alone involves the consideration of definite limits within which the rivers or lakes by which, or in which, they were formed were confined at the time of their deposition. This again would seem unavoidably to bring with it a very large amount of variation in each basin of deposition quite consistently with a general resemblance or agreement in the succession. It seems difficult, if not almost impossible, to suppose that coincidently with any great changes of surface level, &c., which may have affected the whole country, there were not also variations in each more limited area, or drainage basin of the then existing dry land. Thus it seems to me, we are naturally led, *á priori*, to look for a general persistence of type coincidently with a wide limit of variation in detail. And this, I believe, will go far to account for much of the variation we do find. The present distribution of these coal-fields in India, modified, as it undoubtedly has been, by the great destruction and denudation to which not only the coal-bearing, but all subjacent rocks have been subjected, appears to me to point also to this limitation to defined areas. Thus the Ranigunj, the Jherria, the Bokaro, the Ramghur, and the Karunpura fields all belong to the drainage basin of the Damoodah river. Itkuri (Eetcoora), and the Kurhurbari fields are in the basin of the Barakar, the largest affluent of the Damoodah, from which in the upper part of its course it is separated by the lofty ranges of Parasnath and the wide plateau of Hazaribagh. The Kasta deposits and the limited field near Dubrajpur and the Deogur fields are in the valley of the Adjai, and limited to it, while the valley of the More, further to the north, has its small field near to Soory. (In a wider view, all these rivers may be considered to have formed one general estuary at an early period). The Talchir field, near Kattak, the detached areas of Talchir sandstones in the Sumbulpur country, and the Belaspur field, are limited to the Mahanuddy basin; the Palamow, the Singrowli, and South Rewah coals are all strictly confined to the Sone basin;—the Chanda field and the continuation of this field in detached areas down the Godavery valley, considerably below Dumagudiam, all are strictly confined to the basin of the Godavery and its affluents, while similarly the coal-fields of the Nerbudda valley are all limited to the drainage basin of that river.

In other words, it seems to me that there is very strong evidence to lead to the conviction (announced by me at the meeting of the British Association in December 1867, when speaking generally of the Geology of India), that the great drainage basins of this country were on the large scale marked out, and existed (as drainage-basins) at the enormously distant period which marked the commencement of the deposition of the great plant-bearing series to which I have referred.

In this point of view, local variations in the lithological type, and local variations in the thickness of the groups, and even their occurrence or non-occurrence, are only necessary consequences of the mode and limits of formation. And this will, I think, go far to account for these variations.

Mr. Medlicott has arrived at somewhat similar conclusions bearing on the limits of deposition of these beds as applied to some of the basins.

At the commencement of the present season, Mr. Medlicott proceeded to the Nerbudda valley, to work out more closely than had before been practicable the coal-bearing rocks in that area. When first visited, now more than twelve years since, no maps whatever existed of the Nursingpur and Hoshungabad districts, and it was necessary, in order to obtain any record, to carry out a general topographical sketch or survey concurrently with the geological examination. Within the last few months we obtained the finished revenue survey maps of these districts (Hoshungabad and Nursingpur), and I have at once taken advantage of them to ascertain with greater accuracy than was originally possible the distribution and contents of the coal-measure rocks there. The approaching completion

of the line of railway between Jubbulpur and Bombay also rendered it urgently important that this should be done at the earliest date.

Mr. Willson examined in the early part of the year a large portion of the Jhansi and Lullutpur districts, tracing out the remarkable quartz reefs that exist in such numbers and of such size in that area, and mapping with care the limits also of the recent deposits. And he is at present engaged in the continuation of this work, so as to join on his geological boundaries with those already very carefully put in by himself in the Saugor and Dumoh districts and with those in the Gwalior country mapped by Mr. Hacket.

The terrible sufferings of the population in Jeypore and adjoining country from failure of their crops, and the consequences of deficiency of food, rendered it desirable that Mr. Hacket should not return for the present season to the work on which he had been there engaged. He has, therefore, been moved to Jubbulpur, where he will carry out the examination with the detailed maps now available of the south-east portion of the district, and connect it with Rewah to the north and east. In the beginning of the year Mr. Hacket traced out the boundary of the great Deccan trap area, from Neemuch across to the Beeas river, which line has since been embodied in the general map of the Vindhyan area accompanying the published report of Mr. F. Mallet.

Mr. Ball, in the early part of the year, carried out the examination of parts of the Singhbhum country, tracing out carefully the copper-bearing rocks and their limits. And since Mr. Ormsby's return in the autumn, Mr. Ball and Mr. Ormsby have both been sent to revise and bring up to the existing state of knowledge of Indian Geology the maps of Bhagulpur and Birbhum previous to final publication. These districts were among those earliest examined in this country. And since that time very considerable progress has been made in the distinguishing of the rock groups of India. The original examination of these districts had also been more than once necessarily interrupted by disturbances among the Sonthals and other causes, and it was therefore essential that they should be gone over again with a view to general revision.

Mr. Mallet, during the early portion of the year, was engaged in working out in detail, and with the advantage of new and better maps, the relations of the several groups of rocks which occur in the eastern portion of the Sone valley, and which there come between the Vindhyan formation and the gneissose rocks. The more important of his results have been embodied in the Report on the Vindhyan formation, published during the year, which is noticed further on. Mr. Mallet, as already mentioned, has obtained leave for one year, and left India in September.

Mr. W. Blanford rejoined the Geological Survey on his return from deputation as Naturalist and Geologist in connection with the Abyssinian Field Force at the beginning of November. He has taken up the careful examination of the Chanda district with the assistance of Mr. Hughes and Mr. Fedden. Of this district he had himself made a rapid reconnoissance in 1866 and furnished a sketch geological map, which, considering the very unfavorable nature of the country for any geological examination and the brief visit Mr. Blanford paid to the district, was marvellously accurate and good. Mr. Blanford then also was the first to realize the true nature of the coal deposits of the field, which had been searched out with untiring determination by Major Lucie-Smith, the Deputy Commissioner. The occurrence of these coals in this district in a geographical position singularly favorable for the supply of fuel to a very large area both to the west and south, and the considerable difficulties attending the investigation, rendered it highly important that the facts should be ascertained as quickly as possible. I have therefore moved up from Bengal Mr. Theod. Hughes, who has perhaps had more experience and detailed knowledge of the Indian coal-bearing rocks than any one on the Survey, and with Mr. Fedden he will act under Mr. Blanford, Deputy Superintendent. The work was allotted without delay. Mr. Blanford himself, in addition to the general supervision of all, has taken up the detailed investigation of the rocks which come below the coal measure series. Mr. Fedden has been sent to those above the same series, while Mr. Hughes will take up these coal-rocks themselves. The district is most unfavorable for detailed geological examination, being either more than usually covered with very thick deposits of clays and gravels (often cemented into a hard calcareous conglomerate), occasionally containing bones or fragments of bones of large animals, and all probably of the same general age as the similar conglomerates of the Nerbudda and Godavery valleys, *(Pliocene)*, or

concealed by widely spreading jungles and forests often almost impenetrable. Mr. Blanford years since pointed out that it would be impossible to arrive at any satisfactory conclusions without actually boring in many places, and this actual testing of the ground is now being carried out successfully in conjunction with the general examination. Should the officers of the Survey be fortunate enough to preserve good health during the season, this year will see a large area thoroughly explored. As already mentioned, the late rains in October produced a good deal of fever and illness, and, as usual, the Survey parties have also suffered.

MADRAS.—The early part of the year (1869) was given by Mr. King and Mr. Foote to the completion of the geological area occupied by quartzites, slates, limestones, &c., which cover the larger portion of the districts of Kuddapah and Kurnool, and which appear, geologically, to represent in the south the older portion of the great Vindhyan series, to which allusion has already been made. This great area being complete in itself, that is, being surrounded on all sides by rocks of totally different ages and different mineral characters, will be treated of as one. And since the close of the field work, Mr. King has completed a general report on the entire area containing many thousand square miles. This report is now in preparation for the press; and will be issued during the present year. Mr. King took furlough-leave in September, handing over the Madras work to Mr. Foote. For the present season Mr. Foote has been directed to carry on the examination of the rocks, of the same mineral character, which appear under the great flows of the Deccan trap, and resting quite unconformably on the gneiss rocks in parts of the Raichoor Doab, the vicinity of Belgaum, and under parts of the ghats on the western coast. That they belong to the same general series as the rocks in Kuddapah and Kurnool there is no question, and it is hoped that Mr. Foote's acquaintance with the latter will enable him the more easily to identify them. This will connect with the Madras area the work already done by Mr. C. Wilkinson some years since in Rutnagherry and Sawunt Warree, but which was unfortunately left unfinished, when that gentleman was obliged to resign his connection with the Survey, as his health could not bear the great exposure unavoidably entailed by his geological work. This work will also, I think, give us a second complete section (geological) across the Peninsula.

I have had occasion already to notice the decease of Mr. C. Oldham, which untimely event, and Mr. King's absence on leave have reduced the Madras party for the present season to only one, Mr. Bruce Foote.

BOMBAY.—The Bombay party of the Survey continued the examination of Kutch as reported last year. This was completed before the close of the working season of 1869, and Mr. Wynne and Mr. Fedden both deserve much credit for the zealous and earnest spirit with which they carried out this work in a very difficult and in many ways very inaccessible district. Mr. Wynne has subsequently, during the monsoon, prepared a very admirably executed map of the whole of Kutch, and has embodied his own and Mr. Fedden's researches in a general report, accompanied with many excellent and well-drawn sketches. This map is on the same scale as the Atlas of India, namely, 4 miles = one inch, and it will scarcely be practicable to show the detail of the geology on a smaller map, although the publication of this large plan will be difficult.

At the commencement of the present season, as soon as it was practicable to leave Kutch, Mr. Wynne proceeded, as ordered, to the Punjab to take up the detailed examination of that province, while Mr. Fedden proceeded to Bombay, and joining Mr. Blanford took up, under his instructions, the examination of parts of the Chanda and Woon districts, in which he is now engaged.

It had long been my desire to carry out a careful examination of the Punjab, which offers to the Geologist many points of great interest, as well as promise of valuable mineral products. But the pressing demands for geological enquiry in other directions have always hitherto prevented any of the staff of the Survey from being located there. It was, therefore, with pleasure that I found it practicable to send Mr. Wynne there this season, and I doubt not he will exhibit the same zeal and ability there as he has elsewhere. I have asked his special attention to the relations of the beds from which petroleum is obtained or likely to be obtained.

BURMAH.—Mr. W. Theobald has, as anticipated in last year's report, completed the general examination of the Prome district up to the frontier of British Burmah, so far as that lies to the east of the Irawadi. He has this season taken up the country lying to the west of the river in the same parallel, and I hope the season will see it completed. In this

part of the district, nummulitic rocks (limestones, &c.,) occur and form an interesting study. They may be found to contain petroleum, as they occasionally do elsewhere.

PUBLICATIONS.—The first part of the seventh volume of the *Memoirs of the Geological Survey of India* contains a full report on the area occupied in North-Western India by the great series of rocks, to which the name VINDHYAN was first given by myself in 1856. Stretching along the northern escarpments of the Nerbudda valley, passing across the district of Jubbulpur, and forming the whole of the Rewah country north of the Sone, this great series extends in a continuous mass far into Bengal, where the picturesque cliffs of the Rhotasgurh hills form its steeply scarped limits on the left bank of the Sone. Returning towards the west by Sasseram, Chunar, Mirzapur, and a little south of Allahabad, the boundary thence stretches in a great sweeping bay or curve to the south by Kirwee, Bijawur, and crossing the Beas river, trends again north to Gwalior and Agra, and Futtipur Sikri, whence the line again trends to the south and extends to near Neemuch. The rocks belonging to this widely extended and important group constitute one of the most remarkable and interesting series in all India. They become also still more important to the Indian Geologist when he finds representatives of the same great series covering immense areas in the Madras Presidency (Kuddapah, Kurnool, &c.), stretching northwards along the flanks of the ghats, and up the Godavery country, until in Berar and the adjoining parts of the Nizam's dominions, and again in Bustar and Chutteesgurh, they constitute the rocky basis of very extended districts. They are divisible into several different groups characterized by peculiar lithological distinctions, and throughout the whole area described present a wonderful constancy of mineral composition. Mr. Fred. Mallet, who had himself examined much of the area in N. W. India occupied by these rocks, has combined with his personal observations the labours of others, and has given a connected history of the entire series in this part of the Memoirs.

I have always found it exceedingly difficult to lead to a just conception of the immensity of the areas we have to deal with in this country. And it may be useful to draw a comparison here which may tend to a realization of the facts. The small map, which accompanies the report of Mr. Mallet, (a reduction from the larger scale maps used in the field) just noticed, represents an area quite as large as England and Wales; while all the lines of geological division and sub-division shown on it have been actually traced out by detailed examination. The previous part of the *Memoirs*, the last part of Volume VI, contained also a geological map of quite as extended an area, that is, geological maps and reports have been published within twelve months, exhibiting the structure of a country larger in area than the whole of Great Britain and Ireland. And it should be added of a country regarding the structure of which nothing trustworthy was known previously to the commencement of the Geological Survey.

The same part of Volume VII contains also a continuation for 1868 of the annual returns of the quantity of COAL raised in India in continuation of similar returns which I had already published for the years since 1857. The full details will be seen in the tables given.

There is also, in the same part, a careful description of the very interesting area near Cherra Poonji in Eastern Bengal by Mr. Medlicott. As stated in my last report, Mr. Medlicott enjoyed the advantage of visiting these hills at the only time of year in which it was possible for any one, without certainty of serious illness, to visit the lower valleys, which are deadly in the rainy season. He has thus been able to clear up much that was unknown, and the consequence has been a considerable modification of the views originally taken of their structure. Mr. Medlicott has also been able to carry out the separation of the tertiary and cretaceous rocks, the necessity for which, as established by fossils, was indicated by me in 1863, (Quar. Jour. Geol. Soc., Lond. vol. xix, p. 524). His brief memoir will prove a valuable basis on which to carry out the detailed examination of the adjoining hills.

Reports on the Kurhurbari coal-field and on the detached and small fields near Deoghur in Birbhum are ready; their issue being only delayed by the time required for colouring the geological maps.

Of the *Palæontologia Indica*, a part or fasciculus of which was due in October last, I have not issued any part. Several complaints as to the loss and injury sustained in consequence of the issue of this valuable series in small fasciculi having reached me, and desire

having been expressed that they should be sent in larger parts, or volumes, or half volumes I have thought it better to defer the issue for a little until a larger part can be published at once. The four parts, therefore, for the year 1869-70, the last of which will be due in October 1870, will be issued during the year before October, and will constitute half a volume. The plates for all these are quite ready, and separate fasciculi could be issued now, but, for the reasons here given, it is thought wiser to delay a little and give four parts in one, as was done before.

The *Records of the Geological Survey*, which, as announced, are intended to convey a notice of the current work of the Survey, shorter papers, and abstracts of papers which cannot be published in detail at once, with analyses of works bearing upon the Geology of India, have punctually appeared at the stated intervals of three months. In the numbers for the past year, we have given to the public descriptions of the geology of the rich and productive valley of Berar; sketch of the Geology of Kuteh; of the Shillong plateau (since published in detail); of the Kuddapah and Kurnool districts in Madras, (of which detailed report is in press); on parts of Prome in British Burmah; on the general relations of the metamorphic rocks of Bengal; in palæontology, a careful description and plate of the fossil *Pangshura* (*Emys*) *tecta*, and other *Chelonia*. These are of very high interest, as they are truly identical with the same species, now living abundantly in this country, while the remains described were found along with remains of animals which have long ceased to exist in India, (*Hippopotamus*, *Sivatherium*, *Mastodon*, *&c.*). Bearing on the practical applications of Geology, we have notices of gold in Singhbhum: of the mineral statistics of Kumaon, where a considerable amount of copper is still raised by the inhabitants; and on the coal-fields of the Central Provinces: while to meet the general interest excited in the history of the Nicobar Islands, and to answer many enquiries made regarding their geology, I have published a translation of the most recent and valuable contribution to their geological history, which having appeared in German, as a part of an expensive and not generally available series of publications, containing the researches of the scientific expedition which the Austrian Government sent round the world in the "Novara" (1857-59), was not accessible generally to the public here. Full lists of the additions to our library here, of which so large a portion consists of exchanges with scientific institutions and societies in other countries, are also regularly given in the *Records*.

In addition to the ordinary current work of the Survey much additional labour has been undertaken in furnishing brief notices or sketches of different districts or provinces for district officers, and lately more especially for the officers charged with the editing of the several Gazetteers now in preparation. These notices are necessarily required to be brief, but the briefer they are, the more time and trouble they cost. I have further undertaken to continue to supply these notices from time to time, not only for Bengal, but for other parts of the country. Copies of geological maps, and sketch geological maps have also been given to several public authorities and others, who have been interested either in investigations connected with the mineral resources of the country, or for sanitary purposes. Of the value and utility of these maps, we have received cordial acknowledgments from all.

LIBRARY.—During the year just past, 883 volumes or parts of volumes have been added to our library. Of this number 393 were presented by other institutions or societies, or were received in exchange for the publications of the Geological Survey. A full list, as already mentioned, is given of the additions every three months in the Records. As usual, a list is here appended showing all the societies or public institutions from which donations or exchanges have been received during the year 1869.

As with the collections, so also with our books, maps, &c., we are most seriously inconvenienced by the very limited space available for their exhibition or preservation—a difficulty which there is at the present no means of obviating.

MUSEUM.—So far as there has been any room, additions have constantly been made to the collections exhibited in the Museum; and all practicable means are adopted to prepare other series for exhibition, whenever it may be possible to accomplish this. More than 20,000 specimens have passed through the Curator's and Assistant Curator's hands, and have been entered and catalogued for reference during the year. But many of these had to be packed up again, there being no place to keep them otherwise. Cases have been procured as quickly as possible for the additional rooms noticed in last year's report, but they are not all ready yet.

METEORITES.—Our noble collection of Meteorites maintains its excellence. During the twelve months past, we have had additions of a good specimen of the Khetree fall (February 1867), for which we are indebted to Mr. D. Waldie of Calcutta, and specimens of the Ornans fall (July 1868); of that which occurred at Sclavetič in Croatia (May 1868); and of the mass which fell at Krähenberg, near Zweibrücken (May 1869). For the last three we are indebted to Dr. Tschermak of the Imperial Mineral Cabinet at Vienna.

As customary, an Index map, on a small scale, is appended, showing roughly the present state of progress of the Survey; as also a list of those societies or public institutions from which we have received publications, during the twelve months, in exchange for those of the Geological Survey of India.

T. OLDHAM,

CAMP, CHANDA DISTRICT, *January 3rd*, 1870.

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

List of Societies and other Public Institutions, &c., from which publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1869.

BELGIUM.—Academie Royale des Sciences, Bruxelles.
BERLIN.—Academy of Science.
„ Deutsche Geologische Gesellschaft.
BOMBAY.—Geographical Society.
BOSTON.—Society of Natural History.
„ Museum of comparative Zoology.
BRESLAU.—Schlesische Gesellschaft für vaterlændische Cultur.
CALCUTTA.—Asiatic Society of Bengal.
„ Agri-Horticultural Society.
„ Indian Annals of Medical Science.
CORNWALL.—Royal Geological Society.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
DUBLIN.—Royal Society.
„ Royal Geological Society.
EDINBURGH.—Royal Society.
GÖTTINGEN.—Königl. Gesellschaft der Wissenschaften.
HALLE.—Natural History Society.
JUBBULPORE.—Government School of Industry.
LAUSANNE.—Société Vaudoise des Sciences Naturelles.
LONDON.—Royal Geographical Society.
„ Royal Society.
„ Royal Asiatic Society of Great Britain and Ireland.
„ Geological Society.
„ Geological Survey of Great Britain and Ireland.
„ Society of Arts.
MADRID.—Royal Society.
MANCHESTER.—Literary and Philosophical Society.
MOSCOW.—Société Impériale des Naturalistes.
NORWAY.—Royal University of Christiania.
PALERMO.—Scienze Naturali ed Economiche.
PARIS.—Academy of Sciences.
„ Comm. des Annales des Mines.
„ Société Géologique de France.
PHILADELPHIA.—American Philosophical Society.
„ Franklin Institute.
ROORKEE.—Thomason College of Civil Engineering.
SALEM.—Essex Institute.
TORONTO.—Canadian Institute.

TURIN.—Royal Academy of Sciences.
VICTORIA.—Royal Society.
„ Philosophical Institute.
„ Govt. Geological Survey of Victoria.
VIENNA.—Kais. Akad. der Wissenschaften.
„ K. K. Geologische Reichs-Anstalt.
WASHINGTON.—Smithsonian Institute.

Governments of India, Madras, Bombay, Bengal, N. W. Provinces, Punjab; Chief Commissioners, Oude, Central Provinces, British Burmah.

NOTES ON THE GEOLOGY OF THE NEIGHBOURHOOD OF MADRAS,—by R. BRUCE FOOTE, Esq., F. G. S., Geological Survey of India.

The greater part of the Madras district lying north of the Palar river and south of the Pulicat lake is occupied by rocks of the secondary, tertiary, and recent ages, the remainder of the area being taken up by metamorphic rocks forming part of the great gneissic series of Southern India.

The topographical features of this part of the Carnatic are very simple, the ground rising from the coast westward up to the foot of the Eastern ghâts and their outliers, in a very gradually inclined plane which I will call the Madras area. The surface of this plane is varied only by the shallow valleys of the Narnaveram, Cortelliar, and Palar rivers, the latter forming the southern boundary of the tract of country now under consideration. In the north-western part of the district the inclined plane is broken by two groups of hills, the Sattavedu and Alicoor hills, to the west and north-west of which, but just beyond the boundary of the country now to be described, rise the Naggery mountains, which are lofty and conspicuous, but perfectly detached outliers of the Eastern ghâts. The south-eastern corner of the inclined plane is dotted by a number of low, but picturesque, ridgy gneiss hills.

The northern, central, and south-western parts of the Madras area are occupied by the stratified rocks, roughly speaking, the southern and south-eastern parts by the metamorphic rocks, a narrow belt of which must be included all round the western boundary of the area of the stratified rocks.

CLASSIFICATION OF THE ROCKS.

The following tabular statement illustrates the various groups into which the rocks of the Madras area have been classified:—

Recent or quaternary	...	Blown sands. Alluvium, marine, and fluviatile. Laterite and Conjeveram gravels.
Tertiary ...	...	Gritty sandstones. ? Cuddalore sandstones.
Secondary ...	...	(Cretaceous ?) Jurassic, Rajmahal plant beds.
Submetamorphic	...	Cuddapah group.
Metamorphic ...	...	Gneissic series.

The Blown Sands.—These sub-aerial deposits are of no great extent or importance, as they form merely a fringing ridge to the beach. To the south of Madras they are largest at, and to the south of, Covelong (Kovilam of the natives). North of Madras they attain their greatest height, between 40 and 50 feet, at a place called Chintamanikovil, where they have nearly covered up the Kovil (Hindu temple).

The greatest width attained by this coast ridge may be about a mile, but it is generally much less, and the amount of drifting inland is not of any real importance, and easily stopped by plantations of suitable trees, *e. g.*, Casuarinas, Palmyra palms, Screw pines, and Cashewnut trees, all of which flourish near the coast.

The alluvial formations.—These are of two classes, marine (including estuarine) and fluviatile, but they are nearly undistinguishable in character, and at many points graduate into each other imperceptibly.

Their general character, as seen at the surface, is that of pure, or nearly pure, silicious sands, but beds of black, blue, or grey clay occur largely below the surface in the marine alluvium near Madras; these are, however, much less frequent in the fluviatile alluvium higher up the river valleys. The greatest depth to which the marine beds have been pierced by sinkings is 55 feet, when the gneiss was reached. In the marine and estuarine beds along the coast many of the clays are largely filled with shells, all of living species, but in a sub-fossil condition. Such marine beds are known to extend two to three miles inland, but I could not ascertain whether they had been penetrated by any sinkings further inland.

The river alluvia are of more interest than the marine, because they afford evidence of some remarkable changes within the human period in the courses of several of the principal rivers in the district. Lithologically, the fluviatile alluvia are of no interest, for they consist, as a rule, of nothing but coarse, gritty, loose, silicious sand. Gravels or clayey beds are rare, and organic remains are hardly ever met with, excepting a few *Helices* and fresh water shells, (all of living species), in thin beds of reddish loam.

The changes in the course of the rivers above referred to are four in number, and concern three rivers, the Palar, the Cortelliar, and the Naggery river, but I will only notice the two most important here.

The Palar now flows into the sea 42 miles south of Madras, but it, or a large branch of it, formerly flowed down what is now the alluvial valley of the Cortelliar, and debouched into the sea, somewhere to the north of Madras, probably between Ennore and Pulicat. The present Cortelliar valley is very disproportionately large as compared with the river which runs through it in a rather deep channel.

The present valley of the Palar is still more disproportionately small as compared with its river; the two alluvial valleys join, or rather diverge, at a place about 10 miles east of the town of Arcot. A stream is even now connected with the Palar just at the fork by which water is still carried down the Cortelliar valley for many miles and eventually falls into that river.

This stream is considered by the natives to be the old Palar and bears a Sanscrit name, Vridachara nuddee or old milk river, the Tamil word Palar also signifying milk river. A similar change, of course, has occurred to the Naggery river, which in former times fell into the Narnaveram river, close to the Ramaghiri mountain, at Nagloperam. The Naggery river was diverted from its old course at a place about two miles east by south of the town of Naggery, and made, by the cutting of a channel about half a mile in length through gneissic rocks, to turn to the south-east instead of flowing due east and east by north and to fall into the Trittang river, which joins the Cortelliar a few miles further east. The broad alluvial valley which now runs between the Naggery mountain ridge and the Alicoor hills is in consequence of this change drained only by small streams and artificial channels.

I could not obtain any information on this point from the enquiries I made on the spot, but from the appearance of the cut through the neck of gneissic rock above described, I think the change of the river course was the result of human agency. Like the alluvium of the Palar river the alluvia of the Naggery river (both in its old valley and along the newer channel as far as its junction with the Cortelliar) and of the Narnaveram river consist almost entirely of coarse gritty sand; clay beds are rare, but where met with are of black color and regur-like texture. All the rivers named appear to be still cutting their channels deeper and deeper every season.

Lateritic formations.—The formations classed under the above heading are of three principal kinds, namely, clayey conglomerates, gravels, and sands which occur distributed over nearly the whole of the area under consideration.

Their occurrence is, however, not so much in continuous spreads as in detached patches, many of which are but of small size, though some occupy important areas from one hundred to two or nearly three hundred square miles in extent.

These larger areas occupy, as a rule, the higher grounds lying between the different river valleys; the small patches occur at similar levels and are evidently outliers left by partial denudatory action by which the once continuous lateritic deposits have been thus broken up.

The thickness of the lateritic formations is very small when compared to their superficial extension. They rarely attain a thickness of 12 feet or upwards.

The three principal kinds of rock above enumerated which make up the bulk of the lateritic series, namely, clayey conglomerates, gravels, and sands, are found constantly graduating into each other in such a manner that they can only be regarded as parts of one and the same deposit, however various the appearance of the different members.

In the Madras area, and to the north of Madras in the Nellore district, the character of the lateritic formations is considerably different from that of the representatives of the same series further south in Trichinopoly and South Arcot districts, the difference consisting in the much greater frequency of conglomerates and in the presence of large quantities of quartzite pebbles enclosed in the conglomerates. This peculiarity depends on the proximity of the quartzite rocks of the Cuddapah series, which attain their southernmost point in the Naggery mountains, and even more perhaps on the extensive destruction of the much younger conglomerates of the jurassic series which were mainly composed of pebbles and boulders of such quartzite and were of great thickness. The laterites of South Arcot, Trichinopoly, and Tanjore, on the contrary, do not, so far as known, contain any quartzite whatsoever, but only fragments of gneissic rocks, and these but very rarely. The nearer the laterite of the Madras area approaches to the Alicoor and Sattavedu hills, which are entirely composed of the coarse jurassic conglomerate above spoken of, the larger do the quartzite and other pebbles it encloses become. In some of the laterite sections indeed near those hills the conglomerate is so coarse that few of the enclosed pebbles are less in size than a man's head, and many very much larger; some, indeed, though perfectly smooth and well rounded, of such size as to deserve the name of boulders.

In such conglomerates the matrix of ferruginous clay iron stone is almost masked by the included masses.

Near the sea, however, as at the Red Hills, a few miles north-west of Madras, the included quartzite pebbles are small and not numerous, and the conglomeratic character not everywhere visible. Where such is the case, the peculiar characteristics of typical laterite, namely, its ferruginous character, its permeation by tubular and vesicular cavities filled with pale colored sandy clay, and lastly, its hardening and becoming coated with a glaze when exposed to atmospheric influences, are seen to perfection.

The laterite gravels frequently contain pebbles of quartzite and gneiss mixed with the pisiform ferruginous pellets in varying proportion according to their proximity or distance from the older quartzite yielding rocks. The sands associated with the lateritic conglomerates and gravels show considerable variety in texture and color, the latter depending on the percentage of iron. They not unfrequently contain a large quantity of clay, and are then apt to cake and harden, but without the excessive fissuring noticeable in purer clays. These sandy beds are frequently found overlying the highly ferruginous beds and form to a great extent the soil of the laterite areas.

The Conjeveram gravels.—In the south-western part of the Madras area the high grounds north-north-east and north-west of Conjeveram are covered by a peculiar quartzite gravel formation occupying the same relative position as the true laterite further to the east and north, but distinguishable from it by the absence of ferruginous matter, and consequently by its pale color. This change in mineral character (supposing the Conjeveram gravels to belong to the laterite period) takes place a little westward of a line drawn from Wallajahbad due north to the alluvium of the Cortelliar valley, but unfortunately no section occurs showing the two formations in juxtaposition.

Both have so far proved unfossiliferous as far as true organic remains are concerned, but both appear to contain implements of human manufacture in the shape of axes and spear heads made of *chipped* quartzite pebbles and of the same types as those occurring in the gravels of Western Europe. I have given the name of the famous old town of Conjeveram to this non-ferruginous gravel deposit, from its occurring, so far as I know, only within the Conjeveram taluq.

Cuddalore Sandstones.

Underlying the lateritic formations in the northern part of the Madras district is a gritty sandstone of white or drab color sometimes slightly mottled with rusty spots. This sandstone, which is well exposed only in the cliffs on the south side of the Cortelliar river, six miles north-west by north of the Red Hills, bears a strong resemblance lithologically

to some parts of the Cuddalore sandstones as seen near Cuddalore, and like them appears completely unfossiliferous. In the Cortelliar cliffs the following section is exposed:—

Lateritic conglomerate	3 to 4 feet.
Mottled gritty sandstone	6 „
Quartzose grit of buffy white and brown colors, becoming whiter and coarser grained downwards, very friable; beds divided by thin partings of Kunkur	30 to 40 „

The base of the section is unfortunately entirely obscured by fallen masses, or by the water which here remains in a deep pool at the foot of the cliffs.

It is not known what underlies these beds, so they can only be provisionally regarded as representatives of the Cuddalore sandstones. The gritty sandstones west of Poonamallee which Mr. H. F. Blanford was disposed to refer to the same supra-cretaceous position have yielded a few fossils of unmistakeably Rajmahal (jurassic) character.

No representatives of the cretaceous group being as yet known to occur within the limited Madras area I pass on to review the different members of the

Rajmahal or Jurassic Rocks.

Although occupying superficially a lesser area than the lateritic rocks, the Rajmahal beds are of infinitely greater geological importance and deserve considerable attention.

Like the lateritic rocks, the Rajmahal beds are scattered about over the country in a number of detached areas and patches divided from each other by alluvial valleys or by bands of overlying lateritic strata that have escaped denudation. From this broken up condition of the formations added to the absence of really good sections it is difficult and in some cases almost impossible satisfactorily to correlate the different formations occurring in several patches.

For convenience sake it will be better to consider the several distinct patches in four groups, ignoring as much as possible the intervening covering formations of younger date. It is only in the three northern of these four areas that the base of the Rajmahal beds is seen, resting on the gneissic rocks along the foot of the western flanks of the Sattavedu and Alicoor hills and of the low plateau east of the Arconum railway junction.

In the Sripermatoor area the base of the series is nowhere seen owing to the great thickness of the surface deposits. Owing partly to the peculiar shape of the ground, but still more to the general softness of the rocks and to the consequent enormous accumulations of debris covering the surface, no section exists showing the true relations of more than small portions of the Rajmahal series, which renders any stratigraphical sub-division of the entire series very difficult and uncertain. A provisional sub-division into two groups has, however, been proposed, based mainly on lithological differences.

To one group consisting of coarse well consolidated conglomerates and sandstones the name of Sattavedu group has been given, from the fact of these beds having been first studied by my colleague, Mr. King, in the Sattavedu hills.

The other group, consisting of shales, clays, and gritty sandstones and unconsolidated conglomerates, we have called the Sripermatoor group, from its most important members occurring under and around the town of Sripermatoor.

The Sattavedu Group.—In the Sattavedu area the entire series of rocks met with consists of alternate bands of conglomerates and sandstones many hundred feet thick. These beds extend southward into the Alicoor hills area (under the valley of the Narnaveram river) and form the eastern and loftier half of the hill group. The entire eastern base of both the hill groups is covered up by lateritic conglomerates and sand, by which any extension to the east of this series is completely masked.

The chief petrological character of the members of this series is the prodigious coarseness of the conglomerates which are made up of large well rounded smooth pebbles of quartzite with a small number of similarly waterworn masses of granitoid gneiss firmly cemented together by a varying cement which is sometimes argillo-ferruginous, ferrugino-arenaceous, or silicio-calcareous. In some of the sandstone beds in the Sattavedu hills Mr. King discovered the few plant remains, amongst which was part of a recognizable *Dictyopteris* frond, proving the true Rajmahal character of the beds which contained it. In the southern extension of the

same beds in the Alicoor hills no fossils were found. The sandstones are mostly rather gritty in texture and only occasionally sufficiently compact to be useful as building stones.

Sripermatoor Group.—Apparently underlying these Sattavedu beds in perfect conformity are certain conglomerates, gritty clays and shales which form the western and southern parts of the Alicoor hills, and which differ from the beds of the Sattavedu series in being soft and quite uncompacted and of white or grey instead of brown and reddish colors. Even the coarsest conglomerate beds at and near the base of the series are soft, the pebbles and boulders of quartzite and gneiss, instead of being bound together by some firm cementing material, merely lie imbedded in a very friable, more or less clayey, grit consisting of quartzose debris derived from the gneissic rocks. Flanks of the hills consisting of these unconsolidated rocks are deeply covered by debris which is cut through by only a few rain-gullies of recent origin, and it is these only which afford sections of the undisturbed rocks. Many of the gullies, however, do not even cut through the thick coating of debris and rain wash. No section was found showing these unconsolidated beds in contact with the consolidated Sattavedu beds where they approach each other in the centre of the Alicoor hill group, but as far as the rounded outlines of the hills at that point serve to guide the eye there is an undoubted dip of the softer beds under the hard conglomerates of the Sattavedu series. No sign of any fault between the two series could be traced, but a fault might well exist and yet be perfectly masked by talus and debris. The nearest visible point of approach of the two series is a short narrow east and west ridge abutting at right angles against the hard basement-conglomerate bed of the Sattavedu series, which bed here forms a prominent north and south ridge, succeeded to the eastward by several other ridges, corresponding to as many great conglomerate beds. The valleys running down north and south from the cross ridge above mentioned are the two principal valleys in the central mass of the hill group, and the depth to which they are excavated is due to the greater softness of the underlying beds as compared with the overlying series. The southern part of the Alicoor hills, called by the natives the Naikenpolliam hills, is apparently composed only of the unconsolidated beds which have trended in the direction of their strike from north and south to west-north-west and east-south-east.

The basement bed at the south-west of the Alicoor area near the village of Naikenpolliam contains included masses of conglomeratic quartzite of such tremendous size—800 to 1,000 cubic feet in bulk—that they suggest the idea of their being the relics of the basement bed of the Cuddapah rocks, which are so splendidly represented about eight miles to the north-west in the tremendous cliffs of the Naggery ridge, parts of which have a vertical face of 1,000 feet high.

Glacial agency being inadmissible in so southernly a latitude, except on exceedingly strong evidence, the only probable explanation remaining is the one above suggested, which derives great probability from the fact that, on a far smaller scale indeed, similar masses of gneiss are included in situ in the basement bed of the Rajmahal plant beds at Ootatoor and elsewhere in the Trichinopoly district. These great quartzite masses, it is true, are not seen to be resting on the gneiss surface, but the latter can only be a few feet further down the slope. The inclusion of gneiss blocks in the basement bed of the Rajmahal series is to be seen only a few miles to the south in the banks of the Naggery river at Chittapuram. Numerous plant remains of unquestionable Rajmahal species were found in the principal section at the south-west end of the Alicoor hills. Amongst these plant remains were parts of *Tæniopteris*, *Dictyopteris*, *Palæozamia*, and *Pterophyllum*, and *Poacites*-like stalks.

Unfortunately from the friable nature of the clay bed in which they occur the majority appear to have become unrecognizable in drying, though when freshly extracted from the matrix even the most delicate venations and nervures were plainly visible.

On the south side of the Naikenpolliam ridge the lower members only of the series appear to be represented; they consist of unconsolidated conglomerates of various degrees of coarseness, gritty sandstones and micaceous sandy shales, exposed in a few streams and a great many well sections.

The only section which yielded fossils was one on the north bank of the Naggery river opposite to Chittapuram, where two beds of rather friable sandstone were found to contain plant remains, amongst which fragments of *Tæniopteris* and *Dictyopteris* were identifiable.

On the opposite side of the river in the Pyanoor area the same beds reappear, and are there seen to be very low down in the series, in fact only a few feet above the basement bed,

which here includes, or rather is deposited around and among, sundry large masses of syenitoid and gneissic rock. These sandstones with micaceous shales and sundry conglomerate beds of the usual unconsolidated type extend hence throughout the Pyanoor area, as proved by the numerous well sections, which everywhere pierce the superincumbent lateritic conglomerate.

The connection between the beds occurring in the Pyanoor area and those lying within the Sripermatoor area, 12 miles to the south-east, is not clear owing to the difference in petrological characters and to the insufficient evidence afforded by the organic remains. As far as the relative topographical position of the two areas affords any clue it is in favor of the beds of the Sripermatoor area, being simply an extension of those in the Pyanoor area, the difference in mineral character of the respective beds being probably due to the more littoral character of the Pyanoor beds as compared to the Sripermatoor beds, which though not to be considered as deep-sea deposits, yet appear to have been formed at considerable distance from the land of the period. This view is favored by the lithological character of a small series of Rajmahal beds exposed in a section lying about half way between the Pyanoor and Sripermatoor areas.

The most important member of the series in the Sripermatoor area is a white shale, the plant bed *par eminence*, resting on whitish friable gritty sandstone, which is in all probability the basement bed over a great part of the area. In the southern part of the area there is another series of grey clays, reddish sandstones, and buff sandy shales, whose position with reference to the plant-shale could not be ascertained in the absence of any section showing the two series.

The area occupied by the plant-shales is, roughly speaking, a rectangular basin about eight miles long from north to south by four from east to west, formed by the junction of several shallow valleys sloping very gently eastward. Several low hills rise out of the basin and are capped with laterite. The town of Sripermatoor stands in the north-west corner of the basin, which is surrounded by rising ground, the edge of which is here and there slightly scarped. To the south-east, however, a mere roll of the ground occurs much obscured by surface soil, and beyond this the grey clays appear. The plant-shales are apparently continuous all over the basin-like area, and appear to form only one bed which rolls about very slightly at low angles, or is horizontal. The shale is white, pale-grey, or buffy-drab in color, with in one or two places a little reddish or purplish mottling. The plant remains occur scattered through the mass in a fragmentary condition, as if they had been torn off by stormy winds and then drifted out to sea. In many places they are mixed up with remains of marine animals, *e. g.*, at Amarambode and Valerie.

The richest collections of fossils were made in the north-east corner of the basin where the two sections above named yielded specimens of nearly every species in the Rajmahal beds of the Madras area. In the western part of the basin animal remains were rarely found, indeed plants were everywhere more frequent than animal remains. Of the plants several species have been recognized as identical with species from the Rajmahal beds of Bengal and Cutch. These are *Palæozamia Cutchensis* and *acutifolium* and a *Dictyopteris*. The following genera of plants appear also to be represented among the specimens collected by myself: *Taxodites (?)*, *Pterophyllum*, *Tæniopteris*, *Stangerites*, *Pecopteris*, *Lycopodium (?)*, *Poacites*, and parts of exogenous stems perfectly silicified.

The animal remains which I discovered and collected included a considerable number of bivalve shells which, according to Dr. Stoliczka, belong to the genera "*Leda*, *Yoldia*, *Tellina*, *Psammobia*, *Lima*, *Pecten*, &c., all forms with a remarkably thin shell, and the allies of which are usually found living on sandy ground in from eight to ten fathoms of water. Several exhibit a resemblance to species from the cretaceous rocks of Trichinopoly, but *none* appear to be specifically identical".*

Besides the above were several small *Ammonites* referred by Dr. Stoliczka to the "*Dentati*" group (but unfortunately not sufficiently well preserved for specific identification); one a singular conical chambered shell, (? a phragmocone) of apparently cephalopodous origin, and some fish scales.

* See 'General results from an examination of the Gastropodous fauna of the South Indian Cretaceous deposits, by Ferd. Stoliczka, Ph. D., F. G. S., Palæontologist, Geological Survey of India, page 59, in Vol. I of Records, Geological Survey of India.

Reference has already been made to the different lithological character of the rocks occurring in the southern part of the Sripermatoor area and to the absence of sections by which to determine the relationship of the two sets of beds. The series of beds here met with consists of white, grey-buff and black sandy clays, and brown, buff, reddish-purple and white gritty sandstones. One of the pale-buff sandy clays contains remains of *Palæozamia* and *Stangerites*. None of the sections show the base of the series. From its topographical position and petrological character I am inclined to think that this series underlies the great "plant-shale" bed.

Of very similar character and probably occupying the same relations to the "plant-shales" is a series of gritty sandstones and shales exposed in a fine section made by an artificial channel running into the great Chumbrumbaucum tank on its north side. As this section lies two miles outside of the Sripermatoor area and the intervening space is obscured by the laterite, the position of the series here seen relatively to the "plant-shales" can only be guessed at. The Rajmahal character of these beds is proved by the finding of a fragment of a *Dictyopteris* in one of the lower beds of shaley sandstone.

To the south-west of the Sripermatoor area the Rajmahal series appears to extend to some four miles beyond Conjeveram, for shaley and sandy beds of precisely similar character underlying the Conjeveram gravels are to be seen in several well sections. The most westerly point at which unquestionably Rajmahal plant remains were found was one mile to the south-west of Rajah's Choultry.

In conclusion I may point out that these Rajmahal beds of the Madras area contrast in several respects with those of Bengal and Cutch. The Madras Jurassic, or Rajmahal, beds contain no carbonaceous matter, which in their equivalents in other parts of India occurs so largely as to form coal seams. Nothing but silicified wood has been found in the Madras beds, and unlike the Bengal beds, in the Rajmahal hills, with their great intercalated trap flows and the Cutch beds, which are overlaid by trap flows of tertiary age, the Madras series is nowhere penetrated by, or overlaid by, igneous rocks of any kind, nor in the least degree metamorphosed. Another contrast, but of less importance, is, that unlike the Cutch beds, which are often of gay and bright colors, the Madras beds are remarkable for the dullness and sobriety of their coloring, a remark which applies also to their representatives in the Trichinopoly and Nellore districts.

The Submetamorphic and Metamorphic Rocks.

These demand hardly any notice in this place. The younger or sub-metamorphic series—the Kuddapah group—does not come within the area treated of, except in one, and that possibly a doubtful case (see page 11). The metamorphic rock series—the gneiss of Southern India—also presents little of interest locally; near the coast it consists of alternating bands of quartzo-felspathic and hornblendic beds which run to some extent parallel with the coast line. Further inland to the westward of the laterite and Rajmahal areas, the gneiss is more highly crystalline and largely granitoid or syenitoid in structure, and is traversed by a few trap dykes intruded prior to the deposition of even the Kuddapah rocks.

On the alluvial deposits of the Irawadi, more particularly as contrasted with those of the Ganges,—by Wm. Theobald, Junr., Esq., *Geol. Survey of India.*

It may fairly be presumed that the origin and growth of those extended alluvial deposits, forming the plains through which the more important rivers, carve their way to the sea, were, in each several case, very similar, and that the history of the deposition of the "loess" of the Mississippi valley was but little different from that of the "loess" of the Rhine. Each river system of course has its particular history, recorded in the alluvial deposits of its basin, which, in some cases, afford a simple, in others an intricate, record of the geological vicissitudes the area has undergone, and in tracing this record we are not unfrequently brought in contact with problems far more intricate and extensive in their bearing, than the apparently uninteresting character of the beds would suggest, and we have here in India in the "loess" of our larger river basins, the same phenomena to account for, which have so exercised the ingenuity of Geologists in the case of the "loess" of the Rhine.

In every large river basin two distinct alluvial deposits will generally be met with, and this, though it may seem a somewhat obvious fact to lay much stress on, has nevertheless been overlooked in some instances, where its admission was necessary for the true explanation of the geology of the district. One such instance is afforded in Mr. Fergusson's paper in the Quart. Geol. Jour., Vol. XIX, 1863, where the author, from not properly grasping this fact, is betrayed into advocating a theory of elevation of the beds supporting the "Madhopore jungle" which he never would have been, had he rightly comprehended that he was dealing not with *one*, but with *two* groups of alluvial beds unconformable with each other. The older of these groups may be either $\frac{\text{marine}}{\text{estuary}}$, $\frac{\text{fluviatile}}{\text{lacustrine}}$, or of a mixed and alternating character, but the newer group is essentially fluvio-lacustrine, and directly produced by the existing river, albeit at one time, under surface conditions widely different from those now existing; the former of these groups I shall speak of as the older alluvium; the latter, as the "newer" or "Gangetic" or "Irawadi" alluvium, as the case may be. One essential distinction between these two groups, apart from mere stratigraphical differences, is, that whilst no very considerable thickness of the newer group can anywhere have been deposited, without a corresponding subsidence below of the area so raised at top, a very large accumulation of the older or estuary beds may have taken place, during an elevation of the area covered by them.

Under one of three conditions, every river discharges its waters into the sea, namely, within an area of either subsidence, quiescence, or elevation, and how largely, not only the character of the deposits of a large river are influenced by the prevailing conditions at the time of their formation, but the physical peculiarities no less of the delta itself, I shall endeavour to illustrate by the Irawadi, and the contrast which its delta presents to that of its sister stream, the Ganges—as these two rivers, the Ganges and Irawadi, happily furnish us with examples of rivers subjected to respectively the first and last named conditions.

In the Ganges valley the development of the *newer* or *Gangetic* alluvium properly so called (or as I would propose to restrict the term) is very considerable, and its relation and junction with the older deposits usually well defined. In the upper part of the valley it is more or less restricted to the immediate neighbourhood of the river and to the narrow limits within which the river alters its channel, but it at once spreads out on either bank over a vastly broader area than before, so soon as we descend below the confluence, on their respective banks, of the Gandak and Són; the newer deposit assuming, east of those rivers, much of the importance, as far as area goes, which the older group claimed to the west. On the north of the Ganges, in the meridian of Purneah, the newer group is thirty miles broad, which corroborates a native tradition, that that city once stood on the Ganges.*

Eastward from Purneah, in the direction of Rajshaie and Pubna, the newer deposits spread over a wide tract of low-lying country, the older clay being, however, often but a few feet below the surface, and exposed in the beds of tanks or other artificial sections. Where this clay arises from beneath the newer group, we often find it (if not usually) presenting a clearly defined boundary, giving rise to an elevated tract of country, which offers a complete contrast to the low-lying inundated land occupied by the newer alluvium—as an instance of which, I may quote the narrow strip of clay country which runs down through the newer group, and strikes the Ganges above the station of Rampore Beauliah, near Burgatchee. South of the Ganges, all round the Rajmahal hills, the boundary of the two groups is more intricate, and in some of the railway embankments a curious contrast is afforded by the difference in color of the clays belonging to different groups of which the embankment is composed, the earth at one end derived from a patch of old kunker clay being a bright reddish yellow, whilst at the other, it assumes a pitchy hue, from being taken from a bed of the newer deposit, dark-colored from the accident of its forming part of the dried up bed of a

* It is possible that this estimate may require to be enlarged, but after examining the ground, I concluded that the sandy beds north of Purneah pertained to the older rather than the newer group. Though near Purneah very flat and low, they rise and undulate considerably as we approach the hills, and include pebbles gradually increasing in size as we go north (or towards the hills). The gradient of the ground, too, after passing Purneah, is *at once doubled*, going north, that of the thirty miles between Purneah and the Ganges being uniform, so that I think there are substantial grounds for holding the view I have given. The junction is, it is true, confessedly obscure, but this is the result of the sandy nature of the surface beds of the older group, which readily commingle and fuse, so to speak, with the newer deposits, the important fact of the gradient doubling along this line not being cognizable to the eye, but where the kunker clay of the older group is juxtaposed to the sands and silts of the newer alluvium the case is different and little ambiguity results.

marsh close under the hills (trap) in which spots the soil often bears no inconsiderable resemblance to the "Regur"* or dark "cotton soil" so extensively spread over Central and Western India.

If we follow the river by its most direct course to the sea down the Bhagirathi we see the last of the older deposit or "kunker" clay in the steep bluff of Rangamatia ("stained earth") over 100 miles as the crow flies above Calcutta.

Below this to the sea all is Gangetic alluvium, which at Fort William, as revealed to us by the boring operations for an artesian well, is about 70 feet in thickness, resting on the denuded surface of the kunker clay, which is clearly indicated by the "rolled kunker pebbles" strewn over it, and intersected at that depth by the bore. To consider, however, the older deposit, merely in its aspect as regards the Gangetic basin, excavated in it, is to neglect a great and important parz of its history, that is, the entire period during which the great thickness of beds under Fort William, revealed by boring, of which it constitutes the highest member, were being deposited. It is here we require to bear in mind the difference I have insisted on, between the Gangetic group proper and this older group, for there appear to me to be no such cogent reasons why we should consider these beds as "Gangetic" deposits involving thereby a depression of several hundred feet, when it seems a simpler solution equally supported by the facts of the case to regard them as estuary deposits accumulated during an upward movement of the land. The fragmentary condition of the matters brought up by the boring rod prevents any great weight attaching to the mere presence of lacustrine shells and carbonaceous matters at a great depth, as the enormous quantity of wood, vegetable trash and lacustrine shells, swept out to sea, from a tropical shore and forming in places matted rafts, must be quite adequate to leaving a lasting record in the marine strata formed in times past, no less than in those now forming in the Bay. It will hardly be contested that at no very remote period the sea bathed the southern slopes of the Himalayas and stretched from the Bay of Bengal to the Persian Gulf, and to this period during a rise of the land, and long prior to the very existence of the present Gangetic valley or drainage system, would I refer these deep-seated beds, one of the highest of which is the "kunker" clay which it has been the custom hitherto to regard as a Gangetic deposit. It may be so; but I have always held it to be marine on grounds quite independent of those suggested by the Fort William bore.

I do not, however, wish to affirm that this kunker clay which in *lower Bengal* I regard as $\frac{\text{marine}}{\text{estuary}}$ may not elsewhere prove to exhibit fluviatile characteristics, since in the upper part of the Ganges valley, say above Chunar, beds intimately connected with it, certainly afford fluviatile indications, and such variability is to be looked for in a deposit accumulated under such conditions as I have surmised; for supposing an equable elevation to take place over the whole area, still the accumulation of the coarser beds near the centres of supply of sedimentary matter, will be more rapid than that of the more remote, and they will consequently begin first to exhibit marks of fluviatile action as the sea or estuary shoals, whilst no such indications will be afforded by the others deposited in deeper water, and this appears to me a natural explanation of the fact of fluviatile beds occurring in the central and upper portion of the Ganges valley, in intimate connexion with the kunkery clay which itself nowhere exhibits any similar indications.

The reason, apart from any other considerations, which has mainly induced me to regard the old kunker clay, of lower Bengal at least, as a $\frac{\text{marine}}{\text{estuary}}$ deposit, is finding it high up on the flanks of Patarghatta hill, which rises somewhat abruptly from the alluvial plains close to the river, some few miles above Rajmahal. At the time of my visit, the clay was being worked in this position for lime, the kilns being placed near the foot of the hill for the convenience of "tipping" the "kunker" clay down to them. The occurrence of the clay at this

* An opinion I once expressed regarding the probable derivation of the "*Regur*" from the destruction of decaying trap rocks, or some crystalline rocks of similar composition, received curious confirmation during my examination of Eastern Prome. I there heard repeatedly mentioned a certain hill of "black earth" which the Burmese described as forming a curious and isolated feature in the district. Nothing like "Regur" had ever occurred to me, nor were there to my knowledge any rocks in the district, except miocene sands and clays, which did not seem likely to present the appearance described. On reaching the locality, however, I found not one only, but three isolated patches, or three separate hill tops of black earth, in every respect a veritable Regur, being the decomposed surface soil of what I at first regarded as a trap cap to the hill, but which the last examined locality convinced me was a bedded trap ash, subordinate to the beds including it, and which happened to form the summit of the three hills capped by the "black earth" in question.

high level far above that attained by the rest of the bed in the neighbourhood can only be accounted for by one of three suppositions, either that it is a capping of clay carried up *en masse* by the hill whilst being protruded up through the alluvial group surrounding it, a supposition too unsupported by evidence to merit farther examination; or that it represents a remnant of a once continuous bed of like character, which once continuously stretched across and occupied to a corresponding height, the country now forming the broad and low lying valley of the Ganges, to which also the like objection applies as to the last; or lastly it may have been originally deposited where we now see it on the hill side cotemporaneously with the rest of the bed, occupying the plains, when Patarghatta hill constituted a rock, submerged beneath the waters of that sea, which I have previously alluded to as at no distant period occupying the plains of Bengal and upper India.

Much stress should not perhaps be laid on the negative evidence of an entire absence of fossils in this clay, but had it been formed by annual increments during Gangetic floods, it is not easy to understand how in such a homogeneous clay, and one so well adapted to preserve any mulluscous remains deposited in it, no shells are found, either such as occur so abundantly in river rejectamenta; or *Uniones*, for which it must have formed in places a congenial habitat.

In the Nerbudda valley a very similar clay occurs though at a *higher level above the sea*, and though shells are not common in it, yet such shells do occur in places, as are usually swept down into inundated tracts by river floods at present, as *Bulimus pullus*, Gray, *Helix fallaciosa*, Fer, &c., as well as fine specimens of *Uniones* with valves united as in life, of species still living in the district (*U. Indicus*, Sow., and a fine variety of *U. cæruleus*, Lea.)

The above are my grounds for inclining to the belief in the $\frac{\text{marine}}{\text{estuary}}$ origin of the older alluvial clay, in lower Bengal at least, and I will close my remarks on it by briefly describing its character and appearance. Where best seen, in some steep section on the bank of the Ganges, it presents the appearance of a stiff homogeneous clay, of a mottled yellowish or pale buffish hue reddening much by exposure to the atmosphere. It contains a small amount of fine sand, the presence of which in the fields and watercourses of the newer group is an unfailing indication of an approach to the boundary of the older. Dispersed through it also are numerous small ferruginous concretions like shots, but no foreign body either in the shape of pebbles or organic remains*, have to my knowledge been found in it. In some parts, as in the colliery districts about Ranigunj, where older groups of rocks cut out the alluvial deposits, gravelly beds surcharged with pisolitic oxide of iron, varying from a ferruginous gravel (in its consolidated shape termed laterite) to a bed sufficiently pure and unmixed to constitute a workable ore, occur stratigraphically subordinate to this alluvial clay, but they are mere local developments, varying in character, and influenced most probably by the nature of the rocks constituting the neighbouring country. With the exception of these gravelly, ferruginous and lateritic beds, which locally constitute a sort of bottom or junction bed of this clay, we have no knowledge of what it rests on save the rather meagre information to be gathered from the Fort William bore, neither do we know with certainty its total thickness† or if any beds superior to it in position have ever covered it, except, should my view of their relations be the correct one, the sandy beds which in Purneah and the adjoining Zillahs seem to overlie, or perhaps in part replace it; which ignorance arises from the very uniform elevation over its entire area of so thick and homogeneous a bed, and the general absence of artificial sections deep enough to pierce this.

Disseminated throughout this clay occurs the well known kunker or "gooting", occasionally in well defined nodules but more commonly in irregular stringy courses, and often so intimately commingled with the argillaceous portion of the bed, that the clay is dug in bulk for the kilns. Where this bed forms the surface of the country the more argillaceous portions are washed out, leaving the kunker strings, sheets and nodules projecting, or forming on the surface a sparse crust of "gooting" pebbles, and this is more observable in the upper portion of the valley than in lower Bengal, where the clay seems less rich in lime than to the north-westward.‡

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* Bovine bones were found in a well near Patna, at 60 feet. T. OLDHAM.

† Its thickness cannot be regarded as under 60 feet.

‡ Sir Charles Lyell, speaking of the unchanged character of this clay (Principles. Vol. I, 429.) 1,000 miles *north* of Calcutta, doubtless intends the *north-west*, &c., *above* Calcutta following the course of the river.

I cannot here enter at length on the relation of either this clay with that (the identity of which I presume) of the Jumna valley, which has yielded the as yet undescribed "Jumna fossils" (mammalian) or with the analogous fresh water deposit of the Nerbudda valley, so rich in mammalian remains, but will content myself with remarking that the difference of level between these two deposits is such, that the deposition of the one in a series of morasses fed by a sluggish river (which seems to answer the indications of the Nerbudda clay), might have gone on simultaneously with the accumulation in a shallow sea of the other of which the Rewah plateau in part formed the southern shore.

Having dwelt at some length on the older alluvium of Bengal, I will now pass to the newer deposits, or Gangetic alluvium properly so called, which will require a much briefer notice than the last. The newer or Gangetic alluvium comprises a very varied series of beds, directly precipitated from the waters of the Ganges, or its tributaries. It is at once an extensive and important group deposited within the trough excavated by the Ganges in the older clay, or filling up such low lying tracts as receive the flood waters of the Ganges during its annual inundations. It comprises some of the most fertile land in Bengal as in Tirhoot, which is styled the "garden of India" where it is largely developed, as also in Purneah, Rajshaie, Maldah, and in all the Zillahs which intervene between them and the sea. Its mineral character is very varied from a dark silty brown to a dazzling white sand, and in the sections of the deposit exposed in the banks of the larger rivers we see nothing like the homogeneity of the older clay, but a succession of beds of different thickness and various composition, as is the normal condition of an unmixed fluviatile deposit.

It loses something perhaps of its characteristic aspect, within the tideway where the presence of tidal waters, and tidal mud, makes itself felt, but with the exception of the belt of country within the limits of the present tideway, it is essentially a typical river-deposit. About Calcutta however, though its aspect is somewhat altered by the influence of the tides, it must still be ranked as a $\frac{\text{fluviatile}}{\text{lacustrine}}$ deposit, as it contains several beds of peat clearly a marsh accumulation and sufficient to stamp its character and origin. I am aware that at Calcutta, and doubtless elsewhere within the tidal zone, oyster shells have been found and other relics pointing to marine conditions, as soondrie wood *in site of growth*, a tree which only flourishes on land overflowed by the sea, but we must presume that this deposit during the whole period of its growth, of over 60 feet at Calcutta must have been every where traversed by deep tidal creeks on the banks of which the soondrie tree flourished and in whose quiet depths oysters and other marine organisms lived, and the bore at Fort William leaves small doubt that since the epoch when the underlying older clay had been sufficiently elevated to form a tract capable of supporting vegetation, a contrary movement of depression has been going on at a rate which permits the accession of Gangetic sediment at top adequately to counterbalance the subsidence simultaneously going on below.

Let us now compare with the alluvial groups in the Ganges valley as sketched above, the similar deposits which occur in the valley of the Irawadi, prefacing the subject with a few remarks on the physical character of the country which presents some features peculiar to it, resulting from the geological structure of the delta.

The delta of the Irawadi is embraced between the Myit-ma-kha Choung, on the east, which, under the name of the Rangoon river, falls into the sea below that town; and the Bassein river on the west, which is given off as a small stream from the main river near the village of Thambyadeing, and enters the sea near Negrais Island; Elephant and Poorian Points which respectively mark the entrances of these rivers being 137 miles apart as the crow flies. The Bassein river forms naturally the most westerly arm of the Irawadi, though at its origin its size is inconsiderable; but the Myit-ma-kha Choung rises near the town of Prome, and running parallel with that stream first receives the surplus waters of the Irawadi, when flooded by channels which anastomose with it, opposite and below the village of Pouktein, 45 miles above the origin of the Bassein river; Menghee, situated between these two points, may therefore be fairly taken in our calculations as the head or apex of the Irawadi delta; on which supposition, as the distance from Menghee and Elephant and Poorian Points is respectively 129 and 176 miles, the area of the entire delta is about 12,000 square miles. By an independent calculation, I estimate the area of alluvial deposits within the delta at 11,000 square miles, as some groups older than alluvial occur within the delta, but no exact calculation can be made from the want of any, save an arbitrary boundary, of them

to the eastward, where they creep round along the Gulf of Martaban, and blend with the deposits of the Sittang valley. Proportioned thus regularly as the Irawadi delta is, as regards contour, with its three sides respectively 129, 137, and 176 miles long, it may not at once seem obvious how Mr. W. Blanford, in speaking of it, called it "a less perfect delta" than that of the Ganges, I shall, however, endeavour to show wherein it differs essentially from such delta of the Ganges, not in form, but in respect to its composition and history.

The most striking feature connected with it, is not its mere flatness, which is naturally to be looked for in such an area, but its extremely low level. No definite assertion can of course be made, but I think I am well within the mark when I say that 2,000 square miles of this tract must be below the level of a high spring tide and fully as much more not raised more than a foot or so higher. Passing through any of the creeks when a spring tide is at its height, the water is seen pouring inland up every channel and watercourse, and diffusing itself over both fields and uncultivated ground, and the conviction produced is, that a permanent submergence of a considerable tract within the delta would be the result of the water being maintained at the full height of the springs for any considerable period; as it is, however, in the course of an hour or so, the tide falls and the flooded land relieves itself through the usual channels. This extremely flat character of the country may be surmised from a mere inspection of the map, from the numerous lakes or "Engs" as they are called, scattered all over lower Pegu, and from the anastomosing and often tortuous character of even the largest river channels.

For instance, a little below the important town of Nyoung-don the Irawadi divides into two nearly equal branches, each possessing the dimensions of a first class river, one branch flowing south and discharging itself by the Dalla mouth, whilst the more westerly branch enters the sea by the Irawadi mouth. Twenty-five miles as the crow flies below the point of bifurcation of the two streams, is the small village of Tan-ta-lop Kyoung, to which I shall hereafter refer, but following the bank of the former branch or Dalla river on which it is situated, the distance is raised to 45 miles or nearly double. From the same point of bifurcation, at the same distance as the crow flies of 25 miles, on the other branch or Irawadi river is the important town of Shuay-loung; the distance to which, following the river bank, is 42 miles nearly.

Still more tortuous is the Daga river in some parts, which constitutes the most westerly channel of the Irawadi within the delta, and which, though a far narrower river than either of those above mentioned, maintains a deep and permanent channel. From the village of Shekhabyeng to the point of discharge of the Daga lake, is, as the crow flies, 18 miles, but measured along the river bank the distance actually exceeds 55 miles, which will give a notion of the extremely level character of the country it traverses—which character is not confined to the delta merely, but marks more or less all lower Pegu, save in the vicinity of the hills.

Such being the surface, character, and conditions of the delta we might not unreasonably be led to expect within it a great development of the newer or Irawadi alluvium, but so far from this being the case, the country is almost entirely composed of the older group to the almost total supersession of the newer. This will be most forcibly realised from the statement that the entire area (excluding the actual river channel) occupied by the newer or Irawadi alluvium in the valley, amounts to but 200 square miles, of which 60 miles is made up of scattered patches adjoining the river, all lying above the bifurcation of the Dalla and (Pantanau) Irawadi rivers, whilst the remaining 140 square miles constitute an isolated tract or oasis of recent deposits, below Pantanau, which seem to occupy an original trough or depression in the surface of the older group. From this it will be apparent, that with great similarity of surface conditions between the deltas of the Ganges and Irawadi, great dissimilarity exists touching their geological constitution, the newer group of alluvial deposits so largely developed in the former being, so to speak, absent in the latter. The cause of this, briefly stated, is the fact that the delta of the Irawadi at this present time is in precisely the condition of the delta of the Ganges at the time when the first layers of Gangetic alluvium, 70 feet below the present surface at Calcutta, were being deposited, and when through the single or joint action of deposition and elevation, the older marine group had become sufficiently raised to admit the deposition of beds stamped with a fluviatile and terrestrial character, and even the accumulation of such matters as peat, to permit of which the newly raised land must have been at least as high above the sea, as the better raised portions of the Irawadi

delta; since then a steady downward movement of the Gangetic delta has permitted the enormous accumulations of newer or Gangetic alluvium which covers so large an area in Bengal, whilst the future can alone disclose if any similar movement of depression will ever permit a corresponding accumulation of Irawadi alluvium in the delta in Pegu. That no such movement has taken place hitherto is clear from the absence of the newer deposits which would have originated in consequence of it, and moreover the proofs of a general elevation are, as I shall show, sufficiently clear and undeniable.

Let us now consider how far the surface conditions which obtain in lower Pegu correspond with the supposition above advocated, of a somewhat recent elevation of the country from the sea (including, in the term elevation, the accessory agent of silting up), which, be the area rising or sinking, is always going on in so shallow and protected an estuary as the head of the Gulf of Martaban. The appearance of the bed of such an estuary as that in question, would, on its first elevation above the sea, be that of a dead level regarded as a whole—merely furrowed here and there by such channels as the drainage action of the retreating waters would inevitably carve out in a plain of soft easily-removable matter. An exception to this dead level character might here and there exist either in the shape of banks of sand or other accumulations produced by currents; or depressions in the general surface produced either by the locally increased set of currents preventing the deposition of sediment or their absence altogether checking the delivery over particular localities of even the finer sedimentary particles. If we endeavour to follow the history of these suppositious depressions subsequent to their permanent elevation, and conversion into dry land, we shall thereby obtain a clue to the origin of the most prominent features at present of the Irawadi delta, *viz.*, the presence throughout it of innumerable small "engs" or lakes, the occurrence of some of different character, such as the Daga lake, and the existence of the curious isolated tract of newer alluvium, lying south of Pantanau. It is clear that in such a case as that supposed above, one of three results must happen to any depressions which the newly elevated surface may present. If the depressions are of small extent and of a shallow character, they will be converted into small lakes or "engs" in the rainy season, and be more or less dried up and converted into grassy plains, such as are commonly seen in Pegu, with a swampy navel perhaps in the centre, during the dry season. If the depression is of larger dimensions, or receives a larger supply of water than evaporation can dispose of, it drains itself naturally into the nearest or most accessible drainage channel in the country, and this appears to be the case of the Daga lake.

Should again the depression be extensive, and, as its existence might be held to render probable, it should be intersected or connected with one of the main drainage channels of the country, it will in such a case be silted up by repeated accessions of flood waters charged with sediment, and this appears to be the origin and history of the oasis-like tract of newer alluvium near Pantanau, which has all the aspect of being an extensive trough-like depression in the original surface of the land, lying in the course of two of the largest branches of the Irawadi, and in consequence speedily silted up to the level of the surrounding country by its waters.

The difference between this case and the last is one it may be said of degree, but an aboriginal difference of level, though merely one of degree, produces exactly opposite results. A moderate depression, such as the Daga lake (even *cæteris paribus* and in this case the ground surrounding it is the higher), would, during the floods, as a rule, discharge into the nearest river, whilst a greater depression, like the Pantanau trough, would, during floods, never discharge into the river, but always itself be the recipient (*till* silted up) of the waters of the flooded stream.

The Daga lake may be now briefly noticed as it forms a curious feature in the district I am describing. The Daga lake is an annular piece of water situated on the west bank of the Daga river, 25 miles north-west from Pantanau. Its shape is irregularly oval, $2\frac{3}{4}$ miles long, and varying from half a mile to a mile in width. It discharges its surplus waters into the Daga river by a short channel of about $\frac{3}{4}$ of a mile in length, but from always remaining full is probably as deep as the channel of the Daga river itself. It is economically valuable as a fish preserve, and an account of the annual drawing of the lake is given by the late M. O'Riley in the Journal of the Asiatic Society, Bengal. M. O'Riley speculates on the mode in which it has been formed, but as he refers it to some vague intestine movement of the neighbouring strata, I am unable to agree with his conclusions. Did such a piece of

water occur in proximity to a large river-channel in lower Bengal, it would at once, and probably correctly, be referred to a deserted bend or knuckle of the river, and such was my impression in the present case before examining the ground. I anticipated finding a considerable area of newer deposit of river silt marking the former extension of the Daga river, but nothing of the sort exists, the permanent banks of the river displaying the ordinary section of older clay, and the island occupying the centre of the lake being formed of the older clay likewise. No other conclusion therefore remains but to regard it as an annular depression which originally existed on the surface of the older alluvium on its first elevation from the sea, deepened, enlarged, and wrought to its present shape by atmospheric agency. Besides atmospheric agency, which seems scarcely equal of itself to produce such a piece of water (else would they be more common), even when aided by the original contour of the ground, I should suspect some peculiarity in the soil constituting the bed of the lake. The older clay of the delta is, it is true, remarkably homogeneous as a whole, but this is not inconsistent with the occurrence in it of thin bands of a different composition. An instance in point occurs to me in the Purneah district of Bengal, where a thin band-like portion of the older clay usually so tenacious assumes almost the character of a quicksand by mixture with water, forming a sludgy compound, easily removable by the action of either springs or a stream. Some such band may very possibly occur in the older clay of Pegu, and if it occurred at about the mean height of the water on the Daga river, or lower, it would go far to explain, by the facility with which it would pulp down and flow away, the annular shape of the lake, which of course, however obscure the cause, is not purely fortuitous. In this view the original depression of the ground may have been trifling, sufficient perhaps only to give direction to the scouring action subsequently set up.*

A noteworthy point connected with the physical character of the delta of the Irawadi is the more persistent character of the river channels in it. Towards the upper part of the delta and above its proper limits, the Irawadi channel is never more than five miles broad between its *permanent banks* as they may be termed, that is the opposite margins of that trough scooped by the river in the older alluvium, and of which a considerable portion is usually refilled with river deposits. Within the delta proper towards its mouth, the present river channels are more permanent, and evince little tendency to deviate from their established channel. Even such rivers as the Daga, which wind in the most circuitous fashion in a level country, exhibit no such tendency, affording in this respect a striking contrast to the habit of rivers in the Gangetic delta. The Kosi for example oscillates from east to west (its present direction) over an area of probably not less than 30 miles, and a town which stood on the west bank of its main channel at the period of my visiting it first, stood on its east bank the following year, through the re-opening and scouring out of a disused channel in its westerly course. The station of Rampore Beauleah is in like manner suffering from the encroachment of the river, and so long back as 1855, steamers anchored where houses once stood. Nothing too is a commoner process in the Gangetic delta than the obliteration of a river channel, and its conversion into a fertile plain, a change not unfrequently effected in the course of a few years. Now, save within the narrowest limits, nothing of this sort takes place in the Irawadi delta, and this is I think attributable to the different constitution of its delta, and the absence of any extended development of the newer group, within which the incessant changes in the Gangetic rivers take place, or in other words owing to the greater and more equable resistance to erosion of an homogeneous clay like the older deposit, than what is afforded by banks composed of newer silty deposits, and such fluviatile accumulations. Local peculiarities may in some spots cause a wasting of the older clay, as at the important town of Nioungdon, where a great extent of sand flats and shallows have resulted from the excessive denudation suffered by the older clay, giving rise to a sprawling channel very different from the deep permanent channel usually seen in the delta, but the cause is obviously a local one, the clay here resting on an incoherent pebbly sand, which melts away and allows the overlying bed to topple into the river, and the process which is rather exceptional in Pegu in the older group produces the same result as in Bengal, where it is an universal operation in the newer.

* Mr. O'Riley himself subsequently to the publication of the paper referred to, changed his view of the formation of this "lake"; and believed, as certainly appears the much more rational and simple mode of accounting for its formation, that it is simply an unfilled-in bend, or as Mr. Theobald says "knuckle" of the river. Everything seems to be in harmony with this view, and Dr. Day, in his recent Fishery enquiries in Burmah, was also satisfied that this was the true explanation of the facts. T. OLDHAM.

It may perhaps seem strange, that, with so eminently level and low lying a tract of country as I have described above, over which flood waters are repeatedly effused, no considerable deposit of river sediment has taken place. The objection is to some extent plausible, but I shall now hazard a few considerations which greatly diminish its force. In the first place I would beg attention to the fact previously stated by me, which lies at the root of the entire question, and that is, that the Irawadi delta is at this present time in the precise condition which the Gangetic delta presented, when, in the latitude of Calcutta, the older alluvium, now about 65 or 70 feet below the surface and considerably therefore below the sea level, was nearly the height of the present surface and beginning to receive those accretions of fluviatile and lacustrine deposits which now constitute the 70 feet of newer deposits whereon Calcutta stands, as before shown. This is precisely the condition of the Irawadi delta, and a downward movement, with a corresponding development of fluviatile beds, is all that is required to create a strict parallelism between the two deltas. For *corresponding* development I might perhaps rather say *consequent* development, as the deposition of any thickness of these fluviatile beds is proportionate to the subsidence of the area occupied by them, hence their absence in any force, over any elevated area occupied by the older group. At the same time I do not wish to be understood as denying that the flood waters which cross the country leave no deposit, but only as insisting on the superficial and I may say insignificant development of this group in Pegu, from the reasons above given. When the entire country is composed of the older clay a thickness here and there of a few feet scattered over the surface and that after a very sparing fashion, scarcely deserves comparison with the extensive and thick deposits of Gangetic alluvium. In the river banks a couple of feet at most, and this I consider an over estimate, of surface soil is seen, the entire bank being composed of the old homogeneous clay. Farther removed from the main channel the deposition of river silt is even more trifling on two accounts; firstly from the more copious deposit of silt on the river bank, through the diminished velocity of the $\frac{\text{expanding}}{\text{overflowing}}$ waters, and secondly from a cause not usually sufficiently borne in mind. It may seem paradoxical, but the low level and small inclination of the ground is a serious obstacle to its becoming silted as I shall show. When a cross country "spill" takes place and flood waters charged with sediment traverse a low country, deposition of course takes place, as when the floods of the Són abandoning their proper channel pour irregularly across the plains of Behar, and in place of falling into the Ganges above Patna, effect an irregular discharge for themselves below it. Very different, however, is the case of a river running through so flat a country as the Irawadi delta, and possessing a rain-fall such as Pegu does.

The first showers of rain fill the numerous "engs" or depressions scattered over the country, and these gradually enlarging, submerge the country before the turbid floods of the river have risen to a similar height. In default of any effective drainage, the ground adjoining the rivers being higher than the flooded interior, the ordinary rain-fall of the district is usually adequate to produce this effect, but the low land skirting the hills, receives in addition considerable, though irregular supplies through streams which pouring out from the hills diffuse themselves over the country, and lose themselves in the plains. A vast quantity of sand is swept down and forms a sort of encroaching talus margining the plains, but the somewhat depurated water mixed with the pure rain water of the plains, together forms a body of water very limpid and free from sediment, though eventually often tinged with brown from decaying vegetable matter. The turbid waters of the Irawadi now rising, top their banks, but their course is soon arrested by the limpid water of the plains and may often be traced holding on their course without mingling with the other by the contrast in colour the two bodies of water present, and this balance of power of course tends powerfully to reduce the deposition of silt to a minimum over these inundated plains and restrict it to the immediate neighbourhood of the larger streams.

In appearance the older clay of the Irawadi valley much resembles the older clay of Bengal, but it differs from it in being very deficient in lime, and rarely containing, and then but sparingly, these calcareous concretions or kunkur which give a distinctive character to the deposit in Bengal. It is a very homogeneous deposit throughout, but a thin dark band in it shows that it dips seaward, or to the south, at a greater angle than the surface of the land, which proves that the process of elevation has been greater inland than towards the gulf of Martaban. This is quite in accordance with evidence of an increased elevatory movement as we proceed up the coast, northward. Towards Cape Negrais no prominent signs

of elevation present themselves, but as we approach Gwa we find gradually proofs of a somewhat recent rise of the coast, in the shape of coral banks raised above the present limits of its growth and in the presence, a few feet below the surface in the plains now removed from the shore, of shelly sand and shells of species living on the coast. Above Myanoung this dark band is cognizable high above the dry season level of the river, but within the tideway it occurs about midwater mark or lower, and is in many places dug out for pottery, being highly plastic and adapted for such purposes.

Towards the top of the tideway the older alluvium or yellowish clay rests on a pebbly sand, which is visible at Nioungdon, where it is rather better $\frac{\text{developed}}{\text{exposed}}$ than usual. This sandy bed is doubtless the homologue of those extensive beds of gravel which towards the frontier, underlie the older clay. Opposite the village of Monyo, near Nioungwaing, gold washings are carried on in the bed of the river on a shingly bank which belongs to these coarse gravels, and these gravels are probably the source of the gold which in many spots is occasionally washed for in the Irawadi, though the returns are too poor to attract continuous labor. This older clay is not confined to the valley of the Irawadi, but occurs likewise in that of the Sittang—and, which is rather difficult to account for on any other hypothesis than that which I have adopted, of its estuary origin, in the upper parts of the river valleys on the side of the Arakan Coast. In some of these valleys it is seen deeply cut through by the river channels, and very often appearing little more than a remnant of a once extended deposit. In such positions it is often masked and covered over by an enormous accumulation of rocky detritus swept down over it by rains from the adjoining precipitous hills. This is not a situation favorable to the accumulation of a homogeneous clay, through long-continued fluviatile action, but rather points to a period when its equable diffusion took place within the sea. The coarse gravels which underlie the clay towards the upper portion of the delta and towards the frontier are clearly of marine origin, as no other agency is adequate to formations of such coarse shingle as that in question. Opposite Prome this gravel rises to upwards of 60 feet above the flood level of the Irawadi and is fully 30 feet thick reposing on miocene strata. The older clay is not seen here being apparently denuded, but at Thaietmio the relation of the two beds is well seen. In the neighbourhood of Thaietmio, this gravel contains numerous well worn and rounded pieces of fossil wood, six inches in length and occasionally logs two feet and upwards in length. These logs have, of course, not travelled far, and are derived from the miocene sands containing silicified wood in the neighbourhood. Their presence, however, with other hard rocks, in well-rounded lumps is clearly indicative of their origin in situ as a marine shingle bank. Equally conclusive is the thick deposit of coarse shingle comprising well-rounded boulders, many of six and nine inches in length of the hardest schists, exposed in the river bank under the old Fort of Miade above Thaietmio on the opposite bank, and I can draw no other conclusion from these deposits, than that, anterior to the deposition of the older clay, they formed shingle banks in a shallow sea or estuary in which their hard silicious ingredients were rolled about and polished down as we find them in the gravel. Having in a previous notice described the beds whence the fossil wood has been derived I need not here allude to them, but I think I may confidently assume that marine and not atmospheric agency was the force employed in the removal (in part at least) of these fossil-wood beds, and in reducing the silicified trunks so abundantly contained in them into the innumerable smoothed blocks, boulders and pebbles of fossil wood so characteristic of the Irawadi gravels.

I will conclude my remarks on the Irawadi alluvium by pointing out the effect to man, and the extent to which his industry is affected by what might seem merely a trivial or theoretical difference between the delta of the Irawadi and Ganges. I have already shewn that within the Irawadi delta, but 200 square miles occur of the newer or Irawadi alluvium proper, but without affecting to estimate the area occupied by the corresponding Gangetic alluvium it may be taken as far more than two hundred times that amount. Now, it is on this newer alluvium that the finest indigo is grown, and indigo and $\frac{\text{silk}}{\text{mulberry}}$ may be said to be the two main staples of the zillahs in Bengal occupied by the newer deposits. Not only this, but the newer alluvium will produce any crop required of it, either rice, sugar, opium, oil seeds, &c., and hence from the occurrence of these newer deposits over so large an area in Bengal, that province has acquired the name for fertility it possesses. In the Irawadi valley, in place of this fertile deposit, we have the older alluvial clay, which,

though where it forms an undulating country, or beyond the limits of the delta, and on the upper part alike of Pegu or Bengal, is capable of producing valuable crops of various descriptions, yet where it occupies such low land as the delta, is fit to sustain nothing so well as rice crops; and hence the inability of the delta of the Irawadi to compare in richness with that of the Ganges, or to furnish in like abundance the various products, which a seemingly trivial difference in geological composition enables her more favored sister the Ganges to produce.

Rangoon, 15th June 1869.

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Geology of Gwalior and vicinity, by Chas. A. Hacket, Esq., Geological Survey of India.

The following observations will be confined to the southern part of the country near to Gwalior, included in Sheet No. 1 of the Gwalior and Central India Topographical Survey, the northern part being covered by the alluvium, which I did not examine very closely.

Physical features.—The southern part of the area is traversed by six ranges of hills; three of these have an east and west and the other three a north-east and south-west direction. Of the three east and west ranges, that to the south, extending from near the town of Par on the west, to the Sindh river on the east, is between 3 and 400 feet above the level of the plain to the south and presents a steep scarp in that direction. The other two are not so high and are less continuous; the northern range, that north of Gwalior, being formed of a line of isolated hills.

The three north-east and south-west ranges are the continuation of ranges extending to the south beyond Sipri. All of them present a steep scarp to the south-east, and incline, at a small angle, in the opposite direction, roughly parallel to the dip of the rocks.

Two series.—The rocks forming the east and west line of hills belong to an entirely different series from those forming the north-east and south-west line; the former being formed of the Gwalior Series and the latter of the Upper Vindhyan.

Unconformity.—These two series are totally unconformable to each other, the former having been immensely denuded before the deposition of the latter. In fact, I shall show presently that the principal physical features of the Gwalior series, *viz.*, the Par scarp and the two valleys included between the three ranges of hills, were in existence previously to the deposition of the Upper Vindhyan series.

Crystalline.—The narrow strip of country south of the Par scarp is occupied by the crystalline rocks. But except on the scarp and a few hillocks in front of it, the rocks are mostly covered by the alluvium. This area is also traversed by numerous large quartz veins; some of these extend for many miles in length, and attain to a height of 2 or 300 feet above the plain. Further south, these quartz veins are more numerous, longer and sometimes upwards of 500 feet high.

Crystalline Rocks.

Par scarp.—As only a small area of these rocks is exposed within our limits, my observations upon them will be very brief. The greater part of the Par scarp is formed of gneiss. Where highest there is only a capping of a few feet of the Par quartzite, the lowest member of the Gwalior series; but in most of the deep bays, which have been worn out of the scarp, and east of Deogurh where the scarp is cut back by the Sindh river, no gneiss is seen, but the quartzite extends down to the level of the plain.

The gneiss in the scarp is in a very decomposed state, and a good deal covered by the debris of the quartzites, &c. The foliation is obscure, but in places it can be traced; the strike appeared to be east-20°-north.

The gneiss most often seen in the scarp is composed of red felspar, quartz, and black mica; frequently the mica is entirely absent, and sometimes steatite is very abundant.

Another variety of the gneiss occurs at the base of the scarp, at the western end, from Deogurh to Ladera, and also in the hillocks near the latter place. The differences between the two varieties are strongly marked; this second variety is far less decomposed than the former; the hillocks by Ladera are formed of large blocks of it, some as much as 20 feet across. Foliation cannot be traced, and the felspar in it is white. Many sections of the junction between the two varieties are exposed in the scarp, in all of which the boundary between the two is well defined, the particular characters of each being as strongly marked at the junction as at some distance from it.

Quartz veins.—The strike of most of the quartz veins which traverse the gneiss is north 30° to 40° east, but I have met with one or two with a strike of north 10° to 20° west. These veins often run into the Par scarp at a height equal to the height of the scarp. Near the town of Par one of these veins can be traced for some distance through the quartzite; on either side of the vein the quartzite contains the debris of the quartz vein.

The Gwalior Series.

This series of rocks, named after the city of Gwalior, which is built on it, occupies but a small area in this district; the greatest length along the strike of the rocks being about 50 miles and breadth about 15 miles.

The series is composed of a variety of rocks consisting of quartzite, sandstone, limestone, jasper, and contemporaneous trap. The strike of the rocks is east and west, and the dip towards the north seldom at a higher angle than 3°.

I shall divide the series into two groups, viz.,—

The Par Group and the Morar Group.

The first, the lower in the series, consists principally of a quartzite sandstone and some shales; the second includes by far the greater thickness of rocks; but in this group, there is no bed sufficiently strongly marked or continuous along the strike to be used for the purpose of sub-dividing the group.

Par quartzite.—The Par quartzite rests directly on the gneiss; and occupies the top of the escarpment extending from a little west of Par east to the Sindh river.

That the quartzite was deposited upon a very irregularly denuded surface of the gneiss can be seen where the quartz veins penetrate the scarp, as at Goojurra. The gneiss on either side of the vein had been denuded considerably below the general level, and on the east side to a lower level than on the west.

In the scarp behind Par one of these quartz veins can be traced nearly a mile through the quartzite. The vein south of the scarp runs about north-20°-east, and at the top along this line the vein is sometimes seen in the quartzite and at others is covered by it. For several yards, on either side of this line, the quartzite encloses large pebbles of quartz evidently derived from this vein.

A few inches of the base of the quartzite is conglomeritic, being formed of rolled pebbles about the size of a pea, enclosed in a matrix of red decomposed felspar; above this it becomes very fine in texture, of a greyish color and regularly and thinly bedded.

Thickness.—The thickness of the Par quartzite varies considerably. In some places, as on the top of the scarp behind Par, there are only a few feet of it between the gneiss and the Morar group, but whenever a section of the quartzite is exposed some distance north of the scarp, a far greater thickness is seen. In the Badhano gorge, situated between three and four miles north from the edge of the scarp, there is nearly 150 feet of the quartzites exposed.

Shales.—At the east end, about a mile north of the main scarp, there is a second scarp, about 100 feet high, formed of about 40 feet of green and red earthy, slightly micaceous shales at base, capped by about 60 feet of quartzite. These shales do not appear to the west, but are overlapped by the quartzites in that direction.

At the top of this group there is locally a very peculiar rock. Its greatest thickness is not more than six feet. It is best seen near Bara. East of this it is occasionally met

with, but to the west it is not seen in situ. This peculiar bed is very irregularly denuded. Just south of Bara Castle channels are cut through it to the depth of the bed, leaving the rock standing in columns some feet square, and large and irregular patches of it extend for nearly a mile towards the south.

The following is a sketch section of this peculiar bed:—

a—Par quartzite; *bb*$^{\times}$—Peculiar bed; *c*—Shales, &c., of Morar group.

The bed presents some variety. At the point *b*,$^{\times}$ it is composed of alternations of limestone and silicious bands; the former being softer are more worn, leaving the latter in projecting bands round the columns. The silicious bands weather into a very uneven honeycombed surface. Dr. Stoliczka informs me that they are formed of corals. In the outlying patches south of Bara *bb*, the limestone is entirely absent, and the bed is composed of a compact quartzite, often of a peculiar oolitic structure.

Small patches of this bed are seen resting on the Par quartzite eastwards almost as far as the Sindh river, but the bed is thin, and the limestone absent.

Morar Group.

The rocks of this group consist of argillaceous shales, finely laminated ribboned jasper and hornstone beds, frequently exceedingly ferruginous, but in places the iron is entirely absent. There is also some thickness of limestone having the same ribboned structure, the bands of limestone from $\frac{1}{2}$ to 2 and 3 inches thick alternating with silicious bands varying from a line to an inch in thickness. The silicious bands are often of red jasper.

Trap.—The group includes several spreads of contemporaneous trap, one of them of great thickness and extent.

Thickness.—It is difficult to estimate accurately the thickness of this group, as in parts of the section the beds have a slight roll, but I should say that it must be at least 2,000 feet thick.

The line of junction between the rocks of this and the *Par group* is marked by a slight rise in the ground, seldom more than 30 feet above the top of the Par quartzite.

It is an irregular line, roughly parallel to the Par scarp. At the west end it is only a few yards north of the scarp; but eastwards the distance gradually increases, until opposite Deogurh, there is a distance of nearly five miles between the two.

Badhano.—The only actual junction between the two groups seen along the line is at Badhano. Here resting immediately on the Par quartzite are about 30 feet of white, reddish, and light green micaceous shales.

It is doubtful if these shales exist along the whole line; at all events, there can be only a few feet of them in places; they appear to be overlapped to the south, as the further north the section is situated, the greater the thickness of the shales exposed. Thus, a well situate by the side of the Bombay road, just on the top of the Ghat and about two miles north of the Par scarp, is sunk through the jasper beds nearly on to the top of the Par quartzite. In the bottom of the well, several feet of black carbonaceous shales are exposed, but in a gorge extending north from Simiria into the Par scarp to within a mile of the well, although no actual junction sections are exposed, still there is only a foot or two of the section just above the quartzite covered. No black shales are seen in this section, they may occupy the foot or two covered, but even then, there must be a great reduction in the thickness of the shales between the well and the head of the Simiria gorge less than a mile to the south.

Clay beds.—At Dharoli, the beds resting upon the Par quartzite are white clays with bands of various colours. In this section not only are the black shales overlapped, but some other shales above them: thus in the Sindh river at Bijura the following section is exposed, none of which is represented in the Dharoli section.

Bijura.—The Par quartzite is not seen at base—

30 feet		black carbonaceous, slightly micaceous, finely laminated, shales.
2	,,	ditto ditto with silicious concretions.
0	,, 6 inches	red and green shales.
2	,, 0 ,,	ferruginous shales with concretions.
1	,, 6 ,,	red and green shales.
1	,, 3 ,,	shales with silicious concretions.
2	,, 0 ,,	red finely laminated ribboned shales.
4	,, 0 ,,	ditto with silicious concretions.

Concretions.—The concretions occur as flattish round balls of flinty chert, sometimes $1\frac{1}{2}$ inches in the shorter, and $2\frac{1}{2}$ inches in the longer diameter; the longer diameter always being parallel to the bedding.

In the Dharoli section the clay beds pass upwards into an irregularly banded rock; the bands of from one-eighth to one-half an inch in thickness and formed of alternate bands of hornstone and silicious brown hæmatite, the bands of hornstone being most frequently the thicker of the two. The clay beds appear to be very local in their occurrence; for in many places, the hornstone beds form the bottom of this group. It seems possible that the clay beds are the hornstone beds locally decomposed. The two are very similar in structure; the hornstone is seen in all stages of decomposition, and the rocks somewhat higher in the section, and equally silicious with the hornstones have certainly decomposed into a similar clay, as, for instance, at the iron mines near Mangor and Santow, &c., where the red and yellow clays can be traced along the strike into the undecomposed red and yellow jaspers.

The thickness of the clay and hornstone beds is about 50 feet. The section above them in ascending order is as follows:—

	Feet.
Red ribboned jasper with ferruginous bands	150
Ribboned hornstone	50
Red and yellowish, slightly ferruginous, finely laminated, banded shales ...	50
Silicious ribboned shales	40
Felsites and shales	20
Contemporaneous trap (Choura trap)	70
Felsites and shales	40
Limestone with bands of chert	50
Felsites and shales	60
Contemporaneous trap (Bela trap)...	50
Silicious finely laminated ribboned shales, including bands of limestone ...	300
Ribboned jasper and ferruginous shales	300
Contemporaneous trap (Morar trap)	500
Ribboned jasper and ferruginous shales	50
Limestone with bands of chert and jasper	70
Ribboned jasper, with ferruginous bands	50
Semi-jaspideous ribboned shales	100

Concretions.—Concretionary structure is very common in the lower part of this section, particularly in the jasper-beds. Some of the concretions in these beds are four feet long and four inches thick, but the greater number are about six inches long and $1\frac{1}{2}$ inches thick; the longer axis always parallel to the bedding. The concretions are formed of thin laminæ of red jasper and hæmatite, and are mostly irregularly cracked in the interior and the cracks filled up with quartz crystals. In some of the concretions there are irregular cavities, sometimes 4 inches long and $2\frac{1}{2}$ inches high, lined with quartz crystals. The best sections of these beds can be seen in the gorges north of Simiria, where vertical cliffs of them more than 100 feet high are exposed. The beds of this part of the section are locally worked for iron. A description of the mines will be given presently.

Felsites.—The felsites occur above and below the Choura, Bela, and Puniar traps, as well as under the outlying hillock of trap near Fasoulee. They are mostly thin and regularly bedded, and in this respect resemble the silicious shales, with which they alternate.

The most common variety of the felsites is a cream coloured felspathic matrix, in which are imbedded innumerable dark coloured crystals, probably of augite. Another variety consists of alternate irregular, thin light-cream, and dark-green, coloured layers, probably of felspar and hornblende.

The following is an analysis of one of the felsites by Mr. Tween :—

Silica	60·50
Alumina with a little iron	24·51
Lime	2·08
Magnesia	1·32
Potash	9·16
Soda	4·51
Total	102·08

Mr. Medlicott, who has examined a portion of this area, found in the nuddy south of Raipoor some spherical hollow lumps imbedded in the felsites, which he describes as "volcanic (?) bombs, spherical hollow lumps of coarse trappean matter, imbedded numerously like great drops in one of the fine compact intertrappean beds a few feet over the Choura trap flow in section south of Raipoor."

It is difficult to arrive at any conclusion as to the origin of these beds; but from their association with the traps, their general appearance, and composition, it seems probable that they are trappean ash-beds.

Limestone.—The limestones are very uncertain in the section. Of the two limestones exposed in the Dharoli section, the lower, that between the Choura and Bela traps, is covered by the alluvium both in the east and west of the line of section. The upper is very discontinuous along the strike; at some places there is a considerable thickness of it, while in others it is entirely absent.

Uncertain occurrence of limestone.—The best instances of the uncertain occurrence of the limestone are at Bhandaoli, Siharo, and Dangora.

At Bhandaoli the hill is about 150 feet high, in which, in ascending order, the following section is exposed:—

	Feet.
Silicious shales	15
Calcareous shales with bands of limestone	20
Limestone	100
Silicious jasper-shales	20

The beds are nearly horizontal; only a few hundred yards further to the east there is no limestone in the section. On the west side, under the castle, the limestone is replaced by ochreous clay beds, in which are a few thin bands of limestone. A short distance further west, the only limestone in the section is in the calcareous shales at the base of the hill.

Siharo.—About a mile east of Siharo and north of Ootilla there is a hill of limestone nearly detached from the main range. The hill is about 100 feet high. On the south side, on the top, there are about 70 feet of limestone; under this about 20 or 30 feet of calcareous shales with bands of limestone and at base silicious shales. In the main range not 50 yards distant there is not a trace of limestone.

Dangora.—Another instance of the uncertain occurrence of the limestone is at Dangora. Here there are about 50 feet of limestone seen in section. It continues round the north side of the hill, but at a short distance to north-east the limestone becomes more earthy until it passes into the ochreous clays. East of Dangora, the limestone continues for a short distance towards Fasoulee, but at that place none is seen in the section.

I might mention many other cases of the sudden disappearance of the limestone, but I think the above sufficient. The rock that replaces the limestone in the section is always the ochreous clay beds. The limestone and the accompanying rocks are as nearly as possible horizontal, so that the sudden disappearance of the former cannot be accounted for by dip. The beds above and below the limestone being identical with those above and below the ochreous clay beds prove that the limestones are not faulted out of sight.

Trap.

There are at least four separate spreads of trap. I shall name these the "Morar trap," the "Barai trap," the "Choura," and the "Bela trap;" there is also a large spread of trap west of Puniar; this, I think, is a disconnected part of the Barai trap.

Besides these great spreads, several smaller patches occur, as at Kote ki Serai, Malipoora, Singpoora, Baroori, and Fasoulee. It is probable that some, if not all,

of these patches are parts of the four great spreads, although the connection cannot be traced, as these parts of the section are a good deal covered by the alluvium.

Morar trap.—The Morar trap is by far the most important from its greater thickness and extension along the strike. A map would scarcely convey a correct idea of its great extent and thickness; as to the eastwards the trap is only seen at the base of the broken northern range and in the isolated hills dotting the Morar plain; but there can be no doubt, these isolated patches, and the trap under the hills round Gwalior, form part of one great spread, extending from Bitholi on the west to Jhankri on the east, a distance of about 30 miles. The western end of the Morar trap is covered by the Kymore sandstone, and the eastern by the alluvium. There does not appear to be any thinning out at either end, for at Bitholi and Jhankri there is as great a thickness as anywhere along the line. About four miles west of Bitholi, in a gorge near Malipoora, the Kymore sandstone is removed and a considerable thickness of trap is exposed. This is just in the line of the strike of the Morar trap and most probably is a continuation of it.

Thickness.—The thickness of this trap must be considerable, although it is difficult to estimate it accurately. The breadth of the spread, at right angles to the strike, is at the western end upwards of three miles. The rocks immediately above and below the trap dip at an angle of 2°, and if the trap has the same dip, it must be upwards of 500 feet thick. But as there may be an alteration in dip between the northern and southern edges, this estimate is possibly excessive. At all events, there are vertical sections exposed in Gwalior fort hill, and some of the hills to the west, showing nearly 200 feet of trap, and some of the hills on the Morar plain, as at Dhaneli, Atarsoo, and Karwas, are nearly 100 feet high and are formed entirely of trap.

Barai trap.—The Barai trap occurs on the south side of Barai hill. It extends to the east nearly as far as Tigara, where it is covered by the alluvium, and on the west for a mile, and is then covered by the Kymore sandstone. There is about 50 feet of this trap exposed in the Barai hill. The small patches of trap, which crop out from under the Kymore sandstone, south-west of Barai, are obviously parts of this spread. The reason of its occurring in detached patches is, that the trap was largely denuded before the deposition of the Vindhyans, and that now, the Kymore sandstone rests sometimes on the trap and at others on the rocks below.

Puniar.—The trap at Puniar is about 1½ miles south of the southern edge of the Barai trap, and of which, although the continuation cannot now be traced, it probably once formed a part. The traps are of about an equal thickness, and the beds above and below them are very similar.

Choura trap.—The Choura trap is about 70 feet thick, and extends continuously from Naigaon, just east of the trunk road, to Choura. East of this, it is covered by the alluvium, but its continuation can be traced some distance further east, as small hillocks of trap are of frequent occurrence in that direction. It is probable that the trap seen in the stream north of Barori is a continuation of this spread, as the limestone on the top of it is very similar to that over the Choura trap.

Its continuation westwards can also be traced, for in the nuddy south of Raipoor, about two miles west of Naigaon, a small patch of trap is exposed, which is probably a part of this spread.

Bela Trap.—The Bela trap is about 150 feet higher in the section than the Choura. It is covered by the alluvium at both the east and west ends, but to the eastwards, there are many outcrops of trap along this line, the farthest of which is at Kote ki Serai, about six miles distant; these all doubtless belong to this spread.

At the northern end of this spread, in the nuddy near the trunk road, north-west of Bela, the trap has the appearance of having broken through the strata and overflowed the rocks to the south. For a distance of about 20 yards, the nearly horizontal shales, upon which, immediately to the south, the trap rests, are seen in actual contact with the vertical trap for a depth of about six feet. East of this section the trap is covered by the alluvium, but to the west it is regularly interbedded with the shales.

Raipoor.—In the nuddy near Raipoor a similar apparent case of intrusion is seen, but here unconnected with any overflowing trap.

The variety of trap forming the different spreads is diorite. It is mostly largely crystalline, the separate crystals of hornblende and felspar being visible to the naked eye. On the top of the Morar trap near Beipoor magnetic iron is very abundant in the trap, but with this exception there is little variety in the trap of the different spreads.

The Vindhyan Series.

Already described.—The western part of our area is occupied by the rocks of the Upper Vindhyan series. This formation, including that portion of it here represented, has already been reported upon by Mr. Mallet, (Mem. Geol. Surv., India, Vol. VII., Pt. 1).

Relation to Gwalior.—I shall therefore confine my remarks to its relation to the Gwalior, and, principally, to showing the extensive denudation of the latter previously to the deposition of the former. Only the two lower groups of the Upper Vindhyans, *viz.*, the *Kymore* and *Rewah*, are here represented; they form three parallel ranges, extending from the south in a north and south direction, but north of the Par scarp they trend to the north-east. The most easterly range is formed of the Kymore conglomerate and sandstone; the next—a few miles to the west—of the shales and sandstone of the Lower Rewahs, and the third—still farther west—of the shales and sandstone of the Upper Rewahs.

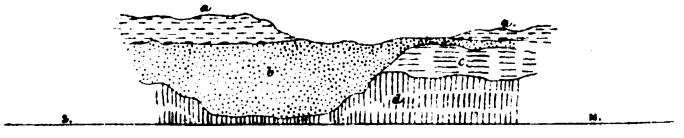
Outliers.—There are also many outliers of the Kymore group resting upon the Gwaliors; one of the largest of these is the Gwalior fort hill, the upper half of which is formed of the Kymore rocks.

Unconformity.—The Kymore cross the whole of the Gwalior section, and along the line of junction numerous sections of the unconformity of the two series are exposed.

Kymore conglomerate.—Further evidence of the unconformity is shown by the Kymore conglomerate, which is formed, almost entirely, where it crosses the Gwaliors, of angular and slightly rolled pebbles of red jasper obviously derived from these.

Doorsari.—But the most interesting sections of the junction of the two series occur in the two gorges near Doorsari at Ladera and near Bhastori. These sections not only show the extensive denudation of the Gwaliors, but also that their present physical features, as, for instance, the Par scarp and the two parallel valleys, existed before the deposition of the Vindhyans.

The Doorsari gorge is situated at the western end of the Par scarp about a mile beyond the western limits of the map. South of the Par scarp the Kymores rest directly on the gneiss and form a scarp running nearly north and south. The section is at the point of contact with the north and south scarp and the Par east and west scarp. The two scarps are each about 200 feet high. The Par scarp is formed of about 150 feet of gneiss capped by 50 feet of Par quartzite. The Kymore scarp a few hundred yards from the contact has about the same thickness of gneiss at base, but capped by the Kymore conglomerate and sandstone. At this point, the conglomerate is only a few feet thick; north of this, the top of the gneiss falls rapidly to nearly the level of the plain, and its place in the scarp is filled by the Kymore conglomerate. At the point of contact of the two scarps, there cannot be less than a hundred feet of the conglomerate resting against the steep Par scarp. At the top of the Par scarp, the conglomerate is only represented by a few pebbles, but it gradually thickens on the low ground to the north.



Junction of the Vindhyan and Par scarps near Doorsari: *a*—Kymore sandstone; *b*—Kymore conglomerate; *c*—Par sandstone; *d*—Gneiss.

The second gorge occurs a short distance east of the above. On the west side, a similar section to that just described is exposed. The gneiss falls to nearly the level of the plain, and the Kymore conglomerate increases proportionally in thickness, until, immediately south of the Par scarp, it is nearly a hundred feet thick.

In fact, the ground between the gorges, nearly half a mile, is occupied by a large outlier of the Kymores, at the southern end of which (about a mile from the Par scarp), the conglomerate is only a foot or so thick, but at the northern, there is a hundred feet of it abutting at base against the steep cliff of gneiss, and at the top against the edges of the horizontal Par quartzite, which at the top of the scarp it covers.

Ladera.—The next case proving the existence of the Par scarp previous to the Vindhyan epoch is near Ladera. It is situated just south of the Par scarp, about 24 miles west of the Doorsari gorge. Here the Kymores are seen at the level of the plain, and abutting against the scarp of gneiss and Par quartzite. It is also seen on the top of the scarp. The gorge in the scarp, just west of the narrow spit of sandstone, is also partially filled up with the Kymore sandstone. The bottom and west side of the gorge are of nearly horizontal Par quartzite, but the east side is formed of the Kymore sandstone.

Western extension of Par scarp.—There is also some evidence that the Par scarp extended west of the Doorsari gorge, for at Sirsa, about three miles west, there is an outcrop of the Par quartzite, and the Kymore sandstone is seen at a lower level immediately to the south of it.

Outlier of Vindhyans at Bastari.—At Bastari there is a large outlier of the Kymores, stretching nearly across the southern valley. The hill is upwards of 100 feet high, composed of massive irregularly bedded horizontal sandstone. The base of the hill is covered by debris, so that the Kymore conglomerate is not exposed. Patches of the sandstone rest, unconformably, on the ridges of the Gwaliors, both north and south of the valley. On the south side many of the steep lateral gorges running into the main valley are partially filled up with the Kymore sandstone and conglomerate. It is obvious that the southern valley and the lateral gorges must have been worn out before the Vindhyan epoch, as no amount of faulting could have brought the sandstone into these gorges.

Section near Bastari: *a*—Kymore sandstone; *b*—Jasper beds of the Gwalior series; *c*—Par sandstone.

Small outliers.—There are many other smaller outliers of the Kymore, particularly near Jarga and Sohnsa. They mostly occupy the low ground, partially filling up gorges, or resting upon the sides of the hills of the Gwaliors, in all cases showing the extensive denudation of the latter previous to the deposition of the Kymores.

The question of the age of the Vindhyan series has already been discussed by Mr. Mallet in his report (Mem. Geol. Surv., India, Vol. VII, Pt. 1).

Gwaliors.—The unconformity of the Gwalior series in our area to the gneiss on which they rest, as well as to the covering Vindhyans, is so great, that no conclusion can be drawn as to the exact place of the Gwalior series in the Indian series.

Hindown.—The only other place where the Gwalior series has been identified to a certainty is near Hindown, about 60 miles north-west of Gwalior. The Gwaliors there form a ridge about ten miles long, extending in a south-west and north-east direction. The beds are thrown up at a high angle, seldom dipping less than 60° in a north-westerly direction. Only a few hundred feet of section is exposed. The ridge is entirely surrounded by the alluvium, and thus isolated from the other rocks of the neighbourhood.

Upper Vindhyans.—The rocks nearest to the Gwalior ridge are the Upper Vindhyans, the upper group of which, the Bundairs, form a high scarp running nearly parallel to the ridge. The Bundairs are for the most part nearly horizontal, but sometimes at their north-western limit dip at a high angle towards the south-east. There are two other broken ridges in front, north-west of the Bundair scarp, dipping at a high angle to the south-east, probably formed of the lower groups of the Upper Vindhyans, *viz.*, the Rewah and Kymore. The nature of the junction between the Vindhyans and the Gwaliors is obscured by the alluvium.

Byana hills.—A few miles north-west of the Gwalior ridge, and roughly parallel to it, is another line of hills extending from Byana in a south-westerly direction.

Quartzite series.—These hills are formed of a series of rocks not yet described, which we have provisionally called the 'quartzite series.' It consists of an immense thickness of quartzite sandstone, shales and conglomerate. The lowest group includes numerous spreads of contemporaneous trap.

The quartzite series is most probably more recent than the Gwalior and older than the Vindhyan, for the conglomerate of the middle group (Dumduma) of the quartzite series contains pebbles of ribboned jasper, &c., almost certainly derived from the Gwalior series; and some distance south-west of Hindown, near Kerowlie, the Upper Vindhyans rest unconformably upon the lowest group of the quartzite series.

Lower Vindhyans.—Lithologically, the Lower Vindhyans of Bundlekund have some resemblance to the Gwaliors, particularly to the silicious shales of the middle range of our area, but the ribboned jaspers, so characteristic of the Gwalior series, are entirely absent.

It is highly improbable that the Lower Vindhyans and the Gwaliors are synchronous deposits, for no unconformity beyond overlap has been detected between the Upper and Lower Vindhyans in Bundlekund, and yet the lowest member of the Upper Vindhyans, the Kymore conglomerate, is composed largely of pebbles of red jasper, almost certainly derived from the Gwalior series. Again, in the Sone valley, a considerable thickness of ribboned jasper occurs, identical in appearance with the jasper of the Gwaliors, and which series it probably there represents. The Lower Vindhyans rest unconformably upon these jasper beds.

Bijawars.—The Bijawar series and the Gwalior have many points in common; but still the characteristic jasper beds of the latter are not represented in the former. The relation of these two series to each other has therefore yet to be determined.

Laterite.

There are two patches of laterite in our area; one at Raipoor hill, of which it forms the peak, the highest ground of the district; the second occurs on the Kymore sandstone, about two miles to the north-west. Both these patches are small in extent and are about 60 feet in thickness. The beds composing these hills are exactly similar to each other, and to the great spread of laterite of Central India—purple clay with bands of brown hæmatite at base, capped by the hard porous rock-laterite,—and no doubt, these two hills are outliers of the Central India spread, which has been traced as far as Sipri, about 60 miles south of the Raipoor hill.

Economic Geology.

Upper Vindhyans.—Mr. Mallet has already described the resources of the Vindhyans in his report on them; in this district the sandstone, both of the Kymore and Lower Rewah, is largely quarried for building stone. The new barracks on the top of the Gwalior Fort hill are built of the Kymore sandstone, quarried from the top of the hill.

Iron.—The principal production of the Gwalior series is iron. Formerly, the workings for iron were far more extensive than now, judging from the large excavations to be met with. The peak of Par hill is completely burrowed by the old workings and a large portion of the hill removed. Similar extensive excavations occur at Mangor and other places. The reason that the workings are not so extensive now as formerly is, not that the iron is exhausted, but that the wood to smelt it is used up; all the hills for many miles round Gwalior being almost entirely bare of any tree or jungle, the ore has now to be taken a long distance to the furnaces.

Par Hill.—The principal iron mines are situated at Par hill, Mangor, and Santow. Nearly all the workings are confined to the lower part of the Morar group, about 100 feet above the Par quartzite. That on Par hill, not now worked, occurs in an outlier of the Morar group, forming a peak rising to the height of about 60 feet above the level of the edge of the scarp. The lower part of the peak is composed of white clay beds with very regular variously coloured bands. The beds of the upper part of the peak are highly ferruginous, the iron occurring in thin laminæ in the variegated clays. It is from these beds that the iron is extracted.

Mangor.—The Mangor mines, about three miles north-north-east of Par hill. These workings are confined to a narrow valley running north and south and nearly half a mile long. On the east side they are bounded by a vertical cliff, the workings extend some 200 yards west of this, but the greater part are close under, or only a few feet west of the cliff. The richest seams are worked by small shafts some 30 or 40 feet deep; but on the west side of the valley iron is quarried from the sides of the low hills. The section in the shafts is very similar to that on Par hill, and the iron occurs in similar fine laminæ in the clays.

In the quarries, on the high ground, on the west side of the valley, the iron is extracted from beds above those on Par hill. These beds, although greatly decomposed, resemble the lower beds of the Morar group; the structure is the same, and they enclose concretions similar to those which occur in the Morar group; but here the jasper and flint, &c., forming the concretions are decomposed into red and white ochreous clays. Both east and west of this valley, the clay beds pass into the undecomposed beds of the Morar group.

Santow.—The workings at Santow are also confined to a narrow space. They are bounded on the north by a large quartz vein, and the principal workings are close to this. The richest beds are reached by small shafts about 50 to 60 feet deep, from which small galleries are extended.

The beds from which the iron is extracted are the same as those worked at Mangor and Par; they are in a similar decomposed state, and pass both to the east and west into the jasper and hornstones of the series.

Smaller mines.—Between Mangor and Santow, on the high ground, there are several workings, but most of them small; there is one place, however, near the curious old tree marked on map, where extensive excavations have been made.

All these workings are on the same horizon as those of Par, Mangor, &c., and the iron is extracted from similar clay beds, which pass into the undecomposed jasper and hornstone rocks in all directions.

The strata in all these mines are locally much contorted. In places there are vertical narrow strips of the undecomposed rocks, running through the clay beds in all directions. These strips are generally from three to six feet wide, and stand up like a wall, sometimes ten feet high. They are mostly formed of thin laminæ of iron, and show sharp contortions, even in their small breadth. They are even harder and more silicious than the unaltered rocks on this horizon, as if the silica from the decomposed beds through which they pass had been secreted in these strips. Iron is not more abundant in the parts worked than in a great part of the series, both on the same horizon and in other parts of the section.

The laminæ of iron are as thick and numerous in the hornstone and jasper beds as in the clay beds derived from them. Again, in the very highest part of the section, above the Morar trap near Kharia, the iron is quite as, if not more, abundant. The reason, that the places worked were selected, was on account of the local decomposition and softening of the rocks containing the iron.

The miners told me that they sold the ore at the pit's mouth at the rate of between 60 and 70 maunds for the rupee.

Limestone.—The limestone is quarried and burned, but not on an extensive scale, as the natives appear to prefer the kunkur to be found in the alluvium just west of Gwalior.

Black shales.—Some small excavations were made in the black shales in the bottom of the well by the side of the trunk road west of Puniar, in the hopes of their leading to coal, but, of course, without success; the shales containing only a trace of carbonaceous matter.

NOTE ON THE SLATES AT CHITÉLÍ, KUMAON, by THEO. W. H. HUGHES, F. G. S., Geological Survey of India.

Whilst at the hill sanatorium of Almora during the late recess season, I was requested, in a letter addressed to me in September last by Colonel Hodgson, R. E., the Secretary to Government, North-Western Provinces, Public Works Department, to express an opinion, after visiting the spot, as tothe suitability of some slate for roofing purposes, which was known to occur near a village called Chitélí, distant only a few miles from Dwara Hát, one of the well known camping localities between Naini Tál and Masúri.

Slate required for roofing.—The question to decide was one of importance, for, if the slate were pronounced suitable, it was intended to use it extensively for roofing the military buildings that were to be constructed at the new station of Ranikhét; it having been estimated by Captain Birney, R. E., the Executive Engineer in charge of Ranikhét, that after taking into consideration the cost of extraction and carriage, the employment of slate would be much cheaper than the corrugated iron in general use for roofing at most of the hill stations.

The following short paper sets forth the views which I entertain regarding both the quality of the slate and the quantity of it available. It would have been impossible, however, for me to have arrived at a satisfactory and reliable conclusion on the first of these points had I not received considerable and courteous assistance from Captain Birney.

Colonel Hodgson's letter reached me on the 17th September, but I did not proceed to Chitélí until the 9th October owing to the lateness of the rains and the reported unhealthiness of the spot.

Position.—The slate occurs in a spur of the hills overlooking a gorge, near the mouth of which the village of Chitélí is built.

In this spur an experimental quarry was opened out, but when I visited it, although efforts had been made to clear away the debris that obscured the section, the extraordinary continuance of the rains prevented the men at the quarry from working as rapidly as they otherwise would have done; and not more than 30 to 40 feet of rocks below the surface were exposed.

The slates dip at high angles; and, as may be presumed, there are different bands varying in their comparative goodness. None of the slates are cleaved in a definite manner, but a few do exhibit this structure in an incipient stage.

Before proceeding to purely economic matters, it may be useful to give, for the information of those who take some interest in geology, a generalised section of the Himalayas, in order to show roughly the horizon which the slate-rocks of Chitélí occupy.

Geological Section.—Commencing at Kálídúngí at the base of the hills, and carrying the section beyond the British frontier through the Milam pass, the rocks occur in the following order of succession:—

A.—Sedimentary rocks. Principally sandstones, shales, and limestones. A few carbonaceous beds occur. Seen on the road from Kálídúngí to Naini Tál.

B.—Metamorphic rocks. Schists, quartzites; different varieties of gneiss; slates and greenstones. Seen at Naini Tál, and from thence to Múnshiárí.

C.—Gneiss, with numerous granite veins. Seen between Múnshiárí and the upper Botiá villages of Búrfú and Milam.

D.—Sedimentary rocks,* corresponding to the older, secondary, and newer rocks of European classification. Seen between Milam and the Sutlej river.

The Chitélí slate forms a horizon in the class of rocks under the heading B,—the same class in which the greater portion of the mineral wealth of the Himalayas is contained.

The general quality of the Chitélí slate bears favorable comparison with other Indian specimens; but it is below the standard of typical Welsh slate.

Quality.—It differs from the latter in splitting along the planes 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. Assuming the value of typical Welsh slate as 10, the general value of the Chitélí slate would not be more than 6. There are, however,

* From this band come the *Ammonites* (Salígrám) and the *Belemnites* (Chúchí pathar), which those who cross the snows bring back with them as mementos of their travails and their travels.

some slates,—those occurring about 40 feet below the slates that crop out at the top edge of the spur above the quarry,—which are of somewhat higher value, being closer grained, possessing very even planes of lamination and splitting into thin slabs. These slates form a distinct band, their colour being darker than that of those above them.

In recommending which slates should be utilised, I would certainly say the lower ones; the upper slates being altogether coarser and containing some iron galls.

I am sorry that I possessed no means of testing the absorbing power of the specimens which I brought away with me from the quarry. But Captain Birney assures me that he has carried on experiments during the past twelve months to prove the porosity of the slate, and that the results have been satisfactory. Captain Birney, to further test the slate, had exposed several slabs to the action of the weather. All, with the exception of one which had cracked, were perfectly sound when I examined them. The cracking of one slab I look upon as a matter of little moment as affecting the quality of the slate, for all the specimens had been procured from near the surface; and I believe that this cracking will not occur when the slates are quarried from a lower depth.

Supply.—With regard to the question of supply there need be no fear. If the spur of the hill be opened out on both sides, there will be a store of slate more than ample to meet all the demands of the barracks at Ranikhét. The beds have only to be followed along their strike to yield an unlimited amount of slate.

To conclude, I consider the Chitéli slate good enough for roofing purposes. And that slabs less than $\frac{1}{4}$ of an inch in thickness and much more than a square foot, superficial measurement, may easily be obtained.

I would recommend, should the working of the quarry be determined upon, that some competent person should be appointed to pass the slates. Native labourers are too indifferent to take any interest in their work, so that no dependance can be placed upon them; and they would just as willingly waste their time in splitting bad slate as they would in splitting good. The employment of one or two skilled slab-men to supervise the other labourers and also to work, would in the end be more economical than trusting to the local abilities of the Chitéli villagers, as they would probably spoil through carelessness an endless number of slates.

NOTE ON THE LEAD VEIN NEAR CHICHOLI, RAIPÚR DISTRICT, by W. T. BLANFORD, Esq., Assoc., ROY. SCHOOL OF MINES, Dep. Supdt., Geological Survey of India.

The following is the result of a brief surface examination of the locality near Chicholi at which lead was discovered three or four years since by Mr. Smart of the Revenue Survey. The spot is rather more than 70 miles west of Raipúr on the road to Bhandára and Nágpúr.

The ore (galena) occurs in a well marked vein, chiefly composed of quartz, which traverses the metamorphic rocks. The latter are not well seen in the neighbourhood of the vein, but in the surrounding country consist chiefly of granite or granitoid gneiss and hornblend schist passing into diorite. Besides quartz the vein contains pink felspar in considerable quantities, green and purple fluorspar, and a green mineral, probably epidote. Galena is sparingly disseminated throughout the mass for some distance on each side of the road, and I found slight, but unmistakeable, indications of the presence of copper; small quantities of the green carbonate occurring in several places.

In some parts of the outcrop there is a large quantity of peroxide of iron, sometimes as a coating on the surface, sometimes irregularly mixed with quartz ("gossan"), and evidently resulting from the decomposition of some other mineral. This is a common occurrence at the outcrop of mineral veins, and is, I believe, usually considered a favorable indication by miners, in copper veins at least. But the value of such indications depends greatly upon local conditions. Large masses of peroxide of iron and quartz, or "gossan" as it is termed in Cornwall, are seen just north of a little peak about quarter of a mile north of the road.

The direction of the vein is N.-10°-E.—S.-10°-W.: it forms a series of ridges, some of which are at least 100 feet high above the surface of the ground. I traced the vein for about half a mile north of the high road and for at least a mile to the south.

Beyond the distance mentioned to the north, I could find no signs at the surface of its occurrence, but I did not search far. To the south it doubtless extends beyond the spot to

which I traced it, and a hill is seen in the direction in which the vein runs, which may be formed of the quartz.

The width of the vein, as usual, varies greatly. Near the high road, both north and south, it cannot be much less than 30 feet. About a quarter of a mile to the south, this thickness gradually decreases to about six feet. At this spot the veinstone rises like a wall above the surface of the little ridge formed of its quartzose debris, and the direction of its dip, obscure elsewhere, is distinctly seen. It here underlays to the eastward at an angle of about 10° from the vertical, in other words, it dips at 80°. Beyond this, to the south, the thickness probably diminishes still further, as, for about quarter of a mile, the vein can no longer be traced at the surface; beyond that distance it again forms a ridge of some height.

It is simply impossible from the surface examination of a metallic vein, especially in a district where no mines exist, to ascertain what its value may be below the surface. All metallic mines are more or less speculations. Taking into consideration the large amount of veinstone exposed, the proportion of galena seen is small, and unless the quantity of lead ore be greater below the surface, it will not alone pay for the working. It should be observed that the fresh unaltered appearance of the galena found renders it impossible that its paucity is due to the greater portion having decomposed. But larger masses may occur below, and there is also a probability of copper ore being found. The occurrence of the ores in a well marked vein is certainly a most important circumstance, and I may add that it is the first instance of a distinct metallic lode that I have seen in India.

Altogether I think it may safely be stated that there is nothing in the appearances presented by the Chicholi lode inconsistent with the occurrence of a good vein of lead and copper ore below the surface. There are two disadvantages in the locality: the absence of workmen acquainted with mining and want of water, not merely as a motive power for pumps, &c., but for stamps and washing floors. But these are only questions of expense, and should rich ores occur, will readily be overcome.

At Wúráband, 16 miles east of the Chicholi lode, two rather irregular quartz veins occur, forming hills of considerable size. I saw no traces of ore or of fluorspar in these, but my search was necessarily hurried. The direction of these veins approximates to that of the Chicholi lode.

17*th March* 1870.

Better specimens than before accessible have been assayed, and yielded 9 oz. 19 dwts. 6 grs. of silver to the ton of lead.

The Wardha river Coal-fields, Berar and Central Provinces.

The last notice of these coal-fields was given in the Records of the Geological Survey of India, Vol. II, pt. 4, p. 94. Since that time great progress has been made in the detailed exploration of the field, and it is now possible to give a tolerably accurate estimate of the extent of area over which the coal can be traced, and of the amount which is available, in the vicinity of the river Wardha.

This river Wardha forms the boundary between the Central Provinces, lying to the east of the river, and the 'Assigned Districts' (Berar) and the Nizam's Territories, lying to the west of the river. The same boundary is continued further to the south by the Pranhita, as the stream is called after the junction of the Wardha and Weinganga, and still further to the south by the Godavery, as the continuation of the same stream is called after the junction of the Pranhita and Godavery, near Sironcha.

Previously to the recent exploration the only places where coal had been actually found, were a few points exposed by the cuttings of this river. The whole surface near the river is so covered with widely extended beds of calcareous gravels and conglomerates (? pliocene) and thick masses of sands and clays and often of regur, or black cotton soil, that, as a rule, very few, and these very limited and imperfect, sections are seen and the structure of the country must to a large extent be imagined or built up from these small sections. Although thick beds of coal were visible in the banks of the river, their continuance inland could not be traced, and even where the rocks were exposed, the denudation had been so great, and the thickness of the covering clays, &c., was so considerable, that the outcrops of beds of such marked character as coal and coaly shale of 40 and 50 feet in thickness were entirely concealed. And it therefore was essential that actual borings should be put down. The results of a few of the early trials were given in the notice referred to above. (Vol. II, p. 94).

Shortly after the publication of that notice three additional sets of boring tools were received from Europe, and were at once turned to account. And sometime later, a steam boring machine of Mather and Platt's construction was delivered at Chanda, and preparations were made for working it. I shall now give briefly the principal results obtained.

The two brace headmen who had been sent out from England had both suffered from the climate. Mr. Heppel had a very serious attack of fever, and was for a time dangerously ill. But he got over this attack, I am happy to say, and resumed his work as zealously as before. Mr. Longridge had suffered slightly at several times from the effects of the sun; and I regret to say, the attacks became more frequent and severe, until it was necessary that he should be invalided and sent home at once. The advantage of his aid was lost from the very commencement of the open season. Mr. Bateman Smythe was appointed (10th December) in lieu of Mr. Longridge, and has proved a most efficient and useful Superintendent of the Works. Mr. W. Penn Mather, who had had very considerable experience in boring with the steam boring machines constructed by the firm with which he was connected (Mather and Platt) and who had temporarily come to India, was appointed to take charge of the Steam Borer, and joined in the beginning of February.

Taking up the narrative of the exploration from the time of last report published in these Records, I will now briefly give a notice of the principal facts.

I shall not at present delay to give the full details of the sections cut through at the various holes, but simply enumerate the localities where these have been put down and state the results. The details will more appropriately be given with a more detailed geological report.

Up to November 1869, as already stated, only a few unsuccessful borings, in which nothing but thin unworkable beds of coal had been met with, had been carried out. A deeper boring to the east of Chanda town on the road to Moolh, and on the banks of the Jhurput Nuddi, was then in progress; and this was subsequently carried down to a depth of 248 feet. At this depth the progress made with the poor windlass power then at command was so slow, and the importance of determining the existence of coal elsewhere so much more pressing, that it appeared wise to stop this boring, more especially as there was nothing definite tending to show the probability of a change in the rocks within a short distance. The tools were therefore moved elsewhere. The same section is now being proved by the steam boring machine, with the additional advantage of testing the upper rocks for a considerably greater thickness. The borings to the south of the town of Chanda, although it was evident that they had been put down altogether outside the outcrop or line where the known coal, if it occur, could be traced, were not resumed, as it seemed better to reserve these for the monsoon, when men could find good shelter in adjoining bungalows at a time when it would not be possible to remain with safety in tents. A systematic examination, therefore, of the country extending northwards from the known coal locality near Ghúgús was commenced, and has since then been steadily carried out. One additional bore hole was put down between the pit sunk on the coal near Chandur on the bank of the Wardha and Nokora. This was due west of the village of Ghúgús, and was intended to supply the information which we had been prevented from obtaining in nearly the same place by the loss of the mineral lifter in the boring there. The object of this was to prove the actual amount of variation which the seams showed within this distance of three miles. This variation will be best seen in the accompanying details.

Ghúgús North.

	Feet.	Inch.
Black shale ...	2	0
Coal	3	0
Dark sandy shale ...	3	0
Coal	3	0
Blue shale ...	5	6
Coal	12	0
Coal with iron pyrites	4	0
Coal	5	0
Shale	0	6
Coal	11	0
White sandstone.		

Ghúgús W. of village.

	Feet.	Inch.
White sandstone ...	8	6
Coal	3	0
Shale mixed with coal	2	0
Coal	3	0
Sandy shale and coal	6	0
Coal	4	0
Coal and shale ...	9	0
Coal	7	0
Sandy shale ...	10	6
Coal, good ...	9	0
Coal, inferior ...	2	0
Coal, good... ...	11	0
Sandy shale ...	0	2
Coal	10	0
White sandstone.		

Nokora.

	Feet.	Inch.
Black shale	1	6
Coal	4	0
Sandy shale, with a trace of coal	2	10
Coal	3	6
Dark sandy shale ...	5	4
Coaly shale with coal (bad coal)	3	6
Black shale	16	10
Coal, inferior	4	0
Coal	5	0
Sandstone mixed with shale	5	0
Very dark shale	3	0
Dark sandy shale ...	2	10
Coal	21	8
White sandy shale ...	0	2
Coal	13	0
White sandstone	7	8

These borings are about 1½ mile from each other; they are beyond a shadow of doubt in the same general beds and the same coals, whereas the very great amount of change in the thickness and character of the seams within this short distance is very evident. This is a very important point as bearing on the question of the economy of working.

Proceeding northwards, two bore holes were next put down at Telwassa, near the river Wardha. The most southerly of these was intended to prove the beds below the thick coals, and to ascertain, if possible, the actual thickness of rock in this Lower Barákar group. It was carried down to 192 feet, and at this depth, when a few feet more would certainly have reached the Talchir beds below, the mineral lifter was allowed to get jammed, and in attempting to raise it, the steel valve box at the end was forced off and left in the hole, which was then abandoned. Some thin seams of very impure coal were found, as anticipated, just at the base of the series, but nothing worth working.

The second boring was fixed about a mile further to the north, on the east side of the river, and here coal was cut at 68 feet below the surface, (of which 29 were surface soil); and the same series of beds as at Ghúgús, again showing considerable variations, were pierced. Altogether 41 feet of coal of varying quality were cut through in a total depth of 138 feet. (See Annual Report, Records, vol. III, p. 1-1).

Another boring was commenced in the lands of the village of Gowarala, near Bhanduk. This was commenced, under a misapprehension of the instructions given, about half a mile from where it was intended to have been, but was useful, inasmuch as the cutters struck the Talchir rocks immediately under the surface clay, and thus effectually proved the absence of coal there.

Two other borings were put down at points intermediate between the Telwassa borings just alluded to and the pit near Chandur. These were near the villages of Belora and Nilja, both in Berar. Both proved the continuance of the same group of beds of coal and shale, exhibiting quite as markedly as elsewhere the great and sudden variation in its character and sub-divisions.

It was next desirable to prove that the coal found on the Chanda side of the Wardha, and there dipping to the west, did actually extend into the country of Berar on the west of the same river. To the south near the villages of Pipalgaon and Ukni small faults affect the continuity of the rocks, and just opposite the point at which the boring in the Telwassa grounds had been put down, the series has been thrown down to the south of a fault which crosses the river. This has enabled some of the beds higher in the series of beds overlying the coal to be here preserved. And they overlap the coal beds to a greater extent than is seen in the adjoining and more denuded area. To test this part of the field, a bore hole was put down, which, however, was not sufficiently far to the west, to avoid this great overlapping, and which, therefore, only touched the extreme outcrop of the coal beds. Another hole about a mile to the north proved very satisfactorily the entire continuance of the coal beds into the country on the west of the river, or into Berar.

Tracing up the same series of beds further to the north, borings were put down in the lands of Konara. This was in the lower rocks (Barákars) and proved no coal: another boring was put down at Borgaon, also without success. Some three miles further north, a boring was put down on the Berar side of the Wardha at Goari (called also Agashi), but nothing but black coaly shales were found here.

These borings were all in the lower rocks. Still further to the north in Chanda district near the village of Majri, a boring was put down, first to the north of a fault which cuts across the beds there, with a view to proving that side, but without success, and then a second boring was commenced to the south of this fault, where the great overlapping of the beds was partially avoided, and here coal was found at 75 feet from surface, and gave a rough section of—

Dark shale, a little coaly 0·2

Coal 51·8. And having proved this thick coal, we proceeded no further. This thick bed, it must be remembered, is not all fair coal, but is split up with many beds of very varying qualities.

A boring, still in progress, was also put down near Nandori, on the Chanda side of the river to the south of the large area of trap which covers many square miles of country near to and around Wurrora. This thickness of trappean rocks effectually conceals

everything beneath them, and looking to the great irregularity with which the coal rocks are overlapped, and the impossibility of drawing any sound conclusion either as to the place or depth below the surface at which coal might be found, fully justifies our putting the entire of this area out of calculation in estimating the extent or quantity of the coal in these Wardha river fields. A boring will be put down to the north of this large area of trappean rocks where the lower beds are again visible over a small area near Panjoorni, a village about six miles north-west of Wurrora and probably near Wurrora itself. But with this exception there will be little use in testing the rocks further in that part of the field *at present*. It is not at all intended to assert that the coal group does not extend under a considerable part of this area, but if it does so extend, the chances of finding it are so uncertain, and the depth at which it probably occurs so doubtful, and in any case so much greater than in adjoining areas that, for the present at least, the coal even, if found, could not be worked to the same advantage or economy as elsewhere.

A boring has also been put down in the Berar country well into the centre of the field and some six miles in a right line from the river Wardha. This was at a place called Rajur, which is near Naith or Nét, and about ten miles to the north-west of Wún town. This was simply intended to test the continuance of the coal under the upper rocks, which cover the whole surface there. Up to the latest reports, 15 feet of coal had been cut into there, quite sufficient to show satisfactorily that the rocks continue.

Two or three more borings will now prove the whole of this northern part of the field with perfect sufficiency, and with detail quite ample as a basis for commencing the actual work of raising coal.

To the south of Chanda, the sections at Balarpur, where good coal is visible at the water level in the river Wardha, in the territories of His Highness the Nizam or on the west side of the river, have been examined. It was concluded from this examination that there was not much prospect of finding this coal extending into the Chanda district, as it had in all probability been very largely denuded or washed away and its place now filled in with beds of great thickness of alluvial clay and sand, &c. Still borings were put down to test the fact, and the rocks were proved at both sides of a marked fault which crosses the section from north-west to south-east, the rocks being down-thrown on the east, but to what extent it was not possible to calculate from the limited exposure visible. These borings proved the existence of a few thin beds of coal, 1 foot to 1½ feet, but nothing worth working.* The full examination of the northern part of the field had then become so much more urgent that the tools were removed there.

All the country south of Balarpur still remains to be examined. There is a certainty of coal occurring in the Nizam's territories in the area between the Pemgunga and the Wardha, and a few borings are there required to test the thickness and quality of this coal. The area stretching from north to south throughout the district of Chanda from east of Wurrora to Bhanduk and Chanda, and southwards by Balarpur to the Wardha near Kirmirri, is all composed of rocks which belong to series above the coal. It is therefore possible that coal may be found to extend under these rocks and so cover a large area. But there is not a trace of these lower coal bearing rocks *visible* anywhere along the line, excepting close to Chanda town. And as the covering rocks dip sharply to the east all along here a short distance only in that direction would throw the coal so deep below the surface that it could not be profitably worked in competition with the more accessible and more favorably placed coal elsewhere. This area ought to be tested by a series of well selected borings at long intervals, and if coal be proved, as I fully anticipate it will be near to Chanda, the indications should be followed up carefully. There is no surface evidence whatever to guide the observer excepting there. I have already mentioned why the borings at Chanda had been deferred until the monsoon weather. But when they are commenced, it will be needful to exercise a little more geological skill than had been shown before, for the holes which were bored were altogether outside or below the horizon of the thick coal which it was sought to prove!

No other group of beds containing coal in a workable thickness has been traced in the field, and none other probably exists. It has been shown that this group of thick beds of shale and coal maintains a constant horizon in the general series, that it is largely and irregularly overlapped by the beds which succeed it, and that with a great amount of variation

* It is stated (Supp. Gaz. India, Jan. 15, 1870, p. 30,) that 6½ feet of coal were proved at a depth of 120 feet from surface, within half a mile of Balarpur!! None of the records of the borings bear out this assertion.

there is still a constancy and continuance of the beds, which is satisfactory. In the former report I gave the results of assays of the coals raised from each successive foot in the boring at Ghúgús; and I showed also what an admirable general index to the value of the coals such assays were. I have had the same done for the coals cut through at Telwassa, and I now give the results of these assays.* It will be seen that the composition of the coal raised here is very similar to that at Ghúgús, and that, as a whole, the coals are of very second rate quality. As shown by assay (Records, Geological Survey, India, vol. II, pt. 4, p. 99), the uppermost seam at Ghúgús was good bright coal. And so it proved on cutting into it in the pit sunk not far off. But like all the bright clean coals of this lower group, it also turned out very brittle and fragile, so that it would bear carriage badly.†

* ASSAYS OF COAL FROM THE CHANDA DISTRICTS.

From No. 1 Seam passed through at No. 2 Bore hole, Telwassa.

Nos.	Carbon.	Volatile.	Ash.	Nos.	Carbon.	Volatile.	Ash.
1	30·9	29·8	39·3	18	44·4	34·6	21·0
2	42·5	32·3	25·2	19	48·9	30·6	20·5
3				20	49·4	30·4	20·2
4	41·6	32·8	25·6	21	50·3	33·4	16·3
5	34·2	32·3	33·5	22	44·0	31·8	24·2
6	35·1	26·7	38·2	23	50·4	31·8	17·8
7	36·9	26·7	36·4	24	50·2	33·0	16·8
8	33·0	25·4	41·6	25	46·7	32·6	20·7
9	42·4	31·6	26·0	26	51·4	30·6	18·0
10	39·1	29·4	31·5	27	51·3	30·6	18·1
11	43·9	32·3	23·8	28	51·2	32·2	16·6
12	46·2	33·4	20·4	29	53·0	30·4	16·6
13	45·4	33·8	20·8	30	52·3	33·4	14·3
14	43·8	34·2	22·0	31	52·0	32·0	16·0
15	45·9	36·0	18·1	32	48·2	30·2	21·6
16	41·9	34·0	24·1	33	43·8	27·4	28·8
17	37·1	32·2	30·7	34	50·1	30·6	19·3

From No. 2 Seam passed through at No. 2 Bore hole, Telwassa.

Nos.	Carbon.	Volatile.	Ash.	Nos.	Carbon.	Volatile.	Ash.
1	46·3	34·5	19·2	5	44·2	33·5	22·3
2	51·2	32·5	16·3	6	43·2	29·8	27·0
3	43·3	29·0	27·7	7	43·4	31·4	25·2
4	49·3	34·0	16·7	8	47·3	28·6	24·1

All burn similarly to the batch sent last September, *i. e.*, vigorously at first, but after the expulsion of the volatile matter only slowly down to the ash. The ash of all the samples (which has been preserved) is very similar, 25 grains mixed of Nos. 31, 32, 33 and 34 on being treated with sulphuric acid, hydrochloric acid, and carbonate of soda left an insoluble residue of 7·5 grains.

On closely inspecting some of the samples some small fragments of a much superior coal may be perceived. From No. 28, which appeared to contain some of the largest of these, I picked out sufficient to make a separate examination. This gave the following result:—

Carbon	62·5
Volatile	34·5
Ash	3·0
	100·0

(Signed) A. TWEEN.

February 28th, 1870.

† This brittle coal could be coked with advantage.

The coals below that were very inferior, and much that has subsequently been furnished from the sinking at this pit for the use of the steam boring machine is scarcely worthy of the name of *coal* at all, with difficulty keeping up the fire, and not giving steam at all in sufficient quantity. The present assays show that this is the character of much of the Telwassa coal also. One thing is quite certain that, as pointed out long since, any estimate of value based on the duty obtained from carefully selected coal from these will certainly give a false idea of the average value of the whole; while in any ordinary mode of mining, the irregularity of these better beds, and the certainty that they will not continue for any great distance on the same horizon, will seriously interfere with the economic working of seams of such thickness as those we have shown to occur.

It remains to consider what is the amount of coal which may be considered fairly and economically accessible in these Wardha river coal-fields so far as examined, that is, in other words, in the country lying between the Wardha and Pemgunga rivers in the south and the general outline of the trappean rocks which cover everything on the north. If we take this estimate in two distinct portions, as referring to the east and to the west side of the river Wardha, we can then combine the two to get the general results. In Wún district, to the west of the Wardha, there may be estimated to be about 70 square miles of country under which the thick coal may fairly be presumed to extend, and will probably be found nowhere at a greater depth than 120 yards below surface. Now, from this we must deduct a fair proportion for ground cut up by faults and disturbances, and so not likely to yield very profitable return from the working of the coal. If for this we deduct, say, one-third of the area, we will have 45 square miles yielding coal. The average thickness of coal established by the numerous trials may be taken as nearly 40 feet, that is, of coal, coaly shale and beds of varying character taken as a whole. As I have shown, a very large deduction from this must be made, and I believe that an admission of 20 feet would be not only a maximum thickness of workable coal, but be even too high a figure. But taking this as 20 feet of workable coal over 40 square miles, and assuming 600,000 tons as a fair amount of coal obtained from the square mile per foot in thickness, we have $600{,}000 \times 40 \times 20 = 480$ millions of tons of coal, of such quality as it is, available in East Berar at depths below the surface not exceeding say 60 fathoms.

Passing into Chanda we have equally an area of about one and half square miles near Ghúgús, (making the same allowance for disturbed ground as before), and an area of about five square miles in the north of the field. And as the beds of coal are precisely the same, we take here the same estimate of thickness, *viz.*, 20 feet of workable coal. And proceeding on the same data, we will have, therefore, in Chanda, $600{,}000 \times 6{\cdot}5 \times 20 = 78$ millions of tons. This latter result fully bears out what was stated months since, that there was a very much larger amount of coal available in the 'Assigned Districts' than in Chanda, in the vicinity of the Wardha.

We certainly ought not to estimate more that one-half of these quantities of *good* coal.

While engaged in the practical exploration of these coal-fields, I had frequent applications from the Engineers employed in making trial sections and estimates for a proposed line of railway for information as to the position, quantity, and quality of the coal, and as to the general question, which would be the line best adapted to meet the requirements of the case, so as to facilitate the transport of this coal to the existing lines of railway to the north and southwards to the Godavery. It was also asked that the opening up of the cotton country should be borne in mind. Every information was readily afforded from time to time as new facts were ascertained.

But this necessarily led to the consideration and discussion of the best direction in which to carry a line of railway with these avowed objects. The intended point of junction with the Bombay and Nagpúr line was stated to be the Wardha station, and it was at first assumed that the line *must* go to Chanda or through the Chanda district. Long since I pointed out that it required but a very trifling acquaintance with the country to show that by much a larger area of coal existed in Berar than in Chanda, and that it was simply misleading opinion to speak of this coal-field as the Chanda coal-field. I also had occasion to show that the pit which was being sunk to the coal near Ghúgús was quite unnecessary if it were only intended as a means of trial of the coal, and that if intended as a means of working

the coal afterwards, it was injudiciously placed, and must be for years to come superseded by others more conveniently located. Such general considerations, however, based on a view of the field at large were of little avail, as compared with 'practical' views, and the work was hastily pushed on. It is to be hoped that the fact, that the Geological Survey have since then pointed out the exact localities for borings and have thus proved the existence of coal within a few feet of the surface, where, they were told, 'such trials were only foolish blunders,' evincing an 'utter ignorance of the teachings of Mining,' and were 'at places where it was impossible that coal could exist,' will be a warning to future enquirers in their researches, and that they will at least try to make themselves acquainted with the geological structure of the area they are about to examine before they trust to preconceived notions or permit themselves to be swayed in their investigation of facts by personal wishes or local tendencies.

The facts stated above are sufficient to show that if the object of a proposed line of railway be to accommodate the largest amount of *coal* traffic, there cannot be a shadow of doubt that that line of railway should go right into the middle of the Wún district.

The consideration next in importance to the establishment of a free communication with the coal-fields was stated to be 'the opening out of the Hingunghat cotton country.'

But what is the Hingunghat cotton country? By much the larger portion of the cotton, which now finds its market at Hingunghat, and all of which is shipped or sent away as Hingunghat cotton, is not grown in the immediate vicinity of Hingunghat, but is brought from very considerable distances. Previously to the opening of the Nagpúr branch of the Great Indian Peninsular Railway, a large share of its supplies was drawn from the country to the north and north-west of the place, and much excellent cotton was brought to Hingunghat, even from Arwee, 50 miles to the north-west, and from the districts in that direction. All this cotton now finds its natural outlet at the nearer marts of Wardha and other places on the line of railway, and scarcely a load, as might have been anticipated, crosses this new line of communication to reach Hingunghat on the south. The country lying between Hingunghat and Wardha must also naturally seek the nearest markets for its produce. For the Hingunghat market, therefore, the supplies must now be derived from the south, south-east, and south-west. But to the south-east, and partly to the south, on the east of the river Wardha, with the exception of a small area near to the town, the country is almost an unbroken jungle for hundreds of square miles. The so-called 'southern road,' although it passes very near to the large towns of Wurrora and Bhanduk, scarcely touches even isolated patches of cultivation for its entire length from near Hingunghat to near Chanda, and again south and south-east of Chanda it sweeps for mile after mile through dense jungle. This belt of forest jungle is in places 30 to 40 miles wide from east to west, and not only does this immense area not yield any cotton at the present, but it is of such a nature that no reasonable hope of its ever producing cotton profitably can be entertained. The surface deposits are derived from the decomposition of coarse ferruginous sandstones and other silicious rocks, which yield a dry thirsty sandy soil, in which the cotton plants cannot flourish. Between this immense range of forests, yielding little but mere jungle produce, and the Wardha river there is a belt of open ground varying in width from two to ten miles, over which are spread thick deposits of alluvial clay and occasionally regur in which a fair amount of cotton is grown. But, as shown, this area is very limited, and the amount of produce must be equally so. On the other hand, to the west of the Wardha, the country is open and cultivated, and produces largely of cotton over an area very many times the extent of the possible cotton yielding country of Chanda. And besides this large area in Berar itself, immediately adjoining to it on the south, is the rich and well known district of Edlabad in His Highness the Nizam's territories, from which, even at present, with all the difficulties of long land carriage (at least 60 miles to Hingunghat) and heavy rivers to cross, by much the most valuable portion of the 'Hingunghat cotton' is obtained. I was led to these considerations myself while engaged in the careful examination of the country (and few persons, if any, see the country with the same detail that geologists do), but I have also been confirmed in this view by those actually engaged in the cotton trade, and who, therefore, were personally able to ascertain the facts. Mr. F. Curwen, agent for Warwick and Company, by far the largest dealers in Hingunghat cotton, stated to me on enquiry that he had given particular attention to this important question of *where* the cotton which came to that market was grown, and had ascertained that taking the ordinary annual sales at Hingunghat as about 30,000 bales, not more than 2,000 out of that quantity were the produce of land

near the town, and to the south and south-east of it on the left side of the Wardha river; by far the largest portion and the best quality coming from the Nizam's territories (Edlabad, &c.,) and from East Berar.*

Equally, therefore, if the object be to open out this valuable cotton yielding country by a line of railway, that railway must be carried through East Berar and to the west of the Wardha.

At present the route commonly taken by the carts bringing cotton to Hingunghat is through Wún, crossing the Wardha river to the south-west of Wurrora, and passing through that town to Hingunghat. In this way it is 'that strings of cotton carts may be seen making their way to Hingunghat,' but a very small portion indeed of their loads is derived from Wurrora or Chanda, or any place on the east of the river.

These facts also account for the small and 'not increasing' cotton trade at Wurrora, which is too near to the larger and more important mart of Hingunghat and too far from the main source of the raw cotton to absorb much of the trade. There can be no doubt that if once railway communication be opened up into the Wún and Edlabad country, new marts and presses for cotton will rapidly spring up in more immediate proximity to the places of growth of the crop, where the risks of injury from exposure on open carts and from delays in bringing to sale will be reduced to a minimum. And in this point of view, it may be well deserving of consideration whether the necessarily reduced trade of Hingunghat will then repay the cost of construction of a branch line of railway.

Other special objects to be gained by the construction of a branch line of railway were stated to be the utilization of the timber forest of Aheree and the connection of the Godavery navigation with Central India. To accomplish either of these objects, it is essential that the proposed line should be carried as far to the south as the bottom of the third barrier on the Godavery river, or to the town of Mogéli, or rather Talye or Talawye, on the west, or of Dewalmurri on the east of the Pranhita. To accomplish this, it was proposed to carry on the line, which it was assumed would go to Chanda town, to Kirmirri, where a sound rocky† foundation for a bridge would be obtained, and crossing the Pranhita there to proceed to Mogéli, on the opposite or west bank of the river. How the timber of Aheree which lies away from the river on the east side was to reach the railway on the west I know not. But there is little need to discuss this, for the surface of the country to the south of Chanda town offers physical difficulties, which will prevent any economical construction of a line of railway there. The line, alluded to above, if carried into East Berar could, on the other hand, be prolonged to Mogéli, or Talye, without meeting with any equally serious difficulty. It could cross the Pemgunga above the junction of the Wardha, where the body of water and the cost of bridge would not be one-half of what it is at Kirmirri, and where it would be close to coal.

Exactly the same arguments suggest themselves if we consider the connection of the Godavery navigation with Central India, to accomplish which, the main point would, of course, be to obtain the cheapest and best road to the bottom of the third barrier. But to these may also be added the fact, that there is every prospect of a considerable area of coal in the Nizam's territories between the Pemgunga and the Pranhita, all of which would be economized by a line of railway on that side of the Pranhita, but would be useless or nearly useless if that communication were carried out on the opposite bank, where no coal occurs.

Any advantages anticipated from the introduction of the Wardha coal into the southern parts of the Peninsula (Madras, Hyderabad, &c.,) would be common to either line. But these may be, I think, put out of present consideration altogether. If, on further investigation, the coal known to occur near Dumagudium and to the south of that place prove abundant

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* The Tehsildar of Wún reports that the ground under cotton cultivation this year was 28,177 acres: the average produce for each acre was 76½lbs., the total produce 1,077,770 seers = 9,000 bojas, or 18,000 guttas (bales). Besides the above, about 12,000 bojas, or 24,000 guttas, are carried through this taluq to Hingunghat from His Highness the Nizam's territories, from Rajur, Manikgur, and Edlabad taluqs.—*April* 1870.

† It is a singularly perverted misapplication of a tolerably well known geological term to speak of the wide spread area of crystalline rocks which are exposed at Kirmirri and to the east as a "gneiss dyke." The only real use of such special terms is to convey accurate ideas without the necessity of long descriptions, but if employed when their meaning is not known they must have exactly the opposite effect, and must lead to confusion and obscurity.

and of fair quality, there would be no hope of contending with that field for the supply of Madras or elsewhere to the south. And it is greatly to be regretted that Colonel Haig was not supplied with the means of investigating this very important question during the present year. And in any case coal does occur many miles to the south of the Chanda coal in the Nizam's territories, which is much more conveniently placed for meeting any demands from the south.

Other considerations have been introduced incidentally as it were, which may be just alluded to. 'The rich iron ores of Chanda would before long,' it is said, 'be smelted at foundries near the coal-field.' Whether such a rapid introduction of iron works can fairly be looked for under any circumstances is more than questionable. That rich iron ores do exist in the Chanda district is well known, and equally that they exist in practically exhaustless quantity (there is a whole mountain nearly a mile long of magnetite in one place), but these ores do *not* occur near the coal-fields. There is also hæmatite ore in the Yanak hills, near to where the line of railway if carried down there ought to cross the Pemgunga, and near to coal.

In all these remarks I would say that I have purposely avoided entering on any question of the comparative facilities, or comparative economy of construction of any such line. Some years' experience in laying out and making railways might justify my discussing these points, but I have known so many instances of absurd mistakes as regards sections and estimates for such works based on a mere inspection of the ground, or put together on the information of others only, that I would not venture to offer an opinion without actual survey. Nor is there any necessity to do so. Trial sections have, I believe, been taken over both the lines referred to, and I am much mistaken if these sections have not shown how entirely below the mark the first estimate of the cost was. But, *cæteris paribus*, I merely wish to assert, that a line of communication direct from Wardha into East Berar will accommodate any likely traffic in coal, and will open out the cotton country infinitely better than a line direct to Chanda, or through the Chanda district.

I cannot close without noticing how much, in my opinion, this matter has been obscured by the unhesitating adoption of the term of the Chanda coal-field. It so happens that just there the territory immediately adjoining is under a separate government, and belongs to a different jurisdiction, and the very existence almost of the Berars has been scarcely alluded to in discussing lines of communication, which were to be designed for the benefit of the country at large. But geological formations are not coincident with political boundaries fixed for the convenience of man. Such examinations acknowledge no fiscal limits; we have but to ascertain the facts carefully, and then to state them freely, convinced that any attempt to force the teachings of those facts into a preconceived groove of local tendencies must fail sooner or later, as does every such effort to run counter to the laws of nature.

Whether even the large extent of coal proved to exist in Berar, of a quality such as it is shown to be, and varying so much as it does at different points, will repay the charges for construction of a line of railway, is, I think, worthy of much closer consideration than it has yet received. The calculations which have been gone into in great detail, although correct in themselves, are based on data, which even the few weeks that have since elapsed show to be fallacious. English coal was taken as costing at Bombay *on an average* Rs. 30 per ton; at Nagpúr Rs. 60 to Rs. 70. And it was calculated, even allowing for the use of two tons of local coal instead of one of English, that at any place east of Bhosawul a saving of £1 6*s*., or Rs. 13 per ton, would be effected by the use of Ghúgús coal. The price of English coal at Bombay is now, April 1870, Rs. 14 per ton, that is, less than one-half the price calculated, or a difference in first cost greater than the estimated saving!! I do not believe that this rate can be maintained, but it is quite possible that the continued use of the Suez Canal will tend to reduce very considerably the average cost of English coal at Bombay.

This one item alone would totally upset all the calculations of cost, of profit, and of traffic even. And before it can be asserted that a branch line of railway to the Wardha river coal-fields will even repay interest on the cost of its construction, vastly more careful and more widely gathered statistics, both as to cost and amount of traffic than have as yet been hastily procured, or at least published, must be sought for.

May 1st, 1870. T. OLDHAM.

REPORT ON THE COAL AT KORBA IN THE BILASPUR DISTRICT, by W. T. BLANFORD, Esq., F. G. S., Ass., ROYAL SCHOOL OF MINES, Dep. Supdt., Geological Survey of India.

1. *Locality and mode of outcrop.*—The village of Korba is situated in the eastern part of the Bilaspúr district belonging to the Chhatisgarh (Chutteesgurh) division of the Central Provinces, and is the residence of a zemindar who owns a large portion of the surrounding country. It lies on the left or eastern bank of the Hasdo river, a large tributary of the Mahanaddi. This stream has in most places a broad sandy bed, varying, however, from about 200 yards to above half a mile in breadth. The country around Korba for many miles in all directions is flat or very gently undulating and usually covered with clay.

Coal is exposed in two places close to the right (western) bank of the river just below Korba. The exposures are in the bed of the river, no section being seen in the bank itself, and, as will presently be shown, it is probable that both belong to the same seam of coal. A very slight rise in the river is sufficient to conceal both outcrops.

The lower outcrop, which is about half a mile below the village, is the best suited for examination, as both the top and bottom of the seam are exposed. A considerable proportion of the section is above water during the dry season, although there is always a great thickness concealed. The seam is remarkably thick, but owing to its mode of occurrence it is impossible to measure it exactly. It may, however, be computed sufficiently closely for all practical purposes. The dip varies in inclination from 13° to about 18°, and in direction from N.-30°-E., at the northern extremity of the section, to N.-16°-E. at the southern end. The horizontal breadth of the outcrop at right angles to the strike is 350 feet, and, taking the average dip at 15,° the corresponding thickness is 90 feet. This, I believe, is rather below the truth than in excess of it.

Both above and below the coal massive felspathic sandstones occur. Below the seam but a small thickness of these rocks is exposed, but above it at least 400 or 500 feet are seen in the river.

2. *Section of Coal seam and quality of Coal.*—Of course the great thickness already mentioned does not consist throughout of workable coal. Bands of shale and of inferior coal are interspersed, as is more or less the case with most Indian coal seams. From the imperfect manner in which the seam is exposed, especially towards the base and from the surface, as usually happens in similar positions, being extensively decomposed, it is impossible to obtain a correct idea of the quality of the coal without cutting into it. I consequently had a series of small pits dug, six to seven feet deep, and from these and the portions of the seam fairly seen in the river bed, I obtained a good section of the whole thickness with the exception of about ten feet. To examine these few feet would have caused some delay with the means at my disposal, and I had already fully ascertained the existence of a large proportion of good coal.

The section of the seam thus ascertained is the following. Of all the bands of coal to which letters are attached specimens have been transmitted to Calcutta for analysis:—

Sandstone.	*Feet.*	*Inch.*	
Shale, about	1	0	
Coal of fair quality	1	0	
Inferior *coal*	1	0	
Shale and inferior *coal*	3	3	
Good *coal*, an inch or two of inferior coal here and there	3	9	*a*
Good *coal*	6	0	*b*
Shale and *coal* mixed	1	6	
Good *coal*	3	0	*c*
Shale with bands of *coal*	3	6	
Good *coal*	4	0	*d*
Coal and shale mixed	2	0	
Shale with bands of coal	2	0	
Coal of fair quality	1	6	
Inferior *coal*	0	6	
Good *coal*	5	6	*e*
Shale	0	6	
Coal	0	3	
Shale	2	0	
Coal	1	0	
Shale and inferior *coal*	2	0	
			45 3
Carried over			45 3

Sandstone.			
		Feet.	*Inch.*
Brought forward		45	3
Good *coal*		4	0 *f*
Shale with bands of *coal*		3	0
Shale and *coal*, the latter good in part		3	0
Coal rather inferior in part, but generally good		3	6
Shale		1	0
Good *coal*		1	0
Not examined, about		3	0
Shale		1	0
Good *coal*		4	6 *g*
Not examined, about		3	0
Good *coal*		4	0
Shale		0	4
Good *coal* containing one or two thin bands of shale		6	8 *i*
Not examined, about		3	0
Shale		0	4
Good *coal*		2	8 *j*
			89
Sandy shale			
Sandstone			

The above section shows a *minimum* thickness of 50 feet of fair coal. The proportion is probably nearer two-thirds of the seam. The best bands appear to be those marked *b*, *g*, and *h*; portions of these and especially the lower two feet of *h* * appeared to me equal in quality to any coal found in the Raniganj field. There is some iron pyrites here and there, but not throughout. The coal ignites readily and burns well with rather more flame than is usual in Indian coal obtained from the surface. The ash left is large in quantity and partly red, partly white.

Probable extent of seam.—Metamorphic rocks are seen in the Hasdo about three miles south of Korba, and also at about the same distance to the north: these mark the limits of the beds accompanying the coal in those directions. East and west the coal-bearing beds extend to a great distance, and to the north-east they are apparently continuous with those forming the hills east of Chúri and Sutringa, and these are probably part of one large field which has been found by Mr. Medlicott to extend beyond Sirgúja. But unfortunately the surface of the country near Korba is so much covered with alluvial deposits that very few rocks are visible, and those seen are almost invariably coarse sandstones, the dip of which can rarely be determined accurately. West of the Hasdo the concealment is even greater than to the east, while in the latter direction the whole country is an immense forest, rendering the relative position of the few outcrops met with very obscure.

But little information can be derived from the rocks seen in the Hasdo. The second outcrop of coal occurs about 300 yards higher up the river than that already described, and close to the same (right) bank. It is distinctly seen to be faulted against the sandstones which overlie the coal exposed at the southern outcrop. About 50 feet of coal are exposed, neither the top nor the base of the seam being visible. The dip is very irregular and twisted owing to the fault close by; it averages about 12° to N.-10°-W.

It appears more probable that this is the same seam as that seen a little further down the river, and that it is brought up again by the fault than that two seams of such unusual thickness should occur in the same beds. This, however, can only be decided positively by boring. The coal at the more northern outcrop appears rather inferior to that seen to the south, but in the latter locality the central portion of the seam contains more shale and inferior coal than the top and bottom, and it is the central portion of the seam which alone is exposed to the north. If the two outcrops belong to the same seam the fault has a downthrow on its eastern side of no great amount, probably not much above 100 feet.

So far as any reliance can be placed upon the dips in the sandstones, the general direction appears to be north by east to north-north-east for about a mile up the river above the coal. Beyond this no rocks are seen. Just above the village of Korba on the left bank there is a reversed dip to the south-west, but it is probably local.

Below the southern outcrop rock is only seen in the river at distant intervals; the few sections observed appear to indicate that the direction of the dip changes to the eastward.

* By a rough experiment, I obtained very fair coke from this part of the seam.

In this case the outcrop of the seam may pass for a long distance down the river, being concealed by the sand in the bed, which is here of great width. All dips seen appear to be lower than those at the outcrop of the coal, and it is highly probable that the amount of inclination may be higher at this spot than it is elsewhere, and the direction of the dip different in consequence of the fault close by. The circumstance already mentioned of the variation in both amount and direction of dip at different parts of the outcrops in the coal seam itself is in favor of this view.

So far as an opinion can be formed on these very imperfect data, it appears that the rocks associated with the coal cover a large tract of country, and it is improbable that so thick a seam should thin out within a short distance. It is, however, quite in accordance with our knowledge of similar seams in other parts of India that the exact thickness, the quality of the coal, and the proportion of good coal to inferior coal and shale should be highly variable.

If the coal seam be continuous it should be found west of the Hasdo throughout a tract from one to two miles broad, extending probably in a west-north-western direction from the river, the southern boundary of this tract passing through the more northern of the two outcrops seen in the river. East of the stream the seam should underlie the village of Korba and the river bank for at least a mile below and probably one to two miles above the village, and it may extend for an indefinite distance to the eastward, but it is possibly at a considerable depth below the surface throughout a large proportion of the area.

It is evident that before attempting to open a coal mine, boring must be resorted to in order to ascertain the extent of the seam and its depth beneath the surface. The best places for boring will depend upon whether it is desirable that the coal should be extracted on the east or on the west side of the Hasdo.*

If to the west, as the strike of the rocks is somewhat uncertain, the first boring should be made about a quarter of a mile west-north-west of the spot where the more northern outcrop appears in the river. Although the strike at the outcrop is west by south, there can be but little doubt that the normal strike is north of west, and that the alteration is due to the fault. Should the coal not be found in the first boring within a depth of 200 feet, two others, one 300 yards further north, the other at the same distance to the south, should be made. When the true direction of the outcrop is ascertained, it will be well to continue the borings along it at distances not exceeding half a mile apart, as any slight change of direction coupled with the high dip (if the latter be constant) will take the coal below the depth to which borings can most conveniently be made. There is also a possibility of other faults occurring besides that seen in the river.

On the east of the Hasdo the question is simpler. The fault so frequently referred to must either pass through the village of Korba or just south-east of it. West of the fault a boring behind the zemindar's residence would probably pass through the seam. East of the fault the best place for boring is at a spot where sandstone occurs in the left bank of the river below Korba, due east of the more southern outcrop on the right bank. Owing to the rather high dip, these borings should be made to a depth of about 400 feet, if coal be not found sooner. But, as I have already suggested, it is far from improbable that the high dip is local, and that on the left bank of the Hasdo the inclination is less, in which case the coal may be found at a moderate depth. Other borings, if the above are successful, may be made at intervals along the east bank of the stream below Korba. To the north of Korba the coal for some distance is probably at a considerable depth, but if continuous, it must again rise towards the surface between one and two miles north of Korba. It is, however, impossible to indicate with accuracy a good spot for boring in this direction. The best plan for examining the ground would be to put down a series of borings along a line running north-north-east from Korba at half mile intervals.

Facilities for mining.—The dip of the seam where seen in the river, although considerable, is by no means so high as to be any impediment to mining beyond its effect in rapidly increasing the depth of the seam below the surface. The sandstone above

* In case of a railway bridge being necessary across the Hasdo, Korba appears to be a more favorable spot than any other in the neighbourhood, as the breadth of the river is moderate and a considerable portion of the channel rocky. For several miles above and below, the breadth is very much greater, and the bed a wide expanse of sand.

the coal is firm and massive, and will probably furnish a good roof. The coal appears compact, the joints or "backs" are rather irregular, but still sufficiently marked in general to facilitate mining. Some of the very best and brightest coal is as usual rather brittle, but the greater portion of the seam bears carriage well. This bright coal, as I have mentioned, makes a very fair coke, and in that state is far less brittle, besides being much lighter and consequently costing less for carriage. The cost of coking in ovens heated by waste coal would be very trifling.

In consequence of the absence of bands of shale in the overlying sandstone, the quantity of water may be rather larger than usual, but in the small pits dug in the bed of the river the coal did not appear in general to be porous.

In mining a seam of such thickness as this, especially where the proportion of good coal is large, if the roof prove as sound as will probably be the case, it will be an important economic question whether some more advantageous method of mining cannot be adopted than that of removing a small section of the seam, not exceeding twelve feet in height, by "long wall" or still worse by "post and stall," more especially as it is highly improbable that the best bands of coal will be found for any distance on the same horizon, a most serious drawback to mining on either of the two English systems mentioned. It would, however, be premature to enter into this subject at present, but the methods adopted for extracting the thick deposits of lignite or brown coal found in parts of Germany are deserving of attention.

Conclusion.—I have endeavoured to show my reasons for the opinion I have formed as to the Korba coal. My conclusions are briefly, that both the quality and mode of occurrence are favorable. In thickness, in quality, and in the proportion of good coal to inferior coal and shale, the seam surpasses that near Chanda. The question of the extent over which the coal extends must be ascertained by boring.

CAMP KORBA,
18*th April* 1870.

The following table gives the result of assay of the coals referred to in Mr. Blanford's report just given :—

	Carbon.	Volatile.	Ash.		Carbon.	Volatile.	Ash.
a	38·7	26·6	34·7	*g*	46·4	23·6	30·
b	45·8	22·4	31·8	*h*	57·5	25·2	17·3
c	42·3	25·2	32·5	*h* lower 2 ft. * ...	60·5	29·5	10·
d	39·6	24·6	35·8	*i*	46·5	22·2	31·3
e	47·8	28·2	24·	*j*	53·3	27·2	19·5
f	32·8	21·4	45·8				

9*th May* 1870.

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* Cakes slightly.

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RECORDS

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THE MOHPANI COAL-FIELD, by H. B. MEDLICOTT, M. A., F. G. S., Deputy Superintendent, Geological Survey of India.

Sketch-map of 1859.—Any one who has examined with attention the sketch-map of the middle Narbadá region, published in 1859 by the Geological Survey of India, must have noticed how few actual coal-crops are marked in the large area colored as possibly coal-bearing; and more especially, how very partially those outcrops are distributed in that area. With the exception of Mohpani, and the less known case near Lokartalai, all the observed coal-localities occur close to the south border of the basin of stratified rocks, far from the Narbadá valley, on the south tributaries of the Upper Tawa and in the valley of the Pench river. A reference to the index of colours on the sketch-map, and to the descriptive text (Vol. II., Mem., Geological Survey, India,) would suggest possible explanations of these peculiarities: two groups or formations, the Damúda and the Talchir, are mapped under one colour. It was known at the time (see. p. 149, etc.) that the coal is confined to the upper group; but the demarcation between the two is very obscure in this region, and it would have been at that time impracticable to have undertaken to separate them, as no sufficiently accurate map of the country was to be had. Another possible explanation of the anomalous distribution to which I have drawn attention is suggested by the somewhat doubtful boundary between the Damúda group and the overlying strata of the Mahadéva series, as noticed at page 191 and elsewhere—the possibility that some of the latter may have been locally included with the former, thus unduly enlarging the apparent area of the coal-bearing rocks.

It has long been the desire of the Superintendent of the Geological Survey to clear up all these known doubts, more especially with reference to the very pressing question of the coal-supply to the railway that now passes close along the northern margin of this area. The much increased knowledge of all these rocks that has been attained within the last few years will greatly facilitate the final separation of the groups; and thus definite information will be available for the guidance of mining experiments. The detailed topographical survey of this region is now nearly completed; and proof copies before publication of some of the sheets having been obligingly supplied from the Surveyor General's Office, the revision of the geological work was commenced in November last. It will be some time before the detailed examination of so large an area can be completed; but some definite results have been already obtained, bearing very importantly upon the question of the coal-supply and the proper direction for further mining explorations.

Alterations to be made.—To any who have not applied the necessary reservations to the indications of the sketch-map, the present information will be somewhat disappointing. It is still to be expected that coal will be found where it is not now known; but observations made this year greatly reduce the area to which such hopes can be applied with any confidence; the negative indications of the sketch-map have been substantiated by the verification of the surmises that have just been pointed out regarding them. The case may be very briefly stated, and easily understood by a reference to the old map: the whole of the Dhúdhi valley, and all the valley of the Denwa (or Deor) north of the Pachmari range, are formed of rocks belonging to the Mahadéva series,* in which there is no prospect whatever of coal; although it may occur beneath them. A note on the sketch-map indicates the

* In the report under notice the name Mahadéva is used as that of a single group; but recent investigations here and elsewhere tend to show that it comprises several groups, for which collectively the name may perhaps be retained. It would be out of place to discuss the question in the present report.

doubts that were entertained regarding the Deor valley. To the south of the Pachmari range, including a large portion of the plain of the Tawa, the rocks, although belonging to the Damúda series, are certainly higher than the true coal-bearing group of this part of India; they are throughout more or less carbonaceous, and contain the Damúda fossil plants; and there is therefore always a chance of coal occurring in them, as will be fully tested by the detailed survey; but every distinct indication of coal at present known throughout the entire region (with the exception of a poor Mahadéva coal to be noticed presently) is referrible to a thin band at the base of these rocks, immediately overlying the Talchir group, and outcropping near the margin of the basin, as indicated on the sketch-map. This restriction of the apparently large area of the coal-bearing rocks brings into greater importance the limited fields that are known, and suggests the close search for similar small outcrops of the measures along the edge of the basin.

The Mohpani field.—The wide separation, by intervening barren (coal-less) rocks, of the several localities where coal appears at the surface within the large area hitherto generally referred to in this connection as the Narbadá coal-basin necessitates the recognition of as many distinct coal-fields. Of these, the Mohpani field is at present by far the most important, on account of its accessible position, and because the value of the seams has been proved by actual mining. It is situated at the south edge of the Narbadá plains, twelve miles from the Great Indian Peninsula Railway at Garrarwarra, and is traversed by the Sitariva river, in which the entire section is exposed. in a length of about a mile and a half. On the south the measures are buried beneath lofty hills of younger rocks; and on the east, from the sharp bend of the river, the field is rapidly cut off by an overlap of those same strata. To the west the extent of the field is very obscure and doubtful: for seven miles from the Sitariva the ground is very much covered, the talus from the ridge to the south of the measures being confluent with the superficial deposits of the plains, so that only a few small and uncertain outcrops can be seen. A little further west, however, in the Dharajhor, a complete section is obtained up to the metamorphic rocks at the edge of the basin; and the coal-measures are there altogether covered and overlapped, the whole ground being occupied by the younger rocks. Thus the possible limits of the field as appearing at the surface are very restricted; and we have no certain knowledge of it beyond the much smaller area bordering the Sitariva. A description of this locality will be the best guide to the experimental investigation of the rest and of the possible extension of the field by working the measures through overlying formations. The accompanying map, copied from the new Revenue Survey sheets, is not on a sufficiently large scale to express on it the detail that would be desirable for such a purpose; but it will at least make the case intelligible: the little map on the one inch to the mile scale shows all that is visible of the coal-measures in this field; the larger map shows the area over which the measures may outcrop; beyond that area they must be sought through other rocks.

Actual observations very limited.—Although it is now several years since mining was commenced by the Narbadá Company, very little has been done to explore the field; all the workings are on one spot close to the outcrop in the river. Two or three borings were made in the immediate neighbourhood, but without cutting the coal, as will be accounted for presently. The Sitariva Company have been too busy opening their pits, close upon the northern outcrop in the river, to have had time for further explorations. Thus, for a description of the field and its extent there is little more data than that available from the natural outcrops. The extent of this information and of the field as at present known may be judged from the statement that one square mile would very nearly include all the localities where coal is visible; and fully one-half of that square mile is occupied by rocks below the coal-measures. It may indeed be confidently expected that the coal exists and can be followed over a much larger area; but it needs no more at present to show how impossible it would be to arrive at a correct estimate of the extent or value of the field until further trials have been made.

Formations:—There are three formations to be considered: the Mahadéva series, the Barákar group (or the coal-measures), and the Talchir group; besides trap-rock, metamorphic rocks, and the superficial clays and gravels, or 'wash-drift':—

Mahadéva Series.—The Mahadéva series is of great thickness, and comprises a large variety of rocks; but as here exposed, at and near the contact with the coal-measures, it maintains very constant characters, being formed of massive coarse conglomerates, sandy or earthy, and generally more or less rusty; with these are freely but capriciously associated beds of deep red clay sometimes mottled and calcareous, or even with nodular layers of limestone. Courses of rusty sandstone are comparatively rare here. These rocks form the base of the lofty ridge of Nimúgarh, as well as the smaller hills bounding the field on the east;

and they are the last rocks seen at the north end of the section in the river. On the tops of the hills, and generally at a distance from the edge of the basin, the Mahadéva formation is largely composed of sandstones above, associated with earthy beds below.

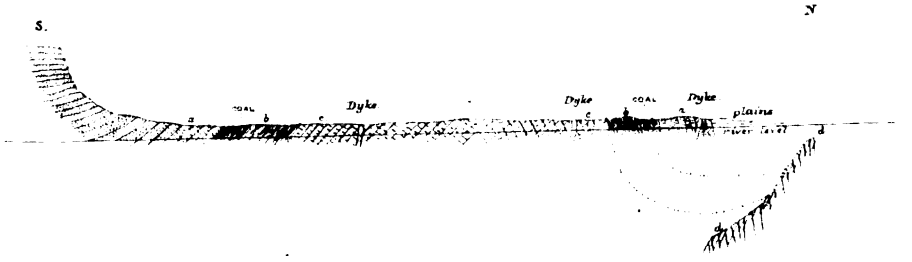
Mahadéva coal.—It is important to notice here the coal that occurs in this formation. Much labor and expense have already been devoted to it; and I am aware that hopes are still entertained of it by intending speculators. Without wishing to deter men finally from exploring what may possibly in some local instance turn out a good thing, it is but right that all should be informed of what is known regarding it. Many thousand maunds of this coal were cut by Mr. Walker, contractor for the Narbadá bridge, at Laméta ghat on the Narbadá, and profitably used for lime and brick-burning. Some was also extracted on the Sher river near Sehora. The same coal has been examined in many other places, as in the Mahanudi, to the north-east of Jabalpúr; in the Hard river, a tributary of the Sakkur; on the flanks of Nimúgarh, south of Mohpani. Many years ago this coal was cut in sinking a well within the station of Jabalpúr. Its characters are everywhere the same,—a bright jetty lignite-coal, disseminated in threads more or less abundantly in thick shale and sandstone; the proportion of coal is exceedingly variable, and, except in rare cases, altogether too small for use. In the nearly continuous rock-section in the Sher and Machariva rivers, this coal is exposed ten or twelve times in a length of as many miles, without any change of character, and offering no encouragement to any attempt at mining. It certainly would not bear transport or keeping; and the most that can ever be expected of it is for local use for rough purposes.

To one who is not familiar with the characters of these formations, and accustomed to discriminate between varieties of similar rocks, this Mahadéva coal-band might readily pass for the true coal-measures, as it often occupies an analogous physical position at the edge of the plains. The simplest criterion is the coal itself, which is quite unlike the Damúda (Barákar) coal. Although found in so many distant localities, the coal-band is certainly not a constant member of the series; nor is it even likely that all the known seams are on the same horizon in the series.

Barákar group.—The Barákar group is not more than 500 to 600 feet thick, composed of strong beds of gray and white felspathic sandstone, alternating near the top with carbonaceous shales and coal-beds. Wherever the section is exposed in the neighbourhood of the Sitariva, these beds are found close beneath the bottom red clays or conglomerates of the Mahadévas.

Talchir group.—The Talchir group is typically characterised by beds of fine greenish silt, or silicious clay and sandstones, in either or both of which pebbles and boulders, often of large size, are thinly scattered. The fine earthy sandstones pass up by imperceptible gradation into the Barákar rock, so that the boundary between them, in the absence of characteristic fossils, must often be arbitrarily assigned. These rocks occupy a large space between the north and south outcrops of the coal-measures on the Sitariva.

Structure of the rocks.—The general section (see figure) north and south across the field will illustrate the relations of the rock-groups and explain the present structure. There is no



General section from south to north, across the Mohpani coal-field.
Scale, 2 inches = 1 mile. *a*, Mahadéva: *b*, coal-measures: *c*, Talchir: *d*, metamorphic.
The dotted lines indicate the probable mode of extinction of the coal-measures to the north.

other locality known where the coal-measures are so much broken as in this field. In the section of the Sitariva, the general character of the disturbance is a normal anticlinal flexure, having moderate dips on the south, but rising to the vertical on the north side of the axis; the last rock seen next the superficial gravels of the plains being vertical beds of the coarse Mahadéva conglomerate. There are numerous minor contortions and dips that are not attempted to be represented in the figure. In an easterly direction from the river, the contortion dies out rapidly; the vertical seams of the northern outcrop flatten and bend southwards, passing round into continuation with the measures on the south of the flexure. The Talchirs are thus covered up at the surface; and, on the other hand, the Mahadévas stretch continuously to the edge of the plains; at Pukuhi they still have a low south-easterly dip, but soon become quite horizontal. In a westerly direction the main feature of the disturbance seems to continue for some distance, as is shown by the steady south-south-east dip of the conglomerate along the base of the Nimúgarh ridge; but this regularity does not obtain along the axis of the flexure, as is shown by the few outcrops that are visible to the north of the ridge. At the west base of the outlying hill of trap near Mohpani, in about the position of the axis of the anticlinal, the coal-measure strata have a steady low easterly dip. This irregularity greatly complicates the attempt to search for such outlying masses of the coal-measures as may exist beneath the superficial gravels at the foot of the hills.

Trap-rock.—Trap-rock forms an important consideration in he valuation of this field. It occurs both in dykes and in overlying masses, but is all of the same description,—a dense basaltic rock; and, as far as present evidence goes, it may be all of the same age. There are three great dykes in the Sitariva: the first is at the very northern edge of the rock-section; it is about twenty yards wide, running through the Mahadéva conglomerate very nearly along the vertical bedding, with a strike of 5° south of west, and a slight southerly underlie. The second dyke is in the Talchirs, oblique to the bedding, some fifteen yards wide, with a strike to 20° north of west, and a slight southerly underlie. The third is also in the Talchirs, about twenty yards wide, running nearly due east and west, and with a very slight southerly underlie. Although all these are remarkably steady for the short length seen in the river banks, they certainly do not continue so, as a rule, for any distance. It is probable that No. 1 represents, or is even continuous with, the strong dyke that is found at or near the base of the hills to the eastwards; but its course must be more or less tortuous. At three miles to the east, in the river's bank just above Dongarkho, there is a very pretty section showing how suddenly these trap dykes may stop out on the rise: at the water's edge the dyke is some twenty yards wide, and all trap; at a height of fifteen feet there is hardly a trace of it to be found, the whole having split up and rapidly thinned out between thick wedges of the overlying massive conglomerate. The dyke No. 3 presents another case of irregularity; if it continued the course which it has in the river, it must have appeared in the upper workings of the Narbadá Company's colliery; but the coal there is totally unaffected by trap. Indeed, it is strange that where trap is so abundant none has been met with as yet in any of the pits, small though these are. There is no doubt, however, that this rock will yet prove troublesome in working the field. Where the coal-outcrop is exposed in the stream beyond the ridge north of the colliery, trap is in force close by, and must greatly affect the coal there.

There are three patches of overlying trap, apparently remnants of a once extensive spread. The detached hill half a mile to south-west of Mohpani is all trap; on the north and east this rock reaches down to the level of the plain; on the south-east Talchir rocks are found close to the base; and on the west side Barákar beds are well exposed to a height of some fifty feet. The trap near Kaklaur and Pipurea scarcely appears above the general level of the plain.

Connexion of the measures on the north and south.—Notwithstanding some slight differences in the details of the sections, and the very marked difference in the quality of the coal, there can be no doubt that the measures worked by the Sitariva Company in the vertical seams on the north are the same as the less troubled beds of the Narbadá Company on the south. There are three or four seams at the southern outcrop, and but two at the northern; and the associated beds do not exactly correspond in the two localities (there are some earthy beds above the coal on the north that are not found in the southern section); but these differences would come well within the known limits of variability of these deposits; and the position of the measures in the general section, with respect to the Mahadévas above and the Talchirs below, is precisely the same in both localities. There is, besides, the direct evidence of continuity; the ground is too covered to show quite an unbroken section, but

observations are close enough to leave no doubt on the point. The change in the quality of the coal is quite in accordance with the crushed condition of the strata. The coal from the vertical seams is friable and dusty, and burns without smoke, all the bituminous matter having apparently been extracted from it; it is consequently slow to ignite, but has strong heating power; the coal in its normal state at the Narbadá Company's mines has the usual composition of Indian coals; the subjoined analyses made by Mr. Tween exhibit the change:—

	Carbon.	Volatile.	Ash.
1. Narbadá Company's mines: top seam (river workings)	55·8	32·6	11·6
2. „ „ „ 2 feet band of spurious cannel coal	33·1	24·6	42·3
3. „ „ main seam	50·4	39·0	10·6
4. „ „ „	51·9	33·4	14·7
5. Sitariva Company's mines: top seam	67·9	8·3	23·3
6. „ „ main seam	59·0	15·0	26·0
7. „ „ „	70·7	9·5	19·8

The Sitariva Company have sunk a shaft on the main vertical east-west seam to a depth of seventy feet, without any change, save a slight tendency to assume a northerly underlie. They have a shaft on the same coal about 200 yards off on the east side of the river, where the seam has already lowered to a dip of 65° to north-north-east. The Narbadá Company's collieries are in a corresponding position on the flat side of the flexure, at the south-east angle, where the strata are bending round the point of the anticlinal; and the galleries bring to sight many minor features of disturbance that could not be detected at the surface. Small as are the workings (the most extensive is about 400 feet long by 150 broad), they are on all sides stopped out against faults; it is true that none of these seem to have any great throw; but their frequency, and the crushing of the coal that attend them, is a serious obstacle and loss. It is to be expected that the coal that exists between the two present collieries is at least as troubled as that seen in the Narbadá Company's pits, probably more so.

Rough estimate of the field so far as proved.—Any estimate of the available coal-supply in this region must be affected by two considerations that do not present themselves in other Indian coal-fields: these are, the frequent high dip of the seam, and the fact that almost at all points thick overlying rocks rise into hills of considerable height close above the outcrop of the coal. Both these conditions will involve the necessity of deeper mining than has yet been attempted in India; in many places here they would restrict the mining to what can be obtained from shafts or galleries on or near the outcrop. Applying this rule to the known length of outcrop in the Mohpani neighbourhood, we may arrive at an approximate estimate of the coal from existing data: it may be said that there are about two miles of known outcrop, the coal being obscurely visible at the surface at several spots along the curved line between the two collieries, *but its thickness or its quality in that position has not been tried.* Assuming it to maintain a mean thickness of workable coal between the aggregates at the two collieries, say twenty-five feet, at the rate of 1,000 tons per foot of thickness per acre of seam, we should have 400,000 tons for every sixty-six feet down the seam along the whole length of two miles. As in many places the seam may be followed for many hundred feet, it is apparent that, without any very unwarrantable assumption, we may count upon a large supply of coal for many years to come.

Probable further extension of the field.—It is, as I have said, unfair to the field to pass an estimate upon it from the very insufficient information at present available; there is much hope that the coal will be found far beyond the limits taken in the estimate just given. I will now attempt to indicate the directions in which an extension may be sought. There are four considerations involved in a judgment: what may have been the original extent of the basin of deposition; how far the Barákar group ever extended in that basin; how far the coal may have been co-extensive with the group; and whether any portion of the group, and hence of the coal which is its uppermost member, had been broken up and destroyed before the Mahadéva deposits succeeded.

The first question affects the important point of the possible northern extension of the coal-measures beneath the plains: for several miles to east and west of the Sitariva no rock is seen to the north of the sedimentary series; and although the front here presented by these rocks is well up to the line of the general run of the metamorphic rocks bounding the basin at some distance to the north-north-east and west-south-west, there would be nothing forced in supposing that there was originally here a curve or bay in that boundary; the appearance here of rocks (the coal-measures) not seen elsewhere in corresponding positions might even suggest such a view. The questions will not, of course, be left to conjecture, but as it is desirable to proceed at first in the most promising direction, I would express my opinion that the measures do not extend northwards to any distance beyond the present known limits: such extreme disturbance of the strata as is seen in the Sitariva Company's collieries is not known to occur except close to the contact with the hard boundary rocks; a second reason is, that the massive coarse conglomerates of the Mahadéva series only occur close to the original rock-boundary, rapidly thinning out as they recede from that boundary; but here we find them in full force. In the figured section I have represented what I conceive to be the character of the section to the north of the present boundary with the superficial deposits.

The second and third considerations are much alike, and neither can be said to be altogether favorable; the Barákar coal is sometimes capricious in its development, as is corroborated by the beds here, the four seams of the Narbadá Company's pits being reduced to two at the Sitariva Company's mines; but certainly there is here no special ground for discouragement on this score. The occurrence of the formation itself is more open to doubt; it certainly is not co-extensive with the Mahadéva rocks; at many points along this boundary the latter are found resting upon the metamorphics, without any intervening representative of the older groups. This chance of failure is most likely to take effect in trials along the outer margin of the hills; but there is decided ground for hope that in a southerly direction, as far as they can be followed, the coal-measures will continue steady.

The fourth consideration is a very important one: if the Barákar group had been to any extent denuded before the deposition of the strata that now cover it, an indeterminate source of error would be introduced that might frustrate the most judicious calculations. This condition, so far as is known, is favorable: the Mahadévas have been subjected to the same disturbance as the coal measures, and wherever the section is visible, the top measures are found in place. There is even some evidence (though insufficient) to suggest a closer relation: thus, at the Sitariva mines the top beds of the measures are earthy, and so are the bottom Mahadévas; while in the southern section of the boundary in the river the rusty sandstone over the coal is not unlike the sandy base of the overlying Mahadéva conglomerate; this assimilation takes place within a thickness of a few feet, so does not seriously affect the position of the boundary. At the same time, at some points of this river section, there are appearances of the measures striking obliquely against the conglomerate; but this may well be due to one of the many small faults that trouble the strata in this locality. There are also some strong general considerations to suggest decided unconformability at this boundary, but they are too vague to be discussed here.

Extension eastwards.—It may be inferred from what has been said that my best hope for the field is in following the seams southwards; but there are other prospects worth investigation. A bore is now being sunk by my recommendation near Pukuhi, the most north-easterly point at which the measures come to the surface: the Barákar sandstone appears immediately beneath the red clays, both having a south-south-easterly dip of about 20°. The result of this trial will give the best indication for further explorations in the covered ground to north and east. The Narbadá Company's workings under the river in the top seam are beneath the conglomerate.

Westwards, on the flat ground.—As for the prospects in the low ground west of Mohpani there is really nothing to guide one, the rocks in that direction being indefinitely tossed about, denuded, and now covered by gravel and clay. The vertical seam worked by the Sitariva Company very soon passes under the deep alluvial clay; and there is no conjecturing what becomes of it: it can at least be said that there is no prospect whatever of the coal or its position being better in that direction. The Talchir rocks certainly reach for some distance to west of the Sitariva; they are seen close to the east base of the Mohpani trap-hill. On the west base of the same hill, the Barákar sandstone is well exposed, dipping under the trap; but it would seem that the upper portion containing the coal-measures has been removed either by the trap or previous to its outflow. Half a mile to west of this, there is another flat outcrop of sandstone, either Damúda or Talchir. In the stream half a mile east of Manigaon village, there is a small section of sandstone, clay and a lumpy limestone, that may be either Talchir or Mahadéva. The largest exposure of rock in this flat ground is

just south of Kaklaur, where sandstones have been extensively quarried in long trenches: they are fine-grained, pale, earthy flaggy sandstones with shaly partings; some are very regularly ripple-marked, and all have a steady dip of 15° to south; they seemed to me most like Upper Talchirs, but at one point next the trap south-east of Kaklaur, there is a thick, black, earthy rock, like a carbonaceous shale, altered by the igneous rock with which it is in contact. These few observations, which are all that I could discover in the flat ground between Mohpani and Khairí, where the metamorphic rocks appear in force, may serve to show how very precarious the search for coal must be in that area.

Southwards and westwards along base of ridge.—I would recommend, therefore, that every endeavour be at present directed to following the run of the coal-measures along the base of the ridge, where they must appear if they exist at all; and for some little distance at least, very positive directions can be given to guide the search. As has been already remarked, the coal in this field, wherever it is seen, occurs within a few yards of the base of the easily distinguished Mahadéva rocks. For a short distance, this character may be taken as a clue; but as the ridge is oblique to the boundary, and thus recedes from it westwards, the Mahadévas alter; sandstones and pale clays take the place of the coarse conglomerate at the base of the series; so that it becomes very difficult indeed to fix the boundary of the two formations where the sections are poor. The last place where this boundary is well seen is in the stream immediately west of Bainar village, where the conglomerate rests upon some sixty feet of sandstone, below which the section ceases. A trial shaft is now being sunk here, at my recommendation, by the Sitariva Company. For several miles to west of this, I only found one spot, on the east side of the recess south of Ríchai, where rock is visible below the conglomerate. South of Kaklaur I could not pronounce positively on the position of the rocks that are obscurely seen at the base of the ridge. For a mile from the base of the ridge in the Khairí stream, there is a fair section of the new bottom Mahadéva strata, pale greenish brown and mottled red clays with sandstones, having a variable dip. It is presumable that the outcrop of the coal-measures (if they have not thinned out and been overlapped) passes, between Kaklaur and the base of the range, towards the metamorphic rocks south-west of Khairí. The safe way to settle the point will be to follow the strike by shallow pits or borings westwards from Bainar.

Evidence as to southward extension.—An idea seems to have obtained that the coal does not exist beneath the Mahadéva rocks to the south, or at least that it is out of reach. This opinion appears to have been started by Mr. Blackwell, the mining engineer who selected the ground for the Narbadá Company: in a section drawn by him on the map of the ground, a great fault is placed along the boundary of the measures with the conglomerate. I can find no confirmation of such a view; and certainly the trap-dyke which Mr. Blackwell introduces along his fault has no existence. It is rather in that southerly direction that I hope the coal may be most favourably worked, as being probably steadier, less affected by faults and trap-dykes. The fact, however, remains to be proved. The Narbadá Company put down a bore (No. 2) to a depth of 256 feet on the flat ground of Mulpi village 1,100 feet from the boundary, in a south-easterly direction from bend of river, and south of the run of Mr. Blackwell's fault. The bore only passed through conglomerate and red clays; but taking the most favourable view of the case,—supposing there to be no faulting whatever, and no thickening of the upper rocks,—the bore stopped just short of the measures. An average of several dips, taken in the conglomerate at the boundary, gives 15°; at 400 yards up the river it has flattened to 6°, which would reduce the mean to 13°5′, in which case the measures would be 266 feet deep at the bore in question. Another bore was put down to a considerable depth at the edge of the river below the bend; but this of course was a failure, being visibly below all the coal, every inch of the section being well exposed in the river close by. The best means of immediately testing the southern extension of the measures is from a shaft (No. 2) that was sunk to a depth of 143 feet close to the bend of the river on left bank. After passing through twenty-eight feet of surface gravel and forty-seven feet of conglomerate and red clay, the measures were reached, and coal was cut at the bottom. Unfortunately at this point the water made so fast that the work had to be stopped. The finding coal beneath the conglomerate does not finally settle the question of a great fault here, the pit being so near the boundary; and I was informed by Mr. Taylor, the very intelligent miner who had charge of the works at the time, that in the upper part of the shaft, and altogether in Mahadévas, the strata were cut by a fault having a steep southerly underlie; there was no means of gauging the amount of throw. The feature is now concealed by the casing of the shaft. Where small faults are so frequent, as in the mines close by, there is really nothing especially discouraging in finding one here; it is probably no greater than those

already known; and it may be hoped that the measures will rapidly assume a steady low dip, conformable to that observed in the overlying Mahadévas. I have urgently recommended that the seam at the foot of this shaft be followed out southwards, and any fault-ground be thoroughly explored. Machinery is being put up to drain the shaft. The difficulty of unwatering mines in this position is one that must be anticipated: at the base of a high ridge, having a trough-shaped arrangement of the strata, a heavy discharge of water seems inevitable; it is possible that the excessive discharge in this particular shaft may be increased by the proximity of a deep pool in the river just above.

The same indications applicable to other localities.—The indications I have here given to guide in the exploration of the Mohpani field ought to be of service in the search for other fields along the margin of the basin: thus, in the gorge south of Fattehpúr, near Bunkheri railway station, the conglomerate laps round the west end of the ridge of metamorphic rocks, the east end of which is at Khairí; a short way up, the river bifurcates; and just above this there is a small patch of the Talchir boulder bed, surrounded by the Mahadéva conglomerate; it is possible, though not very likely, as this is the lowest level, that outcrops of the Damúdas might be found in the neighbourhood; and similarly elsewhere. It is to settle such points that the detailed survey is so much needed; meanwhile the indications I have given may be of service to independent explorers.

I cannot conclude this report without an expression of regret at the obstructions that are being raised to the development of the Mohpani coal-field. Several years ago mining was commenced with the intention of having the works well opened so as to be in a state to turn out a large supply of coal by the time the railway should be finished; all prospects of profit being necessarily dependent upon that event. The completion of the railway was repeatedly postponed year after year, the mining establishment and plant being necessarily maintained all the time. And now that the main line is opened, and there is a prospect of a return for the outlay on the mines, numerous delays and objections are made to the construction of the short branch line, without which the mines cannot be worked. Questions are still raised as to the relative quality of the coal; upon which point all reasonable doubt has been long since settled; for it may be safely asserted that a large portion of the coal now consumed over the East Indian Railway line is no better than the Mohpani coal. For the Jabalpúr line, and even so far as Naini junction, the Mohpani coal could undersell the Bengal coal, and a considerable saving be made in the railway expenditure. Questions of separate accounts and the desire to show profits on one side or other ought not to be allowed to lead to the public being heavy losers.

1*st May* 1870.

NOTE ON THE LEAD-ORE AT SLIMANÁBÁD, JABALPÚR DISTRICT, CENTRAL PROVINCES,—by THEO. W. H. HUGHES, F. G. S., Assoc. Roy. School of Mines, Geological Survey of India.

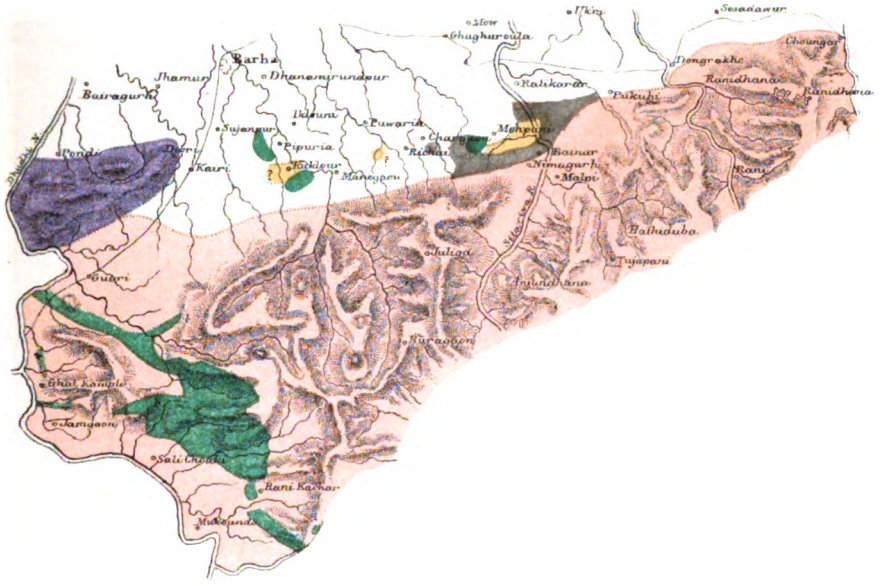
In April last, Mr. Olpherts, Resident Engineer on the Jabalpúr line of railway, announced in a letter addressed to Mr. W. B. Jones, the Deputy Commissioner of Jabalpúr, that he had discovered indications of copper ore about three miles north of the Slimanábád railway station, and expressed a hope that the matter might be further investigated.

Discovery of copper and lead.—Mr Olpherts' attention was first drawn to this subject by noticing some copper stains on the foundation rock of one of the piers for a railway bridge. After making known this discovery, he noted the strike of what he considered the *lode*, and pursuing his researches to the west of the line of railway hit upon another locality—about two miles from the railway station of Slimanábád, and a little off the main road leading to the town, which yielded an ore of lead (galena).

I visited this latter spot accompanied by my colleague, Mr. Fedden.

There was very little to be seen, merely a small ridge of quartzite rock, about eight feet in height, forty feet or so in breadth, and a few yards in length, throughout a narrow band of which galena (Pb. S.) was sparsedly distributed, with here and there a little copper pyrites.

Stratigraphical relation of ridge.—A very important point to determine was the stratigraphical relation of this ridge. It did not strike either my colleague or myself that it was a *lode*, but rather a component bed of the geological series which occurs at Slimanábád. The ridge is made up of quartzite, and not of vein quartz; and though many of the hand



MOHPANI AND NEIGHBOURHOOD

Scale 4 Miles 1 Inch

MOHPANI COAL FIELD

Scale 1 Miles 1 Inch

Mahadeva Coal Measures Talchirs Metamorphic Traps Dips, Shafts o Boring +

The ground covered by superficial deposits is uncoloured

specimens which I brought away, and others that were in Mr. Olpherts' possession, might possibly convey the idea that the ore existed in a lode, such a misapprehension would arise only from the examination of small pieces of the matrix.

The dip of the bedding is rather obscure, but its direction appears to be 45° south of east. There are planes of jointing striking 20° north of west and inclined at an angle of 75° in a southerly direction.

The strike of the beds is north-east—south-west; so that if this line were followed up, we should most probably find a connection between the two localities where lead and copper ore have been respectively found.

Description of ore.—The ore of lead is galena, a combination of lead and sulphur with a certain proportion of silver. An assay made by Mr. Tween in the Office of the Geological Survey proved the ore to contain 19 oz. 12 dwts. of silver to the ton of lead. The ore of copper is pyrites, which is usually a combination of copper, iron, and sulphur.

At the locality where Mr. Olpherts first noticed traces of copper, the ore is principally malachite, but there appears also to be some dioxide of copper (Cu_2O). From a conversation which I had with Mr. Olpherts, I gathered that the ore was only sparingly distributed throughout the matrix.

Origin of ore in the rock.—The lead occurring in a bed, and not in a lode, it is most probable that it was an original constituent of the rock in which it is now found; and that whilst the rock was undergoing metamorphism the lead became segregated.

Economic value.—In order to form a reliable estimate of the probable richness of this find, I had hoped that a fair amount of clean cut surface would have been exposed for examination, but this was not the case, as Mr. Olpherts, who had the management of the prospecting operations, had not had time to open out enough of the bed.

If the indications, however, of lead at the surface may be taken as a fair criterion of the richness of this quartzite, then I would at once condemn the whole, the proportion of ore to matrix being far too small to make the working of this bed a desirable speculation. It may also be stated that lead ores occurring in beds or nests are usually poor in silver. But it would be premature to pass a final condemnation until further investigations had taken place, and although, as I said above, the indications are unpromising, I would yet recommend that a sum of 2 to 300 rupees should be placed at Mr. Olpherts' command in order that he might carry out to a more satisfactory conclusion the researches which he has initiated.

Incidentally, I may mention that Mr. Olpherts possesses an extensive collection of the various iron ores of the country. Many of these are very rich and occur in great abundance near to and around Slimanábád.

June 1st, 1870.

NOTE ON THE OCCURRENCE OF COAL EAST OF CHHATISGARH IN THE COUNTRY BETWEEN BILASPÚR AND RÁNCHI, by W. T. BLANFORD, F. G. S., Depy. Supdt., Geological Survey of India.

The coal bearing (Damúda) beds of Korba extend for about forty miles to the eastward as far as Rábkúb, in Udipúr (Oodeypore). They also extend far to the south-east towards Gángpúr, and to the northwards towards Sirgúja, and in all probability are continuous or nearly so with the deposits of the same nature known to occur in those districts.

Main Pat with the neighbouring hills and all the country on the road from Main Pat through Chándargarh and Jashpúr to Ránchi consist of metamorphic rocks with the exception of a cap of trap and laterite on Main Pat.

The lateness of the season* prevented my searching to any extent for coal seams, indications of the existence of which were afforded by the occurrence of fragments of coal in the rivers, especially in the Mánd. I found a few seams near Chitra, twelve miles west of Rábkúb and nearly thirty east of Korba. Two or three are seen in the Mánd about three to four miles east-north-east of Chitra, but they are only from a foot to eighteen inches in thickness. In a small stream, the Kopa Naddi, which runs south of Chitra, one seam, about three feet in

* After the end of April I had still 250 miles to march to Hazáríbágh.

thickness, is seen near the village of Tendúmúri, more than a mile south-west of Chitra. It is nearly horizontal, having a very low irregular dip to the west or south-west. Part consists of fair coal, the remainder is shaly.

The only seam examined from which it is possible that a useful supply of fuel might be obtained is exposed in the same stream rather nearer to Chitra, being about a mile from that village, close to the boundary of the village of Tendúmúri. It is very badly seen, but appears to be of considerable thickness, perhaps twenty feet. The upper portion is so much decomposed that no trustworthy estimate could be formed of the quality without digging into the seam: the lower portion appeared to be fair in places. The dip is about 15° to north-north-west.

The villagers, as usual, would give no information, so that I could only trace out the coal seams by the laborious process of searching the beds of the streams, and from want of time I was unable to ascertain whence the greater portion of the fragments seen in the Mánd were derived; but when passing through Ránchi, Lieutenant Sale, in charge of the Chota Nágpúr Topographical Survey Party, told me he had found a seam of coal about four miles north-west of Rábkúb in a small stream running into the Mánd, and it is probable that this may be the source of the blocks I saw in the river bed.

I should add that several coal localities have been lately found by the officers of the Topographical Survey and recorded in their maps. They are all north of Korba and Udipúr.

When passing through Jashpúr, the Rajah told me that coal has been found in his territory in the Khurea country, twenty-four miles north-west of Jashpúrnagar. This would be about 100 miles, or rather more, west by south of Ránchi.

Calcutta, 31st May 1870.

NOTE ON PETROLEUM IN BURMAH, &C., by WILLIAM THEOBALD, ESQ., Geological Survey of India.

Two very distinct sorts of earth-oil are met with in the countries lying to the eastward of the Bay of Bengal, *viz.*, the limpid oil of Arakan and the viscid oil of Burmah, which last is commercially known as the Rangoon oil from its port of shipment, though really obtained at the Yenán-khyoung and other wells in Upper Burmah. The limpid oil of Arakan varies in tint from pale yellow to deep sherry brown, with a peculiar opaline tinge, something like that produced in alchoholic fluids by the presence of fusil oil in excess. The Rangoon oil, on the other hand, is of very uniform color, a peculiar yellowish green and of tarry consistency.

I may here remark that the only other Indian oil I am acquainted with is that produced in the salt range in the Punjáb. This oil is of a consistency almost intermediate between the Arakan and Burmah oil, and differs in tint from both, being brown, devoid of the peculiar greenish hue of the Rangoon oil, and of a decidedly reddish color by transmitted light.* The wells producing the limpid oil are situated near Kyoukphoo, Ramree, and the neighbourhood, and are all confined to the western side of the Arakan range, and none of them occur at any great distance from the coast, whilst the viscid oil of commerce is similarly confined to the eastern side of the same range, occurring most plentifully in Upper Burmah, but met with here and there in very sparing quantity as low down as the parallel of Myanoung.

Of the mode of occurrence of the Arakan oil and of the rocks with which it is associated little is known. The wells are mostly shallow, almost superficial, and would seem only to yield sufficient oil for local use, though their productive capacity has probably never been fairly tested.

The Burmese oil is worked much more energetically, though the geological relations of the oil are little better known than in Arakan. Some of the Yenán-khyoung wells are, I am informed, sunk to a depth of 100 or 150 cubits, first through a little surface clay and then in soft sandstone. The age of these beds is not precisely known, but analogy would point to the nummulitic formation as being the source of these oils. In the Punjáb, the oil rises through contorted beds of nummulitic limestone, and is there in all probability derived from thick beds of carbonaceous shale with lignite, which are associated with and underlie the nummulitic group. As the nummulitic group is largely developed in Burmah, we may, in default of any precise information on the subject, refer in like manner the Burmese oils to the same group.

* Dr. Oldham has drawn my attention to a remark of Mr. Wynne, that the oil obtained near Rawul Pindi is green, when it issues to the surface. The distinction, therefore, drawn by me between the color of the Punjáb and Rangoon oils would seem to depend mainly on the relative length of time either has been kept, and does not seem, as at first inferred, to originate in any essential difference of composition.—W. T.

In the province of Pegu no nummulitic rocks occur at the surface east of the Irawadi, which entire region is occupied by a newer group of miocene age or younger, and no petroleum well is authentically known within this area. A little below Namián there is a tradition of petroleum having once been known to occur, but I visited the spot and could detect nothing to countenance the rumour in the appearance of the sandstone or any of the neighbouring rocks. The occurrence of oil, therefore, east of the Irawadi in Pegu must be held to be an open question.

West of the river, the only situation where petroleum is known to occur which I have as yet had an opportunity of visiting, is the newly discovered locality at Padoukbeen west of Thaietmio. The well was here sunk to a depth of about twenty feet in soft argillaceous sandstone, rather tender and incoherent and of a dark bluish color, drying paler. The beds in the neighbourhood are shales and sandstones of the miocene series, dipping at low angles and very little disturbed, and not in the slightest degree altered. The oil seems to have been discovered by its saturating the soft sandstone where cut by a small stream in the bed of which the well is sunk, the top being a little way up the bank, but the well being carried below the level of the bed of the stream. Whether the well continues to yield, I cannot say. At my second visit it was abandoned and dry, but I hear it has again been worked. The oil from this spot is precisely similar in every respect to the commercial or Yenán-khyoung oil, and is regarded as equal to it in value by the natives.

There is no indication at this spot of any fault, and the chances of improving the supply by a deep boring are hardly greater than of failure, as there is so little to guide the judgment as to the source of the oil, and as these beds are, I believe, high in the series to which they belong, a very thick set of unproductive beds would have to be passed through, unless the bore struck a seam containing sufficient oil to constitute a flowing well, the presence of which is by no means assured by the insignificant surface indications.

Note on the Petroleum Locality of Sudkal, near Futtijung, west of Rawul Pindi, Punjáb, by A. B. Wynne, F. G. S., Geological Survey of India.

The petroleum at this place occurs (as usual in the Punjáb, *vide* Geological Reports, Asiatic Society, &c.,) in the nummulitic tertiary rocks. Just near the petroleum pits, as well as to the north and south, fossils occur, orbitolites being by far the most numerous, but bivalve shells in a fragmentary state, teeth of sharks, and large bones are also to be found.

The pits, only one of which is of any depth, are situated in a small open space a couple of hundred yards wide from north to south, covered with superficial debris, and bounded in these directions by rocky ridges of slight elevation. To the east and west are the sources of some of the numerous steep ravines which intersect the country everywhere.

The tertiary rocks on both of these ridges are much contorted along narrow axes, but still possess considerable regularity of strike in a direction about 10° north of east and south of west. They dip at high angles, varying from vertical to 50° or 60° generally west of north and east of south, but lower angles and horizontal beds may also be observed forming parts of curves in the same neighbourhood.

The rocks consist mainly of gray grits and sandstones, with some bands of gray fossiliferous limestone interstratified with thick zones of red shale.

In the immediate vicinity of the pits the strike of the rocks changes to about north-east; they dip at very high angles to the north-west and seem to run against a mass of red shales within a few yards of the principal sinking, being perhaps faulted, but the relations are almost entirely concealed by the covering of superficial debris.

To the southward of the present works within a few feet dark brown shales and sandstones impregnated with petroleum are exposed by an open 'drift' or 'stope' (cut apparently to seek the most productive band), and these as well as a band of limestone in places saturated with the oil may be traced for a few yards north-eastwards, where a quantity of the oil seems to have exuded from the rocks and mingled with the surface soil.

Owing to the abandoned state of the works at present and the insecure gear at the pit's mouth, it was not found practicable to descend, but as the pit is only twenty or thirty feet in depth, the oil could be seen trickling from the highly inclined strata forming the sides, and which dip at the upper part of the pit north-west at 70°. A 'dhol,' lowered quietly and drawn up as rapidly as possible to avoid loss by reason of its leaky condition, contained

about seven or eight vertical inches of the oil floating upon clear water, this being rather less than the probable depth of that in the pit, which had been accumulating for three or four months.

It was stated by a native in charge of the place that the oil ran slowly and coagulated in the cold weather, in consequence of which the works had been temporarily stopped, and that when in operation about one maund of oil daily could be obtained. The colour of that taken from the pit was green, but some found in a neighbouring shed was of a dark brown tinge, and burned readily with dense black smoke.

It is understood that the mineral oil procured from here is to be used in lighting the station of Rawul Pindi with gas. A 'gas house' was seen in course of construction there, and large gas mains lie along some of the roads, so that the question of supply becomes of importance: the quantity reported to be obtainable seems so far from encouraging that I doubt whether some larger prospect must not have existed before an expenditure upon gas pipes, &c., was sanctioned.

The locality where the oil occurs is evidently of but limited extent near the village of Súdkal, and it would appear necessary, in order to develop its resources, to open much more extensively, across the run of the beds, trenches cut downwards to the rocks, which are now so much concealed just near the pits. Even if this was done and other pits sunk, there is no reason to suppose any of them would be more productive than the present shaft, and so far as can be judged from what is visible there is not room for many.

As to the possibility of an increased quantity of the oil being obtained by deepening the existing shaft, it can only be said that as the beds are nearly vertical with some underlie north-westward, if these relations are preserved, the pit in depth ought to pass through the beds at present yielding the oil and to enter those seen at the surface in the drift south of the pit, where it may be presumed the prospect of finding the oil in sufficient quantity was less favourable, or the shaft would have been sunk there. As the bedding of the rocks is much disturbed their continuing to lie in the same position for any distance cannot be calculated upon, but it seems likely that (if it has not already been done) the shaft might with some advantage be carried down to intersect the oil-bearing rocks south of the pit.

To sum up: from what is now to be seen at this petroleum locality, it would be advisable to extend the search further before building hopes upon the place as a source of supply for lighting Rawul Pindi, and the quantity said by the man in charge to have been obtained from the present sinking would hardly warrant expectation that sufficiently large results would be obtained by opening other shafts in the same neighbourhood.

ON THE OCCURRENCE OF ARGENTIFEROUS GALENA AND COPPER IN THE DISTRICT OF MÂNBHÚM, SOUTH-WEST FRONTIER OF BENGAL,—by V. BALL, Esq., B. A., Geological Survey of India.

Although the greater portion of the district of Mânbhúm consists of metamorphic and sub-metamorphic rocks*, both, but especially the latter, likely to contain ores of the useful metals, hitherto no discoveries of the existence of any appear to have been recorded.

The occurrence of gold in the streams of Mânbhúm and the adjoining districts has, however, long been known. Its mode of occurrence has already been described in these pages†.

During my geological examination of Mânbhúm, the discovery of galena or lead ore was made in the following manner:—When at Dadka, a large village forty-five miles south-south-east of Púrúlia, which is the sudder station of Mânbhúm, the *Ghatwal* brought to me a small piece of galena which had been given to him a few years before by some *Kumars*. He did not know what it was, but used some of it instead of *Surma* or antimony for the purpose of anointing the eyes of his female relatives.

By enquiry from the *Kumars* of the neighbourhood, I was, after several failures, at length enabled to trace the source from whence the galena had been obtained. The lode, for it proved to be such, had been struck some years previously by some *Kumars* who were searching for iron on the side of a hill formed of mica schist, in which there are a number of

* Slates, quartzites, schists, &c. † Records, 1869, II.

veins or small lodes filled with brown hæmatite. This hill is close to a *dih* called Jani-jour, where there is an outlying house of the village of Dekia, which lies about a mile east from Dadka.

I could not ascertain that the *Kumars* had met with galena in any other part of the neighbourhood, though excavations for iron were plentiful.

Having found traces of galena on the surface, I proceeded to excavate, and soon obtained a number of fine specimens of the ore. It occurred quite independently of the bedding of the schists, sometimes in lenticular masses five or six inches long surrounded by quartz, and sometimes in a gangue principally composed of brown hæmatite and quartz; these appearances justify the conclusion that this is a case of a true lode. Owing to the excessively jungly and broken condition of the ground, I was unable, during the period of my brief visit, to trace the lode for any distance, and for the same reason I was unable to ascertain its exact width. Although, therefore, much remains to be ascertained regarding it, still, so far as it has been examined, the indications may be affirmed to be promising. All who have given the least attention to the history of mining are aware of the capricious character of lodes, and of the impossibility of forming even an approximately correct opinion as to the value of any particular one—which is not laid open by a natural section—until some outlay for excavation has been incurred.

In addition to the fact of the existence in any part of this country of such an ore as galena—supposing it to be in quantity—there are many collateral questions and conditions to be considered and ascertained before the commercial value can be properly estimated; of these the most important are the presence or absence of other valuable ores or metals in association with the principal, the abundance and quality of labour and fuel to be obtained on the spot, the means of carriage with the distance of the nearest mart, and, perhaps, not of least importance, the healthiness of the locality.

With regard to the first question, the assay of some of my specimens by Mr. Tween has proved the presence of silver in the unusually large proportion of 119 oz. 4 dwts. 16 grs. per ton of lead*. The assays of most other Indian galenas have given a much smaller amount than this. In Europe, from 35 to 40 oz. per ton is considered quite above the average yield, and argentiferous galena containing very much smaller amounts is frequently worked for silver with profit.

Mr. Tween has also ascertained the presence of antimony in combination with the lead.

Regarding the amount of coolie labour to be obtained, I have no hesitation in saying that it would be abundant. Such was found to be the case in Singhbhúm, when the Copper Company was at work there.

Of the fuel, it is not easy to speak with so much confidence: undoubtedly there is a very considerable amount to be had close by, as the locality is almost in the centre of the heaviest tree jungle in Mânbhúm; but all experience goes to show that such a source of supply is very precarious and uncertain. Possibly it might be found more economical to transmit the ore—should it ever be worked—to the neighbourhood of coal, rather than to attempt smelting on the spot.

The means of carriage are indifferent, or rather bad. Dadka is connected with Púrúlia by a partially finished road, without bridges, which was commenced during the famine. From Púrúlia to the Barákar Railway Station there is a road which has for many years been in the hands of the Public Works Department, but is still far from finished. The distance by these roads is about ninety miles. From Dadka to Midnapore *viâ* Silda, the distance over bad roads would be about seventy miles. From Midnapore the ore or metal might be sent by canal to Calcutta.

The climate is not generally considered healthy for Europeans; still there are many worse places in the district. Doubtless the removal of the heavy jungle would ultimately produce a beneficial effect.

The nearest locality to this at which lead has been discovered is at Hisato in Chota Nagpúr. The antimonial galena from that locality has been described by Mr. Piddington.† From the first specimens sent to him by Major Ouseley he obtained silver in the proportion of 70 oz. per ton of ore; but other specimens subsequently received did not contain a trace of silver.

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* This proportion may possibly not be constant throughout.

† Jour., Asiat. Soc., Bengal, XI, p. 892; XII, p. 736; XV, p. 64.

Copper Ores.

Copper ores have been discovered in two localities in Mánbhúm. The principal is situated on the crushed and faulted junction of the metamorphic and sub-metamorphic rocks about one mile north-east of the village of Poordah, Pergunnah Mánbazaar, or about thirty miles from Púrúlia.

The rock in which the ore occurs is a coarse mica schist, which is traversed by numerous veins of quartz. Whatever the amount or quality of the original ore may have been which existed near the surface, it has nearly all been removed by natives, slight stains of the carbonates of copper on the schist and quartz debris alone remaining to indicate the object for which the numerous excavations which occur along the outcrop have been made.

These ancient excavations at the time of my visit were filled up, some with water, others with debris, which circumstance, coupled with the fact of the ore having been removed, rendered it difficult to form a decided opinion as to the precise nature of the deposit. Subsequent examination of the numerous and often well-exposed copper ore deposits of Singhbhúm*, which appear to be of mixed character (generally the ore occurs disseminated through regular beds of schist; but departing from this rule, it occasionally occurs in true lodes), has induced me to believe that these ill-seen Mânbhúm ores also occur in a two-fold manner. It is possible that the copper-bearing beds of Mânbhúm may belong to the same Geological Zone as those of Singhbhúm; but there are arguments against, as well as for, this view. The whole question must be treated in greater detail than is now possible.

The second locality at which copper occurs is near the village of Kulianpúr, or about thirty-two miles due west of that just noticed. It is on a small hill formed of schists and quartzites, which in one place are stained and encrusted with the carbonates of copper. There is an ancient excavation on the south flank of the hill. So far as it is possible to judge, the deposit seems similar to No. 1. It is not improbable that the ore may be found further westwards, but I did not succeed in obtaining any trace of it in the section exposed in the Subanrika river. There is a small quantity of slag at the bottom of the hill, which indicates that the ore which was found here was smelted on the spot.

The small indications of ore to be seen at the two localities mentioned above are certainly not sufficient to justify any expenditure for excavating, more especially as the attempts to work the similar, but vastly more extensive copper deposits of Singhbhúm, have not hitherto proved to be remunerative speculations.

Various rumours of the occurrence of ores of tin and copper in different parts of Mânbhúm have from time to time been promulgated; but the supposed ores of the more valuable metals have generally proved to be either some form of iron ore, the green mineral epidote, or a bronze-coloured mica.

30*th June* 1870.

DONATIONS TO MUSEUM.

April 2*nd*.—Specimens of salt from the Sambur Lake. R. M. Adam, Esq.

„ 25*th*.—Specimen of petrified grass (rushes) from Java. Mrs. Banziger.

May 1*st*.—Two earthen pots from the Andamans and Nicobar Islands, a few stone implements, and fragments of pottery from the Andamans. Ferd. Stoliczka, Ph. D.

„ 1*st*.—A cup carved in serpentine from Skardo, Little Tibet. Ditto.

„ 2*nd*.—Twenty-one ornamental (carved and moulded) bricks from Kishnagurh. Mrs. Wood.

June 13*th*.—A perfect crystal of oxide of iron, pseudomorphic of iron pyrites, from the foot of Sinawur hill, at head of the Suddoom valley. Captain T. T. Carter, R. E.

„ 29*th*.—A complete series of tools, used in South Staffordshire for sinking colliery pits and for working coal and ironstone. S. Minton, Esq., Dudley.

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* A description of these will appear in a future number in the map accompanying which the position of the lead ore will be indicated.

In addition to the above, we have received many specimens of various kinds for assay, or examination, among which some of the more important were of iron ores from various localities.

The results of a recent search in the neighbourhood of Hazáríbágh yielded to Dr. Coates and Mr. Donaldson a considerable variety of ores, the principal of which were from the Káranpúrá coal-field and its vicinity, examined sometime since, but not published from want of a correct map. The following numbers show the percentage of metallic iron contained in each. Of course this is the full percentage, and this proportion would not be obtained in manufacture. As the details of these researches will be given elsewhere, we only give the localities and percentages here:—

Belhargadhá	...	30·6 per cent. of iron.
Chépojúgra in the Káranpúrá valley	...	56·8 „
Muraí Kalan	...	16·4 „
Gondalpúra	...	37·3 „
Áráhárá stream	...	42·12 „
Áráhárá village	...	11·2 „
Seam 12 feet thick in Damúda	...	25·6 „
Mándú	...	33·8 „

A specimen, found loose, to the north-west of Hazáríbágh yielded 68·7 per cent. With the exception of this, which is magnetite, and of the Belhargadhá specimen, all the others are varieties of clay-ironstone.

From the Wún District, East Berar, the Deputy Commissioner forwarded several ores for assay. Some of these were fine rich brown hæmatite traversed by crystalline veins of the pure mineral; these varieties were assayed, yielding, respectively, 60·4, 56·3, and 44·0 per cent. of iron. If with these we take the percentage of the pure limonite, we will have—

$$\begin{matrix}63{\cdot}2\\60{\cdot}4\\56{\cdot}3\\44{\cdot}0\end{matrix} = \frac{224}{4},$$ or an average yield of 56 per cent. of metallic iron. There are distinct traces of phosphorus. These specimens were from veins of segregation traversing the beds; but some of the beds themselves are rich and useful ores yielding 48·0 and 45·8 per cent. of iron.

In the immediate neighbourhood of these ores heaps of old slag are scattered over the ground. These slags, the result generally of very crude and inefficient methods of smelting, often contain a very large dose of iron, and it was interesting to examine them. Two specimens were assayed; and one yielded 38·0, the other 34·8 per cent. of iron—an amount which would be ample to pay for re-smelting these slags in conjunction with other ores.

In the Yenak hills, which occur west of the village of that name, near the river Paíngangá, in the southern part of the Wún District, East Berar, Mr. Hughes and Mr. Fedden, during their recent examination of the country, traced over an extent of some five to six miles in length two thick beds of conglomerate (nowhere less than nine feet) containing a large proportion of rolled lumps of a very rich hæmatite. This on assay yielded no less than 68·5 per cent. of iron with a trace of phosphorus—no manganese.

All these are rich and valuable ores of iron and occur in large abundance. The noted hill from which much of the ore smelted by the natives in North-Eastern Chanda is derived, the Lohara hill, near Bissanpúrí, is one mass of iron-ore of a couple of miles in length. A specimen brought by Mr. W. T. Blanford proved to be nearly pure specular iron with a proportion of magnetic iron, and yielded to assay 70 per cent. of metallic iron!

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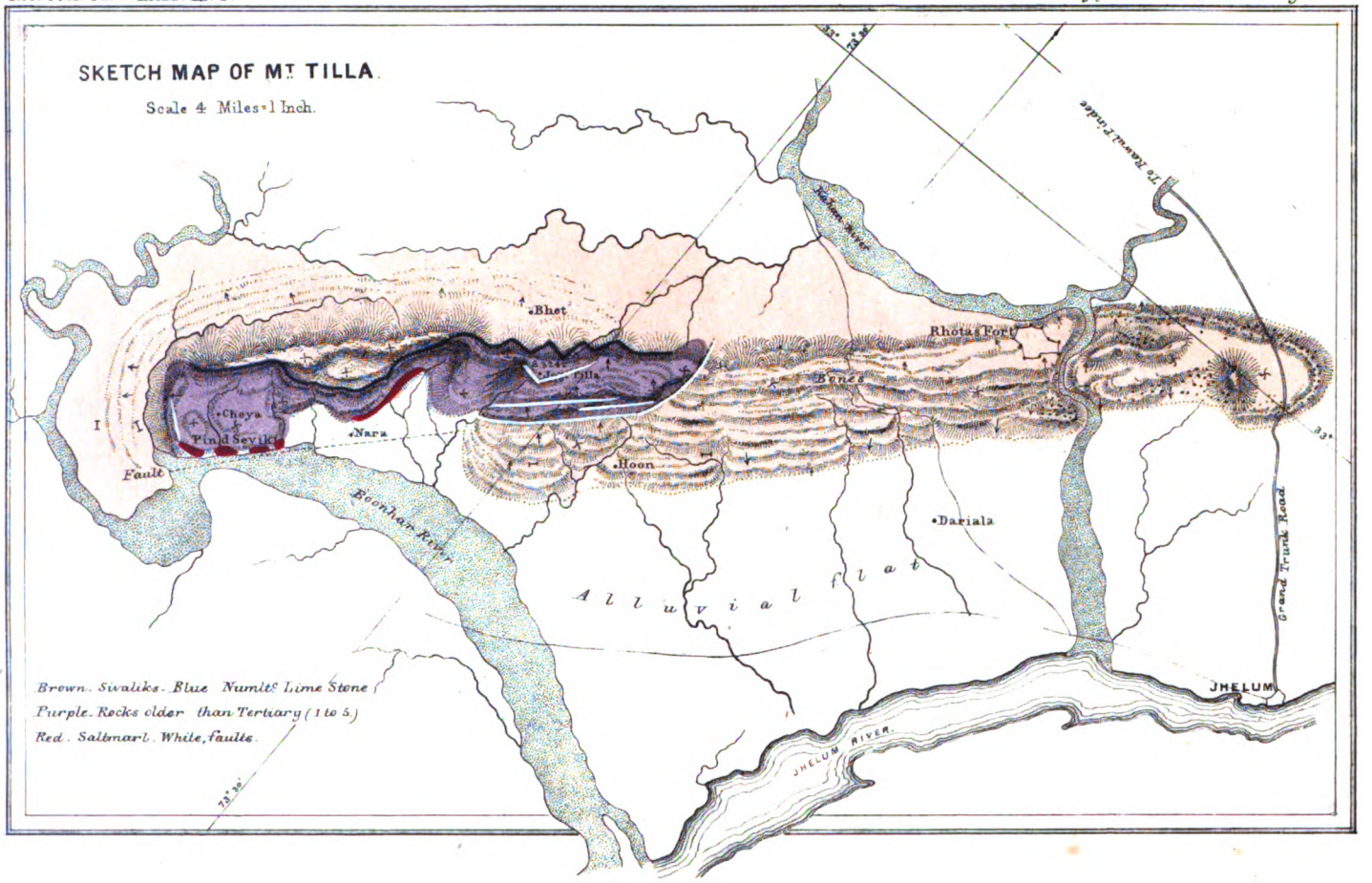


RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 4.] 1870 [November.

On the Geology of Mount Tilla in the Punjab, by A. B. Wynne, F.G.S., Geological Survey of India.

The fine hill which forms the subject of this brief memoir rises between the eastern termination of the Salt Range proper and the outworks of the Western Himalaya where the river Jhelum emerges from them to traverse the vast plain of the *Five Rivers* which united in the Lower Indus (or Sind) reach the sea near Kurrachi.

It is one of three or four minor ranges, all of which form links more or less between the Himalaya and the Salt Range. Of these the parallel chain of the Bukrala Hills to the north seems to form the most continuous connexion; but Mount Tilla exceeds them all in height, reaching an elevation of 3,242 feet above the sea. It runs generally north-easterly by east, commences abruptly at its western end, and continues thence lofty for about ten miles, when it sinks rather suddenly into high ravine ground, with elevations of over 1,200 and 1,300 feet, for about twelve miles further, past the extensive ruined fortress of Rhotas. It terminates in low rounded hills a few miles beyond this point, projecting into the commencement of the alluvial plains of the river Jhelum. It is widest where most lofty, having a base of three miles, but the extension of the range to the eastward is on an average not less than two and half miles in width.

Neither the Mount Tilla range nor that of Bukrala to the north appear to have any strong relation to the drainage depressions of the country in their immediate vicinity, both of these ridges and the valley between being crossed by the usually dry or nearly dry courses of streams, occasionally powerful, as indicated by the depths of their gorges and great width of their sandy beds when the currents become slack. With the Jhelum, however, ordinary relations seem to exist after it has left the Himalaya; the direction of the Tilla range coinciding more or less with that of the river, and the ground falling generally towards the latter—except where one of the other chains or groups of hills intervenes—on the southern side of the ridge.

The existence of Mount Tilla as a striking feature of the country—that of Chambal to the south, of the Bukrala range to the north, and indeed perhaps of the whole Salt Range itself—is, through denudation, directly due to huge dislocation of the stratified rocks, placing certain of the beds of greater or less strength in abnormal contact with others possessing different degrees of resistance to disintegrating forces. The chief line of dislocation affecting Mount Tilla passes along its southern base, obliquely separating the lofty portion from the lower extension to the east, and is perhaps continuous westward, though concealed, to the great fracture lying in the bed of the Boonhar river, which separates the adjacent portion of the Chambal range from the western termination of Tilla, completely discordant dips occurring on each side of the here constricted channel.

As results of the forces, or of similar forces to those, which caused this and other fractures, the whole strata of the country have been subjected to violent contortion, one of the finest curves being the interrupted anticlinal formed by the strata of Mount Tilla itself and traceable round its western end nearly to the line of dislocation occupying the lower gorge of the Boonhar.*

* On one of the early days of last April a somewhat singular occurrence was observed from the higher parts of Mount Tilla. The day was warm and bright, and a very strong breeze blowing, so much so that traversing

The denuding agencies acting strongly upon the varying consistencies of the rocks of this country have not only produced dominant features coinciding with the principal contortions and dislocations, but in much more minute detail caused their stratification so to govern the forms of the ground that the minor contortions in many cases become plainly visible in the ornamental hill-shading upon the very excellent one-inch (to the mile) maps produced by the Topographical Survey. This is much most prominent in the soft tertiary rocks which form so much of the surrounding country stretching far into the outer Himalaya; and it is partly a consequence of the steepness of the angles at which the strata are inclined in various directions. A wide belt of these tertiary rocks is known to border much of the Western Himalaya. Those which underlie them in the hills between the Ganges and Ravee have also been ascertained and described by Mr. Medlicott in one of the Survey Memoirs. Westwards or north-westwards from the Ravee river this succession has not yet been clearly worked out, but what is known renders it probable that the geology of this part of the hills will be found a continuation of that to the south-east. The very interesting Salt Range also exposes rocks older than this tertiary series which have not hitherto been identified with the infra-tertiary rocks of the Himalaya range. These lower rocks of the Salt Range, however, exhibit local changes, going from east to west, chiefly by the admission of new zones and by increase or diminution of thickness, and present a marked absence of all metamorphic strata. Hence it becomes a fair inference that the formations inferior to those of the tertiary belt above alluded to, and the conditions which produced them, had very considerably altered within the large area indicated; and some knowledge of the region wherein the transition commences would be very desirable. This region cannot be yet pointed out, indeed it may very possibly be entirely concealed by the newer rocks; but Mount Tilla is one of the nearest known places to the Himalaya range where the rocks next beneath the tertiary belt appear, outside or within its limits, as these may be assumed. These lower rocks appear only at the top and southern side of the lofty western part of the mountain, the extension of the ridge from this to beyond Rhotas being formed of the tertiary beds.

The section afforded by the hill is as follows in descending or natural order:—*

				Average thickness.
6.	Tertiary	Sandstone and clays chiefly, with some conglomerate beds	Sivalik ...	Only part in section, about 6,080 feet.
5.	Nummulitic limestone	... ...	...	Maximum 30 „
4.	Red shaly and flaggy zone, with pseudomorphic crystals	... ...	...	Very variable, about 120 „
3.	Pseudo-limestone and compact sandstone zone		...	150—200 „
2.	Black-shaly zone		...	200 „
1.	Purple sandstone zone	... ...	Saline group ...	250—300 „
	Purple shale and			100 „
	Red saline marl			20— 30 „

a knife-edge surmounting a precipice of several hundred feet in height, it was found necessary to proceed on all-fours. The wind came from the northward in such a way that much of the nearly two-miles-broad channel of the Boonhar river to the south just below the mountain would have been thought sheltered. So far from this being the case, it was here only that the gale seemed to take effect, raising vast clouds of sand, completely obscuring the distant country, while on either side beyond the limits of the mountain where the river course was not so sheltered the equally dry sand was not seen to rise at all. My guide observed, "*the winds are born on Tilla*," and it certainly seemed as if its great mass had so influenced the temperature of the air that the storm was local, or its strength limited to the vicinity of the mountain: or it may have been an eddy behind the obstructing hill-mass.—A. B. W.

* For the purpose of comparison with the distant succession between the Ganges and Ravee, the following general section is abstracted from Mr. Medlicott's Memoir:—

Sub-Himalayan Series.			
Upper	Sivalik ...	...	Conglomerates, sandstones, and clays.
Middle	Nahun ...	...	Lignite sandstones and clays.
Lower	Subathu ...	...	Kasaoli, gray and purple sandstones. Dugshai, purple sandstones and red clays. Subathu, fine silty clays, with limestone.—*(Nummulitic).*
Himalayan Series.			
Unmetamorphic—			
Krol	Krol Hill ...	...	Limestones.
Infra-Krol ...	ditto ...	...	Carbonaceous shales or slates.
Blini	Blini River ...	...	Limestone and conglomerate.
Infra-Blini ...	Simla ...	...	Slates.
Metamorphic ...	...	...	Crystalline and sub-crystalline rocks.

Comparing the two sections, it will be seen that the Nahun and Subathu groups, excepting the lowest portion of the latter, are probably unrepresented on Mount Tilla; purple sandstones, if occurring at all, being quite inseparable from the remainder of the lower tertiary sandstones and clays, which, from their fossils, were identified by the late Dr. Falconer with the Sivalik rocks.

But little of the nummulitic (? Subathu) beds are seen at Tilla; and there is no appearance here of the unconformity to their underlying strata recorded by Mr. Medlicott, though this would not be reason for its non-existence. Omitting the red shaly and flaggy zone of Mount Tilla,—which is variable in thickness and not always present,—some parallel may exist between the calcareous pseudo-limestone with its underlying black shaly zone and the Krol and infra-Krol groups of Mr. Medlicott's unmetamorphic Himalayan series; but even with the aid of that gentleman's able memoir it would be hazardous at present to attempt the correlation of these rocks.

Several beds of the sections to the westward have disappeared at Tilla; notably the black-shale group beneath the nummulitic limestone, containing all the coal and coaly deposits of the eastern portion of the Salt Range, and which can hardly be said to be represented by a few traces of dark coloured shale, existing where they ought to come in.

The true red salt-marl of the Salt Range makes but a very poor show along the southern base of Mount Tilla. It can be seen in some places near the villages of Nara and Pind Sevicki, but is greatly overrun and concealed by detrital accumulations from the cliffs and hills above. Only 20 or 30 feet have been given for it in the section; the thickness would, however, doubtless much exceed this if it could be well seen. It is of the usual bright red color, and gypseous saline nature; but although salt has been manufactured from the impregnated water it discharges, no actual rock-salt has been found in it.

The upper portion of the marl is, as usual, purple, and more shaly, and is frequently seen at the base of the purple sandstone cliffs. Its thickness, as estimated, may be too great, but allowance has been made for a portion that is unseen in most of its exposures.

This shaly portion of the marl passes up rapidly into strong purple sandstones of exactly the same color. They are generally fine grained, have no pebbles scattered through them, and, from being somewhat saline, have white efflorescences, yielding easily to the weather; they contain spangles of mica; and the stronger beds, from the ease with which they can be dressed, are used as building stone. The thickness of this rock, from causes to be presently pointed out, is sometimes deceptive. It forms a very considerable portion of some of the finest cliffs, where it cannot be much less than 300 feet, though in such situations its depth could be only estimated.

Next above the purple sandstone is a strong band of dark colored gritty shales and lighter colored sandy flags and layers (2); the whole having a lumpy aspect, and glistening with mica; the deposition surfaces are frequently glossy and covered with black earthy films. In these beds *annelidan*, *crustacean* or *fucoid* markings are numerous; and elsewhere they have furnished the earliest traces of distinct fossils in the Salt Range, these consisting of small bivalve shells as yet undetermined; strong ripple-marks also occasionally occur. Resting immediately upon this shaly zone is a massive band of compact silicious sandstones and sub-calcareous rocks (3) of light color, often nearly white. Some of them are brecciated or pseudo-conglomeratic; and many, under the influence of the weather, assume the peculiar fantastic forms of decomposing limestone. A specimen of the latter variety from Mount Tilla yielded on analysis, according to Dr. Fleming, nearly equal parts of white quartzose sand, carbonate of lime, and carbonate of magnesia. Their rough aspect and a peculiar surface appearance, as if likely to contain fossils, has led to frequent searches, but nothing of organic form has been found beyond the obscure tracks noticed in the foregoing group. The beds are frequently massive; this character, their strength and the association with softer beds below, having doubtless been the first conditions that resulted in the fine cliffs along the southern face of the range. Many valuable building stones could be obtained from this group, and some are said by Dr. Fleming to bear a high polish (Jour., Asiat. Soc., Beng., Vol. xxii, p. 265).

The next overlying group (4) is largely developed only at the western end of the range. It presents a strong contrast to that just mentioned, being formed of deep-red flags and shales, sometimes spotted with green, the flaggy slabs being often studded with projecting angles of casts of cubic crystals, the mineral—in all probability salt—having been entirely replaced by sand. The flaggy layers are frequently of light color internally, the bright-red hue

being derived from the intervening earthy shale layers highly charged with iron-oxides. The latter become more numerous upwards, until the superior portion of the band is found to consist entirely of crimson and purple clay or shale. This group occupies a good deal of the ground from near Pind Sevicki by Choya Goojaron-ki, and above Nara; beyond which place it passes to the north side of the mountain, becomes thin, and thereafter is seen but fugitively here and there as well as near the summit.*

In some spots, particularly on the northern slopes of the mountain, vestiges of the nummulitic limestone group (5) so largely developed westward are apparent, resting either upon the red zone or, in its absence, upon the strong band beneath. It is seldom at all clearly seen; generally appearing as a thin white streak of debris, somewhat shifted and borne down the hill, and often overrun by other detritus; but at one spot, where rather thicker than usual, it was found to consist mainly of the white, lumpy or yellowish variety usually occurring near the base of the group. Some gray, compact beds overlie this; and there are traces of a few dark shales in its lower part, as also of a peculiar bed of compact, variegated, red and white clay rock, frequently observed elsewhere at the base of this limestone group. The rocks on Mount Tilla contain but few of the numerous fossils of the group so far as could be seen.

A small outlier of this limestone occurs below the road north-east of the houses on the summit of the hill, having subsided with the other strata along a fault; and in the opposite direction, just beneath the precipice on the edge of which the highest bungalow is perched, remnants of the variegated clay-bed before mentioned indicate that the limestone has barely been removed if, indeed, some of it *in situ* is not concealed by sub-aerial rain-wash.

The inferior portion of the Sivalik group (6), which rests apparently with complete conformity upon the nummulitic limestone, is mainly composed of strong, gray sandstones of rough texture and softer nature than any of those lower in the series. Thick beds of lumpy pseudo-conglomeratic shale also occur, and some beds of red, shaly or marly clay. Large fragments of silicified fossil wood are very numerous in some localities, particularly on top of the western end of the mountain. Over these clays comes a broad zone in which the sandstones alternate with thick beds of red clay at the northern base of the hill for fully 1,600 feet; and this zone is succeeded by another of probably much greater thickness, in which the intercalated beds of clay are of a pale brown color, there being little difference in the sandstones throughout.

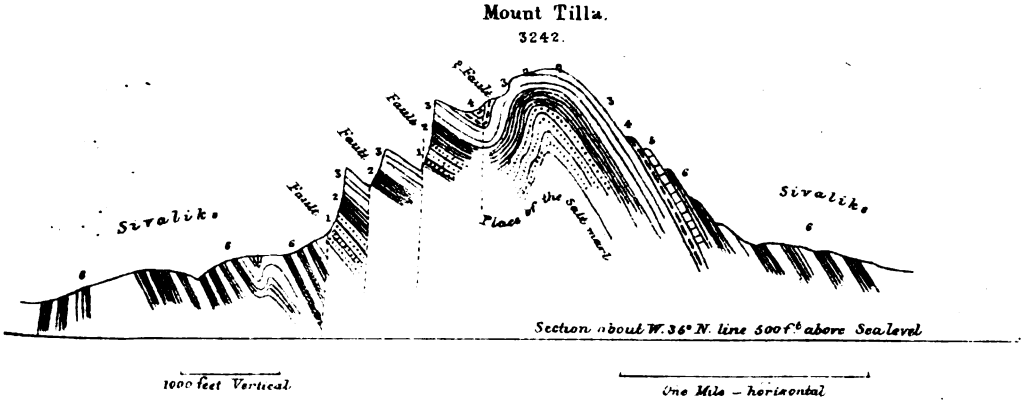
The less elevated continuation of the ridge from Mount Tilla proper on by Rhotas is formed almost entirely of what appear to be the lower portion of these Sivalik rocks, greatly crushed and contorted, generally inclined at steep angles to the north-west, but in some places more nearly horizontal; while contrary dips occur on the Jhelum (or south-east) side of this extension of the ridge.

To the eastward and east by north of Rhotas, the termination of the Tilla chain is fringed by low, rounded hills of loose conglomerate or pebble beds, mainly composed of smooth well-worn limestone and metamorphic rock debris. These pebble beds also appear, generally in a disintegrated state, in the fine anticlinal section of the Kahan gorge near Rhotas, and in one place were seen to rest unconformably upon the Sivalik rocks; but, owing to the extremely incoherent nature of the rock and its liability to have its debris re-arranged by atmospheric action, this cannot be asserted without considerable doubt; though to the east, along and near the Grand Trunk Road, the general arrangement of the conglomerate seemed discordant to the undulating dips of the Sivalik beds; while the way in which the hills were overrun with pebbles and boulders left small hope of satisfactory evidence being here obtained upon the point.

Besides the fossil wood observed upon Mount Tilla, some fine mammalian remains were formerly procured from the Sivalik beds between that and Rhotas, and were determined by Dr. Falconer, as already mentioned. A set of beds containing numerous imperfect fragments of these bones runs along the summit of this lower portion of the ridge close by the road from Rhotas to Tilla, near a place called Thurbole. The bones were found in a fragmentary state, imbedded in the matrix as well as lying loose upon the surface, but though some time was spent in the search, few useful specimens unfortunately could be obtained; and, to procure such, a subsequent and special mission would be probably required.

* The thinning out of this red zone may, perhaps, be partly due to pressure and slipping on the highly inclined slope of the beds at the north side of the hill, where the flaggy lower portion only is seen.

It will perhaps be observed that—though, as has been said, the lofty portion of the ridge of Mount Tilla coincides with a fractured anticlinal curvature of the strata which might be expected to assume approximate horizontality on the axis of the ridge—the height of the hill is given at over 3,200 feet, while the total amount of the thicknesses of groups in the sectional table only reaches about 1,000 feet, excluding the tertiary Sivalik rocks which mainly lie in the plain below and on the northern slopes of the hill. To explain this seeming discrepancy, it may be stated, 1*st*, that the height of 3,200 feet is attained by the mountain just at the point where the beds commence to turn over: 2*nd*, that the axis of the contortion rises towards the summit of the hill: 3*rd*, that 800 or perhaps 900 feet must be allowed for the height of the general southern base (the outcrop side) of the mountain, and that a considerable sloping talus above this is formed of slipped masses and debris at the top of which the section of the vertical cliffs begins to become visible. Added to these there are three, if not four, step-faults along the south-eastern side of the highest part of the hill, each of which repeats some portion of the strata, as seen in the accompanying sketch section :—



Section across Mount Tilla, looking south-west.

1. Purple sandstone.
2. Black, shaly zone.
3. Pseudo-limestone and compact sandstone.
4. Red, shaly, and flaggy zone.
5. Nummulitic limestone.
6. Tertiary (Sivalik) beds.

With regard to the physical structure of the remainder of the hill, the upper portion of the anticlinal curve expands to the west, beyond two deep coombs or glens, one of which opens broadly to the south, but enters into the very heart of the mountain; this expansion of the arch being accompanied by so slight a southerly dip that the lower members of the series present, even to the lowest of all (the red marl), appear at the base of the hill along a line which sinks gently to the west-south-west.

Along the Boonhar fault in this neighbourhood, some difference in the section is perceptible, the group No. 2 of the above figure having apparently thinned out both on the Tilla and the opposite side of the gorge: the purple band beneath seems to be also thinner; but the ground is much obscured by local slips, small faults, and large detritus from the pseudo-limestone group which, with many undulations, sheets the hilly ground or plateau about Choya.

Beyond this plateau and above it a somewhat tortuous cliff-line extends along the brow of the hill, broadly edged by the nearly horizontally rolling beds of the red, flaggy, and shaly band; while the tertiary strata of the plain beneath rise at a steep angle on the northern slopes, and, like the crest of a wave, overlap the ridge, forming most of the lofty ground westward of the summit.

The extreme western termination of the hill is very abrupt, and some complicated faulting occurs just at Pind Sevicki, the last of the high ground being formed of the red, flaggy, and the underlying group, either vertical along a west-north-west line (coinciding with that of the Chambal scarp), or dipping with the steep ground at high angles to the westward, but

curving suddenly round the peak called Thob, at which place the north-westerly inclinations commence, that fix the steep character of all the northern side of the lofty ground. Round this peak of Thob, too, as a centre the strongly marked strata of the Sivalik (tertiary) group are boldly curved so as to enfold those which form the hill; the former, all more or less on edge, being frequently so perfectly vertical that all trace of their outward dip is lost.

At the north-eastern extremity of the lofty ground the dislocation of the rocks is accompanied by violent contortion both of the Sivalik and older beds, its intensity diminishing considerably along the lower extension of the ridge to the north-east.

Gold is said to be washed from the sand of the Boonhar river. Its source is probably among the Sivalik sandstones and conglomerates, formed of Himalayan detritus. The washing is carried on after rain.

The summit of Mount Tilla, though affording small space of at all level ground, will doubtless attract attention as a sanitarium within easy reach of the Military station of Jhelum. It commands a splendid view of the snowy Pir Punjal range; is said to be, and most probably is, much cooler than the plains, for when visited on an extremely hot April day, the temperature in the shade was very refreshing.

A road in excellent repair, save where it passes through the tertiary ravine-ground near Dariala, leads from Jhelum to the houses on the summit; and the hill, though by no means completely bare on top or on the northern slopes, is not crowded with jungle.

The chief difficulty, as usual, would be a large and continuous supply of water. Extensive tanks exist, one of which is well placed, but lies rather low in order to obtain a catchment basin. The disposition of the strata affords little encouragement to sink wells; though the black, shaly zone might be found retentive. Some springs there are, and others might be found, where the tertiary strata cap the ridge, but this is at a distance of from four to six miles, and a road would have to be made to them, so that probably the best method of increasing the supply would be by multiplying the number of tanks and making them as little liable to leakage as possible, one large structure of the kind on the north side of the hill having been found quite empty, owing, as was said, to this fact of its leaking.

The Copper Deposits of Dhalbhúm and Singhbhúm.

The following papers on these copper deposits consist of, 1*st*, abstracts of two papers by M. Emil Stœhr, the accomplished mining geologist employed by the Company formed to work the mines; one in the "Vierteljahrschrift der Naturforschenden Gesellschaft" in Zurich, Vol. V, p. 329, 1860; the other in the "Neues Jahrbuch fur Min. Geo. u. Pal." for 1864; and, 2*ndly*, a recent report by Mr. V. Ball, of the Geological Survey. Scientific observations in connection with mining operations in India are so rare that it is important to place the experience and the opinions of M. Stœhr on record in a form easily accessible to the Indian public. The works being abandoned, the mine-sections were not accessible to the Geological Surveyors. The localities mentioned by M. Stœhr may be followed upon the map attached to the second paper.

1.—The Copper Mines of Singhbhúm, by M. Emil Stœhr.

1. *General Geological features: Schists.*—It is only in the south and west of the region under notice that granite and gneiss-granite appear, forming dome-shaped hillocks seldom more than 100 feet above the flat. The old rock-formations—metamorphics—of Lyell behave very differently; they form a system of parallel ridges from west-north-west to east-south-east, ranging in elevation to 1,900 feet and under. The strike of the ridges is for the most part the same as that of the schists, except in a few places to the east; up to Sideshor the strike varies from east-7°-south to east-30°-south; from there it is east 37°-to 60°-south. The dip is constantly to northwards, at from 15° to 50,° mostly from 20° to 35°. This structure decides the form of the hills—steep on the south and sloping on the north.

These schists present many varieties, scarcely any form of metamorphic rock is unrepresented; clay-slate of the most various types, from soft clay-slate to roofing slate, with quartzose varieties, or sometimes quartzites, forming the ridges; mica-, chlorite-, talc-, hornblende-, and quartz-schist with quartz-rock are the most prevalent. Occasionally gneiss is found, but without any continuity or constant position in the series. There is a peculiar rock composed of round grains of quartz in great number (often exceeding the matrix) in a base

of clay-slate. At the junction of the sedimentaries and the granitics there occurs a strange quartzose formation, a true arkose, many feet thick and almost vertical; in which are found angular fragments of the different metamorphics, in a fine quartzose mass. Of minerals I obtained garnet, schorl, kyanite, rhatizite, and chloritoid (of Kenngott); also a blue-black mineral of an elongated form, which Kenngott considered to be apatite united with a carbonaceous substance.

2. *Greenstone dykes.*—The irregularities that these ranges exhibit are due to the presence of transverse dykes, especially of diorite. Simple inspection cannot determine whether the greenstone is amphibolic or pyroxenic—diorite or diobase; I incline to consider it diorite. Generally hard, it often becomes soft, changing to aphanite; at Paraum near Dhoba it is almost serpentinous, containing nearly 10 per cent. of water. Not far off are considerable runs of potstone, which this aphanite seems at all events to approach. In other places the greenstone passes into greenstone-schist, following the strike of the series. Although these dykes do not always come to the surface, they can be traced at intervals in long ridges recognisable from a distance as longitudinally extended lines of conical hills, generally double-topped. The strike of these diorite masses varies, generally north and south, or 15° on either side. Where such a north-south range crosses those of the older rocks all is confused; still a most picturesque conical hill always detaches itself from the mass. This very hornblendic diorite has a remarkable tendency to spheroidal structure, and appears on the summits split into vertical columns, like ruined castles. It is noteworthy that one often finds such clefts with quite fresh surfaces of fracture: this is the result of the sudden cooling by rain of the rocks when highly heated by the sun's rays, as I determined by direct experiment. These diorites are so rich in iron that they often disturb the magnetic needle, and weather into iron-sand. The diorite cones seldom form considerable elevations; but this is not without exception, as at Bagmuri, 2,000 feet high. Where the diorites come in contact with the sedimentaries these are altogether metamorphosed; basalt-jasper occurs; the schists are calcined, and columnar divisions are frequent. These greenstones are not limited to the north and south dykes.

Whether the introduction of the greenstones has had any connection with the appearance of the copper ore must for the present remain undetermined; it would seem the more likely, inasmuch as the potstone and serpentine formation is certainly so connected.

3. *Granitics.*—These diorites run into the granitic area to the south and west; where gneiss-granite and, less frequently, true granite form dome-shaped hills; these also here observe an east-west direction in long parallel ranges above the plain, traversed by the north-south diorites—an arrangement that gives to the whole area a strange chessboard-like aspect. At the intersections of the two systems of ranges, the most picturesque cones occur; and remarkable development of mica appears in the granitic rock, so that the mica is applied to many ornamental purposes.

4. *Laterite.*—In India many different formations are grouped under the name of laterite. There is the laterite of the plains formed of detrital matter into which the iron constituent came from without, probably from springs; such is the laterite of Midnapur. From these are to be distinguished that which owes its formation to the decomposition *in situ* of ferriferous rocks; such is the only laterite known to me in our district, as on the summit of Mahadeo, derived from the ferriferous diorites.

5. *Mineral products.*—I have already mentioned the potstone that is worked into various utensils. I may here notice an ochreous schist that is used as a dye. Of ores there are—iron ore, sometimes as a vein, sometimes stratified; mostly pure magnetic iron (see Berg- und Huttenmännischen Zeitung for 1863); seldom red hæmatite, and once only brown hæmatite; then the rich copper ore, which was the object of my journey to India.

6. *Copper ore: its range.*—This copper ore would be interesting if only on account of its unusual longitudinal extension—for 80 miles if not more. I have examined it more closely through a length of 65 miles, from Lopso hill in the west to as far as Badia in the east. I know nothing of its further distribution in the western forest-clad hills, but in its eastern range it goes far beyond Badia to Bairagurha, the most south-east point on my map; and so far as I examined the intermediate hills, traces of the ore were found everywhere; but in its longitudinal range, it appears most in the northern hills.

7. *A lode, or bedded.*—The strike and dip so coincide with those of the containing strata that one is induced to consider the mineral deposit as stratified; against such a supposition there is the vein-like mode of deposit, the frequent cuirasses and slickensides, the occurrence of druses, and the broken outcrop. At all events the deposit is a filling of

cracks parallel to the layers of the containing rock; and the formation of these cracks was probably contemporaneous with the upraising of the schists. Following the structure of the containing rock, the deposit was originally variously irregular; and this condition was aggravated by the intrusion of the diorite.

8. *Several outcrops.*—Proceeding from north to south there frequently appear two or even three consecutive runs of copper ore; it would thus seem, partly that one and the same band was brought several times to the surface by upheavals, partly that a system of parallel deposits truly exists. At all events we can recognise at several places two parallel ridges, or lines of outcrop, sometimes miles apart, sometimes coming so close that they almost commingle. Going from west to east we find, quite to the west, near the Lopso hills, two runs of ore scarcely ten minutes from each other; a third more northern locality seems only due to a local disturbance. These two runs separate to eastward, being several miles apart at Khursowa, until they appear to come together again in the Akarsuni hill. From there to Tamba-dungri (copper hill) the deposit is buried beneath the deep soil of the plains. At Tamba-dungri one run appears which can be traced over Jamjura, then bending southward to Landu, and then again northwards to the summit of the conical hill Chundra. A little north from Jamjura a second band shows, which runs northwards from Landu to Chundra, at the summit of which these two runs are scarcely two fathoms apart. From here the two separate again, one goes south to Matku in the plain, where it is concealed; one to Hitku, Banka, etc., in the north flanks of the Rangi hills. Here there is a break of several miles where I was not fortunate enough to find the ore: finally it appears again at Racka and proceeds then in a long line following the north hill-flank. Between Bindrabun and Sideshor the strike alters, from east-37°-south to east-60°-south; also the intruding diorites disturb the rocks much, and with them the deposit. In their further course eastward the hills trend rather back, and the deposit gets gradually into the plains. At Pathur-ghora, we find again two lodes, probably, however, only the broken parts of one and the same main lode which unite at Bairagurha. From here all goes straight, except once at Karapathur there is a disturbance; the contorted and crushed strata are confused and the rock almost altered into gneiss. These schists are stuck up to north by a south to north upheaval, and twisted round the Karapathur, till at last all becomes normal again.

9. *Varieties of the ore and gangue.*—As for the ores themselves:—when removed from the influence of the atmosphere the iron ores are, mostly magnetic iron, less often pyrites: the copper ore, too, is seldom pyrites, mostly glance-copper and red copper ore; either ore indeed is seldom pure, but mostly the two in intimate variable mixture, so they almost form a peculiar ore of blue-red colour, soft, and with red streak. According to several analyses (among others by Fresenius and Roth of Heidelberg) the proportion of sulphur varies from 9 and more per cent. to complete absence; and also the total of copper from 42 to 64 per cent.; the ore is always contaminated with iron, from 5 to 12 per cent. It seems that when sulphur is quite absent, glance-copper is also wanting and the red-copper is not pure but mixed with black-copper; also in many places black copper occurs in strings and disseminated, and is used by the native beauties as a black dye for the teeth. Beautiful rosettes of red-copper appear detached, no doubt the result of decomposition. In the upper levels the saline ores occur as the result of alteration, malachite, less often azurite, and brown spar. The whole gangue and ore are often so decomposed that these products are formed to a depth of 15 fathoms. As a ternary product of decomposition, on the heaps and scattered, I may mention chrysocolla, libethenite, and chalcophyllite.

I must again notice the intense atmospheric action; often at the depth of 30 running fathoms the decomposition had not ended; the earthy quartzite-schist had become decomposed and penetrated with malachite and brown iron ore.

Malachite, in solid masses, compact and earthy, seldom fibrous; in the upper levels the only ore, where it occurs in film and fragments, or mixed with brown hæmatite, impregnating the whole gangue, which then contains from 2 to 8 per cent. of copper. It occurs besides as infiltrations in cracks and slender clefts where a rich deposit ends or begins. It is always more or less mixed with silicious earth and ochre; the purest pieces give—

Oxide of copper	54·73
Iron oxide	6·20
Water	6·87
Carbonic acid	15·15
Alumina	·83
Insoluble	15·95
	99·73

Red copper ore, in solid masses from the size of a nut to several feet in diameter in a silicious matrix, sometimes filling the whole lode and enclosing angular pieces of quartz, sometimes in strings and flakes ramifying through the rock. This is the most important ore, seldom indeed pure, almost always mixed with black copper and iron oxide. As the malachite is due to the further decomposition of this ore, so is it of glance-copper; some specimens show the three states. It is difficult to find red copper entirely free from copper-glance; apparently pure red copper specimens have given 8 per cent. of sulphur. The mixture with iron oxide varies from 0·25 to 18 per cent. It is too always mixed with black copper; and it was interesting to know if the proportion were constant; analysis showed it to vary from 63·7 per cent. sub-oxide and 33·6 of oxide to 50·14 per cent. of sub-oxide and 46·74 of the oxide. It is only an indefinite mixture. Often the oxyde is in excess, the ore being dark brown, with black metallic streak. The common variety is brown red to cochineal red, with red streak, and in pure pieces, a fine crystalline texture. This quality, with hardness of 3, sp. gr. 5·623, gave—

Sub-oxide ...	63·72
Black oxide ...	33·60
Silica ...	1·02
Alumina and iron ...	0·75
Lime ...	0·64
Magnesia ...	0·10
	99·83

Others gave traces of manganese and bismuth.

Black copper occurs only as a coating, and at most in strings as thick as the back of a knife and always mixed with red copper and iron oxide.

Copper-glance, massive, mostly in kernels. It is at all events the original undecomposed ore; seldom pure, almost always with iron oxide.

Copper pyrites seldom found; and only sprinkled here and there.

Azurite, as a crust. It is remarkable how seldom it appears where malachite is so abundant; I only know of one locality.

Libethenite and *Chalcophyllite*, in small crystals in the old refuse heaps; similarly *Chrysocolla*.

Native copper, in massy rosettes and flakes; rare, and only where surface water can penetrate; associated with malachite, of which it seems to be a reduction and not of red copper.

Copper uranite was found on Lopso.

Iron ores.—Brown iron ore; in the upper levels often filling the whole lode, as ochre or as solid brown hæmatite.

Magnetic iron in crystalline granular masses, sometimes even filling the whole lode mostly mixed with specular iron (Eisenglanz). Analyses of fragments of the old copper regulus gave traces of silver and gold, and 10 per cent. of iron. Assays made in London proved the ores to contain silver: an ore of 31 per cent. of copper gave 0·0078 per cent. of silver, one of 60 per cent. of copper gave 0·0039 of silver. The silver then cannot be principally contained in the copper ore, but in the gangue.

10. *Distribution of the ore.*—Copper is not the only metal this deposit contains; iron predominates; so that one may describe the deposit as one of iron ore rich in copper. The copper-contents are themselves very variable, from traces up to the richest ore. The action of the intruded diorites appears to influence the proportion of copper; they may come quite to the surface or only produce a north-south upheaval, the richest copper deposits always being in their neighbourhood. In the preponderating quartzose gangue the ores occur in leaves or threads, from paper thickness to several inches, ramifying through the mass; sometimes binding angular quartz fragments, sometimes in compact masses; often filling the whole vein. Elsewhere they show in lenticular lumps from the size of a hazelnut to that of the head, having then generally a covering of talc or chlorite in the quartzose base. Sometimes, but seldom, the quartzose veinstone fails, and contorted, crushed, broken chlorite- and talc-schist enclose lumps of quartz and strings and pieces of ore. Once or twice the veinstone was quite porphyritic.

The roof and floor of the deposit are not confined to any particular kind of rock of the metamorphic series; many different rocks occur as such,—clay-slate, chlorite-, talc- and mica-schist; but always a schist; quartz rock never occurs as roof and floor. The strike is the same as that of the rocks; in the west, from east-west to east-35°-south; in the east so much as east-60°-south. The dip is 15° to 50° to northward, mostly 20° to 36°. The normal width of the lode is 20 to 22 inches, at which the ore is richest; sometimes filling the whole vein. It often expands to three feet and over; but then the ore scatters and the richness suffers. Whether a workable ore extends, and how deep, is unknown; the ancients only worked that nearest the surface; but wherever I opened old works and went deeper good ore was found, generally after cutting through some poor ground, so that at 100 to 120 feet the ore still always held out. At the time of my departure the point at which research had been carried farthest was at Landu; there 212 feet had been reached, but already at 190 feet the ore had decreased, and at last was quite lost. Whether there only happened to be poor ground at this spot, or whether generally the ore does not extend to the deep, is unascertained: I would almost decide for the latter opinion. The deposit is of course not worth working throughout its entire extent; but rich parts alternate with poor or even with barren; to find the first was therefore the chief endeavour; and we were successful at many points in finding such rich localities.

In the Lopso and Sirsu section the ore is associated with quartz- and mica-schist.

At Podumpur with a sandy mica-schist containing schorl.

At Akarsuni with black mica-schist and quartzose clay-slate, close to greenstone; granite also shows in the neighbourhood. The detritus on this granite is washed for gold.

At Tamba-dungri, a greenstone that does not reach the surface seems to have raised the schists and partly metamorphosed them locally into gneiss and quasi-granite, and the ferruginous schist into jasper. The top of the hill is burrowed all over with little pits 60 feet deep.

The northern run at Landu is in quartzose schist accompanied by mica-and chlorite-schist: the southern in mica- and chlorite-schist with associated quartz.

At Chundra the ore occurs with quartz gangue in mica- and chlorite-schist and quartzose clay-slate.

At Matku in the quartzose clay-slate and quartz-schist.

The northern lode at Chura-dungri and Hitku is in quartz-schist; at Pahlu-dungri in chlorite-schist; at Banka it is greatly disturbed and seems to be cut out suddenly by a mass of potstone.

At Racka and Bagh-ghura the rock is sandy schist and quartzite, but mica-, chlorite- and talc-schist are not absent. It was here that disthene-rock was found. The ore is in a silicious schist and occasionally in mica- (black mica), actinolite- and chlorite-schist.

At Sukurna, near Sideshor, the ore is in silicious schist, associated with mica-, chlorite- and quartz-schist. Sideshor appears to be the production of a penetrating north-south upheaval; and in its quartzites traces of the ore are found, as malachite,—a proof that many beds of the metamorphic series are cupriferous. At Bindrabun immediately under the ore is a massive rock composed of quartz and tourmaline with a little mica,—a granite formation, except that felspar is wanting; one might almost call it greisen. A run of jasper occurs close by, in the formation of which, as well as in the elevating of Sideshor, this peculiar rock may have taken part. Malachite traces are found in it too.

At Pathur-dungri the rock is quartz-schist; but on the south-west of the hill ore occurs in mica-, chlorite-and hornblende-schist.

At Súrda the ore is in dark mica-schist containing garnet, chlorotoid, and hornblende crystals. Near Pathurghora the ore is in more or less metamorphic schist; near the village red felspar is associated, and the rock becomes granitoid.

The distribution of the ore in the lode follows no certain order; unless one is to consider as such its constant association with quartz, which is always the preponderating gangue. From the agreement of the dip and strike of the deposit with that of rocks, one would consider it as a stratified ore, were there not much against such a supposition. I do not here allude to the cuirasses and quartz druses, but especially to the variable strength of the deposit itself, and the interruption and separations of the outcrops; which then again follow

the strata and lie in many patches close to each other. The normal thickness may be about 20 inches; in rich spots it reaches 3 feet; while elsewhere it intermits, the deposit is compressed and decreased with only scattered ore, till this also disappears and the deposit can no longer be traced. All this suggests to me separate lodes, *i. e.*, an impregnation of cracks parallel to the rocks, and probably formed at the time of their elevation.

11. *Peculiar carbonaceous mineral.*—I conclude this short description of the deposit with a notice of a mineralogical peculiarity occurring in it. At Jamjura the lode was sought for beneath the thick soil of the plains, and found with good ore. In this newly opened work a fault was struck, in the neighbourhood of which the veinstone seemed quite altered, the quartzose mass had become almost porous, the quartz had lost its lustre, and had become almost friable. In this rock and in the ore itself there occurred as rarities in, as it seemed, octahedral or rhombohedral cavities, loose pieces of a peculiar coal-like substance. It was found at 37 feet below the surface, or at 100 feet along the slope of the deposit, at 30°. I had early sent from India some specimens to Bergrath Breithaupt at Freiberg, who has described this strange mineral in the Mining and Metallurgical Journal for 3rd January 1859, from which I here give an abstract of the principal characters:—black; semi-metallic lustre on fresh fracture; black streak; opaque; blunt pieces of size of an egg and under; internally crystalline, very fine grained; sp., gr. 1-92; hardness 4-25 to 4-75, between calc and fluor spar; brittle; very difficult to burn before the blowpipe. Composition, mean of Sheerer and Ruhe:—

Carbon	...	...	...	...	...	...	93·945
Water	...	...	...	...	...	...	1·440
Acid	...	...	...	...	...	...	2·895
Ash	...	...	...	...	...	...	1·720
							100·

It is considered by Breithaupt as a middle condition between anthracite and graphite.

Breithaupt thinks that the tabular impressions on the carbon may be due to calcspar—that in the druses calcspar crystals were produced. This is surely an error, for I never saw such crystals; on the contrary, the coaly matter is loose in cavities lined with lamellar quartz, which is often imposed upon it. The hardness given by Breithaupt is not correct for all the specimens; many are easily scratched by calcspar. I would mention that I possessed a piece of veinstone which together with this mineral contained undoubted flakes of graphite, as also two different forms of the mineral close together.

Professor Kenngott and Escher de la Linth have more closely examined this substance; on the same veinstone were found white particles of a silicious substance with a deep black nucleus, the white exterior being the result of decomposition; hence Professor Kenngott takes this substance to be the remains of the decomposition of a highly carbonaceous silicious mineral, whereby the silica was removed, leaving the carbon.

12. *Mining experiments.*—In order to exhibit the special conditions of the deposit I will now describe the most important mining experiments. Special mining experiments could not be attempted over the whole area within little more than three years' time; they were limited to between Jamjura and Rangi. Landu was the centre; there were extensive old works there, and the flat ground offered an untouched field for exploration. The diggings that gave the best opening were No. 1, near Landu, in the north lode. At 7⅓ running fathoms we got to the end of the old workings, where the width, originally considerable, was reduced to 15 inches. There was great trouble in getting the men to continue the work; and when, among a lot of jackal bones, a piece of a human skull was found, all green with copper, great terror spread, and only the most pressing representations, that the skull must have been brought there by some beast of prey and did not belong to a man who had perished on the spot, could induce the men to carry on the work. The layer was only 15 inches from roof to floor, almost filled with rotten slate and quartz fragments, rich in iron, but almost without copper, only here and there a sprinkle of malachite incrustation. The ancients had evidently abstracted all the good ore till they came to this barren run. After a little the malachite increased, enveloping the quartz, and so ramifying through the still broken schist that it yielded from 1·8 to 4·5 per cent. of copper. The roof and floor were of chlorite-schist, quite devoid of copper save by infiltration in the little cracks. At 12·7 running fathoms strings of malachite occurred one-half of an inch thick; and the lode was 2 feet wide. From here it increased; and at 15½ fathoms an easterly drift was started that soon disclosed the most splendid ore; first malachite, then this passing into red-copper, and this again into glance-copper. This ore finally filled the

whole vein, 3 feet thick, enclosing angular pieces of quartz; and also occurred in large elliptical nodules several feet in diameter lying in a gangue of silicious slate, in such numbers that a fine roof-face could be worked; at 25 fathoms along the drift, the lode split, one branch going southwards soon became barren, while the northern one yielded fine ore. In a northern trial-drift from here another vein was cut more or less rich in ore, and still further eastward three others. Down from this drift a small hading shaft was sunk; and here, at 28½ fathoms the ore began to decrease, and died out altogether. So far the underlie was 35°; here it rose to 60° or 70°; the thickness of the lode decreasing to a few inches; below this trouble it became flatter again and traces of ore re-appeared, till at 32 fathoms this too disappeared with a new trouble. It was in this state of affairs that the hand pumps could no longer keep under the water of the rainy season, and the progress discontinued at 12 fathoms vertical from the level of the valley.

Four miles to the west, at Jamjura, under the alluvium of the plain, a very rich ore was cut, occurring in a very similar manner to that at Landu. At 18 fathoms the ore was still good. In a westerly direction it was less rich, but continued to eastward. In a trouble of this vein the carbonaceous mineral was found; not only in quartz, but in solid malachite. Here, too, was found the native copper, reduced from malachite by the action of this carbon.

A third important locality was No. 6 of Landu, in the south lode; chlorite-schist and sandy mica-schist contain grains and nodules of quartz, often coated with talc; these are sometimes several feet in diameter. In and around these generally flattened lumps, partly following the layers of the schist, partly, too, itself forming kernels, or surrounding fragments of quartz, comes the ore in threads, from the thickness of a knife to several inches, thus uninterruptedly arranged in nuts and lumps, and in this manner forming the lode, 18 to 24 inches wide. These conditions obtained to 16 running fathoms, then the ore ceased, and at my departure the work was in barren rock. In the upper part the ore was all malachite, but in the hard undecomposed masses there was a mixture of red and black copper with glance-copper. The ore was besides always very rich in iron. At about 80 fathoms to the east, in a small trial pit, the lode was almost entirely made up of coarsely granular crystalline magnetic iron.

At Hitku in the northern, and Matku in the southern, lode there occurred quartzose, porphyry-like gangue; and the ore predominated as nodules of oxides, with glance-copper. In neither place was it worth working, appearing to cease in depth.

At Banka a clear-ringing, columnar, fissured quartzite is penetrated in every direction by thin strings of ore, black, with glance-copper. Sometimes it is scattered through the quartzite, giving it a porphyritic aspect; the quartz being then altered, dull, fragile as if burnt. Low down there appeared an agglomeration of quartzose talc-schist and nearly massive talc, where the lode stopped out suddenly.

According to the results at Landu, the cubic fathom of 96 to 150 cwts. of raw ore gave an average of 6 per cent. of copper; and the cost of extraction of the same, including haulage, amounted to Rs. 22 to 23 per 100 cwts. of raw ore.

The preparation by hand-picking must be regulated according to the proportion of saline ores; here the average of 100 cwts. of raw ore was—

3	cwts. of rich picked ore of	...	...	...	20	to	35	per cent.	copper.
60	„ average ore of ...	...	...	...	8	„	9	„	„
13	„ dust ore of ...	...	...	...	0	„	5	„	„
24	„ rubble and poor ore of	...	...	...	¾	„	1½	„	„

All the poor ore was considered as rubble for crushing. In the best rubble there occurred but 8 to 10 per cent., very seldom 20 per cent.

13. *Labour.*—Most of the coolies were Dhangha Kols. On the whole, they proved themselves very intelligent and skillful; on an average more so than our European workmen; only they are weaker; but, whether mentally or bodily, they are very slothful, so that they require constant watching. The daily wage of a workman is 4 to 6 pice; with which they receive the powder and tools supplied; yet job-work was only undertaken by experienced workmen. The gang at one face could not amount to less than four to six men. It was impossible to get the people to work uninterruptedly, so that a face 1½ fathoms high thus worked only advanced 0·8 of a fathom monthly.

14. *Prospects.*—Since 1862 great endeavours have been made in London to get up a limited company with £120,000 capital to work the Singhbhúm mines. The original company

had dissolved about 1859; its history was this: after Captain Haughton in 1854, in the Journal, As. Society, Bengal, had first called attention to the mineral treasures of the district, two Calcutta merchants resolved to start mines, and I went to Bengal by their instructions to make investigations and to establish the mining. When it was certified that at many places fine ore occurred a company was formed in 1857, having at its head the two original firms; and everything was then started on a very great scale. Mining commenced at Landu and Jamjura, and fine raw ore was turned out at the rate of 1,200 to 1,300 cwts. monthly. Other works were at that time not yet opened and in order; still already the erection of a foundry with steam engine at a great cost was insisted on: and consequently, after my departure, what was expected befell: there was not yet enough ore there for the supply of a large foundry; the company dissolved in 1859; and the stores, building, and machinery fell to a transferee at an insignificant price. So very costly a management had only accelerated the dissolution of the company. In India every administration is costly: here it was the case in a remarkable degree, as this single circumstance fully proves—Rs. 9,200 had to be paid yearly to the two rajahs of Ghatsilla and Seraikela, in whose land the works were situated, for the right of mining and smelting.

As above stated, since 1862 great exertion has been made to form a grand new company; and in the prospectus mention is made of my name with reference to my report to the former company, so I do not hesitate to declare that without further information than that already known and established—so long as nothing positive is settled regarding the continuation of the ore in depth—the formation of a company with a capital of £1,20,000 is unwarrantable. Ore, and very fine ore, is undoubtedly to be got; and the works already undertaken might be carried on to advantage in spite of the deficient communications, if with moderate expectations an economical enterprise be undertaken, but for this so colossal a company is not suited. If the works are to be again established, mining experiments should be extended before everything, and according to the results thus obtained such a company might be formed or not. No one could expect an exhaustive judgment from the works already accomplished, and considering the time spent upon them, the first surface labor took place in the end of 1855, and already in 1859 all was discontinued.

15. *Ancient mines.*—Almost wherever the deposit comes to-day and is not concealed beneath the alluvium one finds old buildings and refuse heaps, where there was formerly a mine. In spite of the rudeness of the mode of extraction the work must be admitted to have been sagaciously conducted. The ancients never went deep; sometimes hindered by the water which everywhere is reached below the level of the valleys, sometimes by the fear of working under ground. The use of powder in blasting must have been unknown to the people of that time, for I everywhere found in the old works, where open, single pillars undisturbed, very rich in ore, but in such hard rock as only to be won by blasting. The ancients seem to have smelted the ore in little furnaces on the spot, for one finds remains of walls, heaps of slag, and even copper bloom in many places. It is impossible to determine the age of the old workings; the heaps and fallen-in pits are mostly overgrown by thick jungle and covered by old trees; only here and there one finds large openings in the rock, at present the refuge of crowds of bats, whose dung covers the floor more than a foot deep; the cavity itself being converted into a beautiful green hall by a thick crust of malachite. If one asks the inhabitants when such work was in progress, they do not know; and they speak of 100 years with the vague ideas of Asiatics about time, representing thereby an arbitrarily long period. It seems to me, however, certain that the present half-wild inhabitants are not in a condition to carry out such works; and these may be the relics of an ancient civilization, like the rock-temples of the neighbouring Orissa, like the fruit trees (mango and tamarind) that one often finds as very old trees in the middle of the thickest forest; as again the remains of the great town Dulmi, which once stood in the thick woods of the Subanrika. Only one story has reached me of the ancient mines. Where from the lofty Sideshor, the ridges of Bindrabun, Ruamgurh, and Mahadeo descend into the valleys as spurs, one finds on Bindrabun extensive old diggings and pits, and on Ruamgurh slag-heaps and remains of brick walls. There, at Ruamgurh, a rajah of the name of Ruam must have lived and have made the diggings and houses. In the story this rajah is reported to have had two tongues,* so I must consider him as a person who spoke two languages, in fact a foreigner. The period may have been the 11th century, when the Kingdom of Orissa flourished.

* For another explanation of the two tongues, see a paper by Mr. Ball, Proc. As. Soc., Bengal, June 1869.

2.—On the Copper of Dhalbhúm and Singhbhúm, by V. Ball, B. A., Geological Survey of India.

The district of Singhbhúm, first brought to the notice of the British in the year 1820, when the internal disturbances rendered interference necessary, was not placed permanently under British officers until 1836. In the interval that elapsed between these two periods, the discovery of copper and ancient native copper mines appears to have been made.

The first published intimation of the existence of copper in Dhalbhúm was given in 1833 in a paper by a Mr. Jones* who was engaged in making researches regarding the coal of Bengal. He writes—"I have reason to suppose copper may be found in Dhalbhúm near Ragwaha (Rajdoha) in a stream called Gura Nadi that empties itself into the Subanrika." Whether this supposition, which subsequent investigation has proved to have been well founded, was based on information received from natives or from personal observation we are not informed.

In the year 1854, the existence of extensive copper deposits which had been much worked by the ancients in the above-named districts was forcibly impressed upon public notice by Captain now Colonel J. C. Haughton, Assistant to the Governor General's Agent in the South-West Frontier.†

In the same year the mines were visited by H. Ricketts, Esq., C. S., who proposed to Government that "a small sum be expended in working for a short period in order thoroughly "to test the produce and to show the people of the country how to turn the veins to the "best advantage."

M. Stœhr in the paper printed herewith details the circumstances under which he came out to this country and the steps which led to the formation of the first Singhbhúm Copper Company. Since his return to Europe, this company ceased operations in 1859; and a second, formed on the ruins of its predecessor, lasted only from 1862 to 1864, when it also was dissolved.

In 1857, M. Durrschmidt published a report (with a map) on the "copper mines of Singhbhúm." All the important part of the information is derived from Colonel Haughton and M. Stœhr. Some of the minor details would be of interest only to persons purposing to re-open the works. Speaking generally, this report takes a much more favourable view of the prospects of mining than was justified by the facts available at the time.

In the prospectus of the second or Hindostan (Singhbhúm) Copper Company, a number of analyses and opinions regarding the quality of the ore by various assayers and others are quoted. These or rather a portion of them will be found incorporated in the following pages.

The fact of the copper ores having been worked by the ancients has been above alluded to. It is probable that the greater number of old excavations enumerated in the table on p. 100 are of considerable antiquity. Elsewhere‡ I have discussed the reasons which have led me to the conclusion that the ancient workers were an early Aryan race called *Seraks*.

Within recent years a rude kind of working has been undertaken by the local rajahs and zemindars. But in consequence of poverty of the ore, flooding of the mines, want of labor (the pay perhaps being neither liberal enough nor regularly bestowed), or finally, as has sometimes been the case, sudden discovery on the part of the rajahs that their dignity was being compromised by the work, all such operations have been discontinued.

Geology.—In order to render the following account intelligible, it will be necessary to give a brief sketch of the geology of the district in anticipation of the full account of it, which will be published when the examination of the whole area shall have been completed.

The rocks of Singhbhúm, so far as they have been examined, are referable to two formations. The metamorphic, consisting of granitic and foliated gneiss, schists, &c., and the sub-metamorphic, consisting of slates, quartzites and schists, which latter are sometimes not lithologically distinguishable from those belonging to the metamorphic.

In Manbhúm, exclusive of the coal-fields, something less than four-fifths of the area is occupied by metamorphic rocks. In the remaining fifth at the south of the district the

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* Asiatic Researches, vol. 18, p. 170, 1833.

† J. A. S. B., XXIII, p. 103, 1854.

‡ Proc., A. S. B., June 1869, p. 170.

sub-metamorphic rocks are let in by an east and west fault; thence southwards they pass into the district of Singhbhúm, where they cloke round irregular areas of metamorphic rocks. The principal of these areas lies east of the station of Chaibassa. The rocks seen are coarse granitic and porphyritic boss-forming gneisses which are traversed by a perfect network of trap (diorite) dykes. This combination produces a very peculiar effect which, as seen from the top of a high hill, has been aptly compared to a chessboard. The walls formed of trap dykes constitute substantial boundaries between adjoining properties. North and north-west of Chaibassa there is another area of the same metamorphic rocks which is, however, free from trap or nearly so. A third small area exists near Khursowa, regarding which something will be said again further on. The appearance of the sub-metamorphic area is very different from that just described; it is characterised by being traversed by long ranges of hills with deep intervening valleys which correspond to the position of the softer varieties of rock of which the formation is composed.

The copper ores to which this account refers occur for the most part in a zone of schists whose geological position is situated near the base of the sub-metamorphic rocks. These schists form the northern flank of a broken spur of hills which leaving the Chota Nagpúr plateau strikes eastwards for a distance of 40 miles through the estates of the rajahs of Khursowa, Seraikela, and Dhalbhúm, then bending round gradually to south-east and ultimately to south, it disappears under the alluvium of Midnapur.

The principal ranges composing this spur are of quartzite, upon which incrustations of the copper salts are occasionally found; but the ore which has been worked is, with a few exceptions to be noted hereafter, associated only with schists.

Measured along the strike, these copper-bearing rocks extend for a distance little short of 80 miles. Copper ores have not been discovered west of Lopso; but there is no geological reason why they should not be found for many miles further in that direction in the Chota Nagpúr highlands.

In the tables appended an abstract is given of the principal facts which have been observed at the various localities in which the copper has been found. And in the accompanying map all these localities are indicated. M. Stœhr's paper contains all the available reliable information regarding the working of the mines.

The determination of the question as to the manner in which the copper occurs, whether in lodes or as a deposit, is one of no less difficulty than it is of importance. M. Stœhr holds the opinion that it occurs in lodes, though admitting that much may be said in favor of the opposite view. He describes the variable strength of the deposit itself and the interruption and separation of the outcrops which in some places are close to each other. Carrying out this view, he distributes the localities where ore occurs along two lodes which he calls the north and south. He alludes to the fact of the existence of particular beds of rock in the vicinity of the copper showing signs of excessive metamorphism which he considers to be due to local action; but he does not mention that the copper, if followed along its line of strike, is found to penetrate into areas occupied by rocks which are undistinguishable in their lithological characters from the most crystalline rocks occurring in the older series. Of course it may be that these, like the single beds above mentioned, have been affected by local metamorphism, possibly caused by the intrusion of granite, but the granite which occurs is not distinguishable from that which is often found in Bengal to alternate with well foliated rocks, and is therefore believed to be of metamorphic origin. Thus this circumstance, which might otherwise be used as a crucial test of the validity of the lode hypothesis, is itself so uncertain and fraught with doubt that it is a rather dangerous description of evidence to make use of in such a discussion.

In support of the view that the copper partakes of the nature of a mechanical or chemical deposit in the beds, there is the fact that the underlie of the ore as seen at the surface nearly always appears to correspond with the dip of the schists, and that sometimes the schists appear to be permeated throughout with the ore. Adopting this view for the moment, the following supposition would appear to afford a possible explanation of most of the phenomena with regard to the ore, which have as yet been observed. With the original materials of the sandstones and mudstone shales, which subsequently become metamorphosed into schists, the ore may have been either chemically or mechanically deposited. At some period the crushing and tilting up of the rocks, of which there is abundant evidence, produced cracks and possibly openings between adjacent beds, towards which a segregation of the copper particles which until that time were equally disseminated throughout the mass

of the schists may have taken place and continued until they became filled with ore and so given rise to the appearances which have been regarded as indicating the existence of lodes. If this view be correct then the highly metamorphosed rocks which occur in the otherwise uninterrupted strike of schists at Akarsuni and Kumerara must be derived from the schists by excessive local metamorphism. But if, on the other hand, these rocks belong to the older metamorphics which they certainly at first sight appear to do, then the lode hypothesis must be admitted to be true.

Reviewing the evidence on both sides, the legitimate conclusion to be drawn would seem to be that the copper of Singhbhúm in all probability occurs both in lodes and as a deposit disseminated throughout the materials which compose the schists. Similar cases of double conditions of occurrence are not unknown in other countries, as will be alluded to again further on.

Ores.

The ores of the upper part, or, as it is technically called the 'back' of the deposit, have all been converted into carbonates and oxides.

In assays made upon eight different qualities of ore by M. R. Schenck, and quoted in the Hindostan Copper Company's prospectus, the contained copper varies between 35·03 per cent. and 1·46 per cent. Three analyses by Messrs. Phillips and Darlington of specimens of carbonates gave the following results:—

No. 1.—Copper	31·5	per cent.	Silver	2oz.	5dwts.	17grs.	per ton of ore.			
No. 2.— „	6·26	„	„	1 „	2 „	20 „	„	„		
No. 3.— „	6·0	„	„	0 „	19 „	14 „	„	„		

Three other specimens were examined by Messrs. Howard and Dollman and gave the following results:—

No. 1.—18·8 per cent. of copper.
No. 2.—21·8 „ „
No. 3.—24·0 „ „

Three specimens brought by me from Jamjura yielded according to Mr. Tween's analysis—

No. 1.—Jamjura ore, copper = 52·0 per cent.
No. 2.— „ „ = 44·5 „
No. 3.—Dugni „ = 36·5 „

Nos. 1 and 2 were picked specimens, but No. 3 was the ordinary ore to be found at Dugni.

Messrs. Henry Bath & Sons, to whom some of the ores, smelted to a regulus, were sent in 1854, reported as follows:—"Our assayer has carefully tested the samples thou sent us; they contain about 50 per cent. of iron which makes them very difficult to smelt, and is also very prejudicial to their sale; we think, however, that the prices affixed to them may be obtained."

We are thy sincere friends,

HENRY BATH & SONS.*

Mining Office, Swansea, 8mo., 19, 1854.

No. 1.—Copper,	42	per cent.	£37	per 21 cwt.	
No. 2— „	41	„	35·15	„ „	„
No. 3.— „	39	„	34·2	„ „	„
No. 4.— „	36	„	31	„ „	„

The assays above quoted were of the carbonates or of grey-copper.

Copper pyrites occurs in the schists at Rajdoha; it was first found there by the second company; fragments of rock permeated with it are still to be found in the debris. It seems to have been little affected by the weather.

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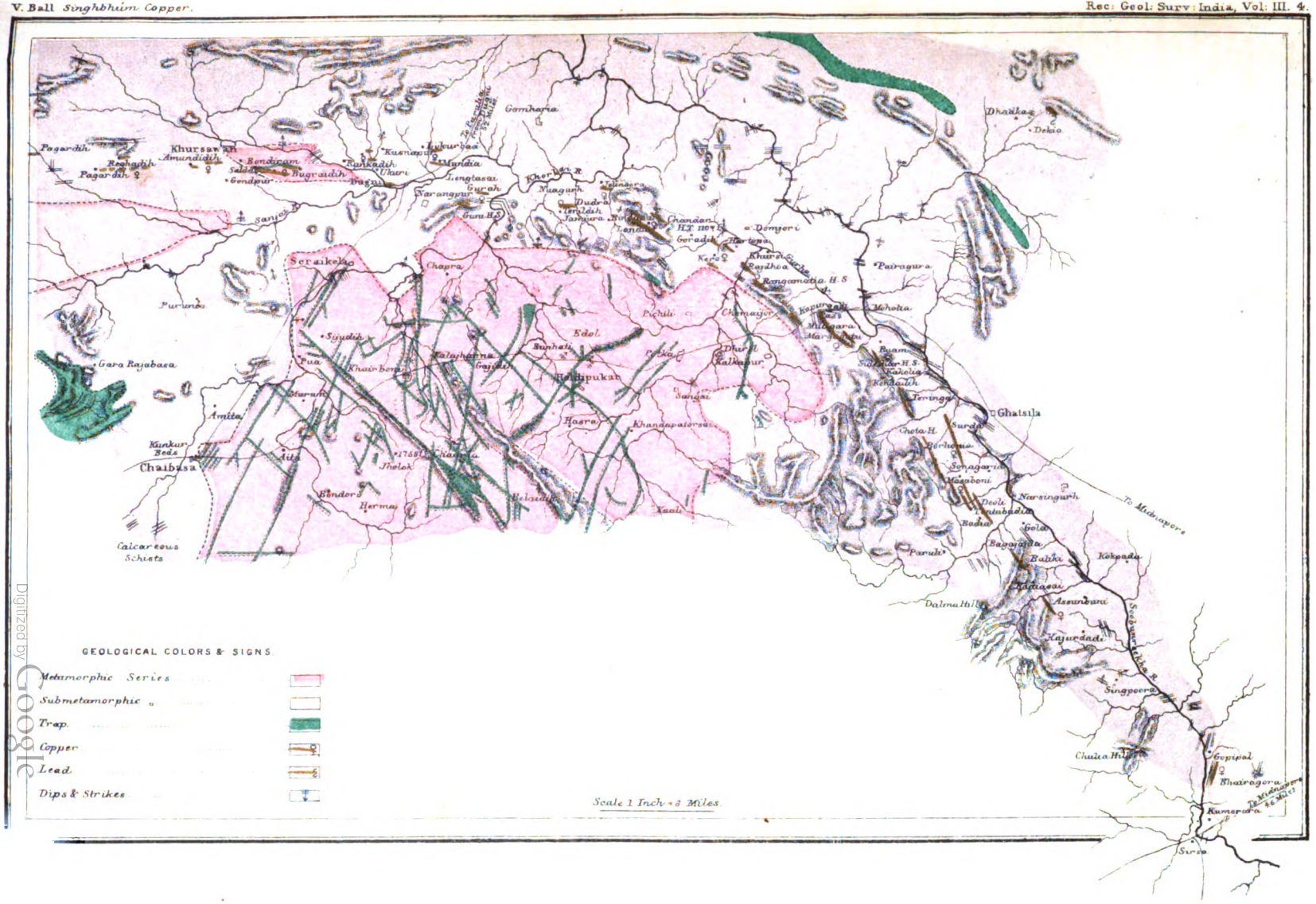
* Proceedings Asiatic Society of Bengal, XXIV, 1855, p. 706.

NOTE.—Of the minerals occurring in the schists, the following are the principal which have been met with: Garnet, Schorl, Kyanite, Chlorite, Tremolite, and Actinolite. In the hill Dari, which is formed of potstone underlying the schists, a peculiar indurated talc occurs in veins. The potstones are extensively quarried, and supply a plate factory in the neighbouring village. At Jamjura M. Stœhr discovered an interesting carbonaceous mineral, of which I also obtained specimens in the refuse heaps when I visited that locality; it is described in the Mining and Metallurgical Journal for 3rd June 1859.



Some of the manufactured copper was thus reported on at the Calcutta Mint:—

"Three slabs weighing about 139 lbs.; these were subjected to lamination and proved to be suited in all respects for purposes of coinage. The quality of this metal is excellent, being scarcely inferior to the best, equal to the average and decidedly superior to several shipments of imported copper."

(Sd.) R. BAIRD SMITH,
Mint Master.

As it is almost impossible at the present day, without excavating in the mines to a considerable depth, to obtain more than a few specimens of the carbonates or oxides of copper which lie near the surface or incrust the walls of the galleries, it is most fortunate that we are able to avail ourselves of M. Stœhr's researches and opinions. His presence during the mining operations and subsequent examination of the ores in Europe have afforded him the most favorable opportunities for ascertaining the precise nature of the ores obtainable in the deep mines.

It may be taken as a fact fully established by the analyses quoted above, that exceedingly rich ores of copper do occur in Singhbhúm. Before proceeding to the discussion of the practical question in reference to the possibility of working the ore with profit, it is necessary to allude to the—

METALS IN ASSOCIATION WITH THE COPPER.

It is a matter of the greatest importance to ascertain the proportion of other metals which ordinarily occur associated with the copper. Supposing the ore even not to contain a sufficient quantity of copper to make it pay to extract it alone, it might still, if it included precious metals, be worked with profit. Such is the case with the argentiferous ore or Fahlerz from Eisleben in Prussian Saxony.

In the assays of three specimens of ore by Messrs. Phillips and Darlington quoted above, the ounces of silver per ton of ore vary between 1 and 2¼. M. Stœhr found traces, but only traces, of gold and silver; while Mr. Tween did not obtain even a trace in some ores and smelted copper which I brought from Jamjura.

Small quantities of Bismuth were found in some of the ores.

Having in the previous pages pointed out the two-fold manner in which the copper ores occur—both in lodes and in beds—and their quality, the discussion of the practical question whether the ores are such as can be worked with profit in this country may now be entered upon. The facts and collateral circumstances which must influence a decision may be grouped under the following heads:—

I. Character of the ores and their mode of occurrence.

II. Experience of previous miners, ancient and modern.

III. Local circumstances.—Position of mines; Means of communication and distance of marts; Supplies of labor, fuel and lime; Proprietory; Climate.

IV. Comparison with other countries where ores of similar character and occurring in a similar manner have been worked.

I. Although rich ores exist, their mode of occurrence is so capricious and uncertain that working them must necessarily involve an enormous expenditure.

Ores of very much inferior quality if they occurred with a continuous unbroken lead which could steadily be followed up by the miners might, even under various unfavorable conditions existing in Singhbhúm, be worked with profit.

M. Stœhr distinctly speaks of good ore having been found at many points, but in nearly all cases an unusual richness of the deposit proved to be purely local and confined to nests which were speedily worked out, and unremunerative copper-permeated schist met with further down.

II. Many of the ancient mines have been so thoroughly worked out that it is often impossible to find more than mere particles of carbonate incrustations.

It may be argued with an apparent amount of plausibility that the ancient mines, their number and extent, indicate a prosperous condition of the industry at some former period. We do not, however, know under what circumstances they were worked. In the early times to which they seem chiefly to belong, copper may have possessed a value relative to the precious metals much higher than it does at present. And, again, although it may have paid parties of natives to work with their simple furnaces which could without loss be relinquished when the supply of ore failed and others be erected in a new locality, we cannot feel assured that it would prove proportionally profitable to a European Company, whose chief prospect of success would depend on the possibility of applying machinery for the extraction and reduction of the ore continuously in one place.

With regard to the experience gained by the companies, beyond M. Stœhr's and M. Durrschmidt's papers, there seems to be now no accessible information. Without being able to refer to the records of either of the companies, it is impossible to form any estimate of what their working expenses amounted to.

Copper was manufactured during the time of the second company and forwarded to Calcutta, but what proportion its price in the market bore to the cost of its production I have been unable to ascertain.

M. Stœhr's opinions on the first company and on the proposition to form a second are printed herewith. He concludes that notwithstanding the disadvantages, some of the old mines might be worked profitably, but for that purpose so colossal a company* was not suited. But *moderate expectations*, such as M. Stœhr speaks of, are not generally sufficient to attract speculators and capitalists; and a really economical enterprise such as might easily be carried out on the continent of Europe is scarcely practicable here.

III.—Local circumstances.—*Position of Mines.* On all sides the range in which the copper ores occur is surrounded by broken hilly country, which is drained by a number of rivers of sufficient dimensions to seriously impede traffic during the rainy season.

The only made road in the vicinity of the mines is the one between Chaibassa and Midnapur. It is unprovided with bridges: the portion of it in Singhbhúm and Dhalbhúm alone is (May 1869) in fair condition.

In reference to the roads, Colonel Haughton, who was anxious to represent the prospects of a mining enterprise in the most favorable light possible, wrote:—"From the digg-"ings at Kumerara† there is a good road only 85 miles in length to Tumlook. The distance "from Landu or Jamjura to the Cossye river at Dhee Kulliánpúr is about 70 miles; and that "river might, it seems probable, be available for water carriage during short periods in the "rains, as the Damúda is at points far above those where it is ordinarily navigable. There "is every facility for the construction of a good road to Dhee Kulliánpúr or to Midnapur, "and in fact there was formerly a Government route in nearly the same direction. * * * "The distance from Tumlook *viâ* Midnapur would be about 132 miles." The copper which was made in 1862-64 was not despatched by either of these routes but *viâ* Purulia to Raniganj, the distance of which place from Landu being 130 miles, and the roads little better than cart tracks.

Should the proposed direct line of railway *viâ* Midnapur to Bombay be opened up, the copper mines will probably be rendered much more accessible than they are at present.

Labour.—Coolies can be obtained in abundance. The Chota Nagpur Dhangas were found to be the best workmen.

Fuel.—The supply of wood to be obtained in the immediate neighbourhood is limited, and a few years would exhaust the timber on the hills composed of the copper-bearing rocks. There is, however, a considerable amount of heavy timber on the rises to the Chota Nagpur plateau.

The discovery of coal at Midnapur is a fact which may prove favorable to the prospects of working the copper with profit.

Lime.—The only lime which was used for fluxing the ore was manufactured from 'kunkur.' No hope of any more regular or economical source can be held out at present. Some calcareous schists do, indeed, exist near Chaibassa, but in them the quantity of other minerals mixed up with the carbonate of lime is so great as to make it doubtful whether they could be successfully burnt for lime.

* The capital of the 2nd or Hindostan Copper Company was £120,000 in 24,000 shares.
† The most eastern locality.

Proprietory.—Singhbhúm proper belongs to several members of the Porahat family, of whom the principal are the Koer of Seraikela and the Thakúr of Khursowa; they both give service to Government as Magistrates, but pay no tribute whatever for their estates. The Dugni Baboo in whose lands copper also occurs is a cadet of the same family.

In the estate of the Rajah of Dhálbhúm, the remainder of the copper localities, including those at Landu and Rajdoha, are situated.

The first company, confident in the productiveness of the mines, agreed according to M. Stœhr to pay the Rajahs of Seraikela and Dhalbhúm Rs. 9,200 for the right to mine. In the prospectus of the second company the annual rent is stated to be Rs. 4,500. A considerable portion of this rent for the years while operations were being carried on is still due. Acting on a decree of the Singhbhúm Deputy Commissioner, the Rajah of Dhalbhúm has seized the houses and engine of the company at Rajdoha; but the former have already fallen to pieces, and the latter uncared for and neglected will soon become worthless.

Climate.—The climate of Singhbhúm is decidedly unhealthy; this point is one of no small importance where a number of Europeans might have to be employed. I have been informed that the employés of the two copper companies suffered much from fever. My own experience is, that natives of India, especially men from the north-west, suffer excessively from fever in Singhbhúm; of course both Europeans and natives might, to a certain extent, become acclimatized, as has happened in other parts of India.

IV.—Examples are not wanting in other parts of the world where ores of similar character and mode of occurrence to those of Singhbhúm have been worked, with which a brief comparison may be usefully instituted.

Copper Mines of Eisleben.—At Eisleben in Mansfeld, Prussian Saxony, the ore of copper extracted permeates a schist (Kupferschiefer) which can be worked with as much regularity as a coal seam.* Notwithstanding the perfection of the machinery and the comparative ease with which the ore is extracted, it is a fact that the copper is manufactured at a loss. "Every ton of refined copper as it leaves the works has actually cost more than an equal weight of metal could be purchased for on the spot from the merchant."

The profits of these great and unique mines (which more or less directly support 60,000 people) are nearly all derived from the small proportion of silver which occurs in the ores and is extracted during the process at but little additional cost. The magnitude of the operations and the immense quantities of the copper ore which are smelted alone enable the work to be carried on with profit.

In the copper ores of Singhbhúm silver does sometimes occur as is shown by the assays on page 96. But the amount is so small that it is extremely doubtful whether it could be extracted with profit.

It has been stated that *for the most part* the underlie of the ores in Singhbhúm corresponds with the dip of the schists; but it can scarcely be said of them, owing to their steep inclination and irregular lateral extension, that they could be 'worked like a coal seam.'

South-West of Ireland.—In the south and south-west of Ireland copper ores occur disseminated throughout a zone of Devonian sandstones; for a long time it was doubted whether true metalliferous lodes existed, all the copper being supposed to occur "as a mechanical deposit derived from the waste and destruction of some original mineral vein district."† Recent deep mining operations which have been carried on with success have proved the existence of true lodes.‡ Thus there would appear to be a double mode of occurrence of the ore there, similar to that which has been supposed to be the case in Singhbhúm.

In the preceding pages the object sought after has been to give a simple statement of facts, from which those who may be interested will doubtless draw their own conclusions.

In mining operations such as would be necessary in Singhbhúm so much depends upon the regularity with which the ore occurs that no one could with any confidence venture to predict the result of excavation on a large scale.

Courageous enterprise guided by the best professional skill in mining has both its triumphant successes and its heavy losses and disappointments: until underground exploration has extended much further in Singhbhúm, it will be uncertain which fate awaits those who may at any future time venture upon copper mining in that district.

* These mines are fully described in a paper by Mr. Jervis, Jour. Soc., Arts, vol. IX, 1860-61.
† Memoirs of Geological Survey of Great Britain and Ireland, explanations to sheets 200, 203, and pp. 278.
‡ Geological Magazine, vol. VII, No. 5, p. 241.

COPPER ORES

Proprietors.	No.	Localities East to West.	Number of Mines.	Nature of Mines.	Dip or Underlie.
Rajah of Dhalbhdm.	1	Madhopur, 3 miles north of Kumerara.	2	Outcrop excavations ...	.....
	2	Hills, W. of Asunbuni	Numerous ...	Ditto ...	40° E. N. E.
	3	Hills, S. E. of Badia	.....	.....	.....
	4	Badia	Very numerous ...	Ditto and shafts ...	40° to E. 25° N.
	5	Mosabuni	Numerous ...	Outcrop excavations ...	Ditto ...
	6	Surda	12	Ditto ...	?
	7	Hills, W. & W. N. W. of Surda ...	Numerous ...	Quarries, shafts, inclines	40°
	8	Hills, W. of Teringa & Kendadih ...	Ditto ...	Outcrop excavations & inclines.	30°-35° E. N. E.
	9	Sideshur Hill, S. of Ruam... ...	3 or 4	Ditto & shafts ...	35° N. E.
	10	Mahadeo Hill	.....	.....	.....
	11	Baghghura	Several ...	Inclines ...	.....
	12	Hills, S. & S. W. of Matigara (=Raga of Dr. Stœhr).	Numerous ...	Ditto & shafts ...	N. E.
	13	Rangamatti Hill, S. E. corner, N. of Banjo.	1	Shaft	.....
	14	Rajdoha a	1	Incline and adit ...	.....
		Ditto b	1	Incline	25° N. N. E.
		Ditto c	1	Shaft	Ditto ...
		Ditto d	1	Incline	Ditto ...
	15	Matku	1	Shaft	.....
	16	Hurtopa	1	Ditto	.....
	17	Hitku	1	Ditto	.....
	18	Landu Barut-ghur Hill	Numerous ...	Shafts, inclines, adit, trench.	35°—, 55° to 10° E. of N.

OF SINGHBHÚM.

No.	Ore.	Rock.	Remarks.
1	Traces of carbonate: a specimen yielded according to Col. Haughton 24¾ p. c. of copper.	Quartz and black mica-schist, strike 10° E. of N., granite close by.	These mines are full of water, to remove which and renew excavation would be necessary before the condition of the ore could be ascertained.
2	No traces of ore *in situ* ...	Black and grey mica-schists ...	Slag close by, indicating that ore was once found.
3	.....	.....	This locality is given by M. Stœhr.
4	Traces of carbonates abundant.	Grey and black mica-schists, strike 25° W. of N. Towards Mosabuni gneissose rocks strike more to north.	The relative positions of the Badia excavations indicate four distinct outcrops of ore. The principal of these passes through the village of Badia, near which are great heaps of slag. This was evidently a centre of extensive operations.
5	Ditto.		
6	No trace of ore at present exposed.	Schists.	
7	Incrustations of the carbonates on the walls.	Black mica-schist	From the abundance of slag it would appear that here, as at Badia, considerable quantities of ore must have been smelted by the ancients.
8	Traces of carbonates rare ...	Mica-schist.	
9	Ditto slag abundant ...	Ferruginous mica-schist ...	At the site of the old town of Ruam, there are several tanks covered up by jungle and immense quantities of slag.
10	.....	.....	This locality is given by M. Stœhr.
11	Ditto ...	Mica-schist.	
12	Ditto ...	Ditto	A number of deserted potstone mines and some which are still worked occur along this range.
13	Traces of carbonates ...	Ditto & quartzite ...	Incrustations of the carbonates and black oxides occur on the quartzites forming the main axis of the hill.
14	Ditto ...	Slaty blue schists	These are situated on a spur of Rangamatti.
	Ditto ...	Ditto ...	These were worked by the Copper Company. But the pyrites was only just reached a short time before working was discontinued; d is west of the river, b and c being to the east.
	Copper pyrites	Ditto ...	
	Traces of carbonates ...	Ditto ...	
15	Carbonates, traces of red copper and pyrites.	Greenish talcose schist and quartzo-felspathic grit.	
16	No ore seen	Quartzite.	
17	Traces of carbonates ...	Schist and quartzite	Originally commenced by the ancients; it was deepened by the Company, but has subsequently become filled up.
18	Ditto ...	Quartz and mica-schist much contorted and baked. Banded jaspery quartzites close by.	A considerable amount of ore appears to have been obtained here by the Company. M. Stœhr's papers give the details of workings carried on at Landu.

COPPER ORES OF

Proprietors.	No.	Localities East to West.	Number of Mines.	Nature of Mines.	Dip or Underlie.
Rajah of Dhalbhúm.		Landu Chundra Hill b	Numerous ...	Inclines	35°, 55° to 10° E. of N.
		Ditto Hill, N. of Turamdih c	Ditto ...	Ditto	40°—50° N., or 10° E. of N.
		Ditto Hill, N. of Tulsa d ...	Ditto ...	Ditto and adit ...	40° N.
Koer of Seraikela.	19	Jeling { gora ... ... / bera	2	Shaft and incline ...	?
	20	Jamjura (*Tschamtschura* of M. Stœhr)	Several ...	Shafts	.....
	21	Gura	0	.....	.....
	22	Tamba—dungri	6 ?	Shafts	25° N.
	23	Saldih	1	Ditto	N. N. W. 50°
	24	Múndrú	1	.....	N. N. E. 40°
	25	Dúgni	0	0	60° N.
	26	Ukri	1	Outcrop excavation ...	,,
	27	Komulpur (Banksai)	1	Ditto ...	?
Thakúr of Khursowa.	28	Akarsúni a	Several	Ditto ...	N. W.
		,, b	1	Ditto ...	?
	29	Podumpur	2	Ditto ...	?
	30	Regadih	4 (a-d)	Ditto ...	?
	31	Lopso Hill	1	Ditto ...	40° N.

SINGHBHÚM,—*(Continued).*

No.	Ore.	Rock.	Remarks.
	Traces of carbonates ...	Schist.	
	Ditto ...	Contorted talcose quartzite and micaceous schists.	These works were chiefly made by the Company, but all along the outcrop of the schists there are ancient excavations. In one place the ore permeates 6' of rock.
	Ditto ...	Ditto ...	The mines here were worked by the Company.
19	Ditto ...	Talcose and mica-schist.	
20	Ditto and grey copper.	.....	These shafts were worked by the Company; one of them fell in while the operations were going on.
21	Traces of carbonates ...	Schist	No mines opened at this locality.
22	Ditto ...	Sandy and fibrous mica-schists	Shafts in very irregular positions and without reference to the lie of the deposit.
23	No trace of ore ...	Mica-schists.	
24	Ditto ...	Soft satiny felspathic and talcose schist.	Said to have been excavated by the father of the present Baboo of Dugni, Rungit Singh.
25	Traces of carbonates ...	Mica-schists	This is situated in the village of Dugni; there has never been any excavation.
26	Ditto abundant, a specimen yielded 36·5 per cent. of copper.	White talcose mica-schists and granitic gneisses.	Said to have been worked with profit by the Dugni Baboo about three years ago.
27	Ditto ...	Schists and gneiss.	
28	Traces of carbonate ...	Schists, granitic gneiss and trap close by.	A series of excavations in the fields are nearly filled up with surface soil.
	Ditto ...	Ditto.	
29	Ditto ...	Mica-schists and quartz ...	Rocks much covered; no strike apparent.
30	Ditto ...	Micaceous and quartzose schists, also gneiss and trap close by (c).	Copper is said to have been manufactured from ore extracted from (d) twelve years ago.
31	Ditto ...	Coarse mica-schists	Situated at foot of the hill west of Kanrudih.

V. BALL,
Geological Survey of India.

METEORITES.—During the past quarter we have received an addition of four specimens of meteorites, representing 3 falls, of which no specimens existed in the Calcutta collections previously.

1st.—From DR. TSCHERMÁK, the present zealous Director of the Mineral Cabinet at Vienna, came a very perfect, though not large, specimen of the fall at Hessle, near Upsala, which took place on the 1st of January 1869. And a very good specimen of the remarkable stone-fall which took place at Kernouve, Napoleonville, Morbihan, France, on the 23rd May 1869. 2ndly, from PROFESSOR DAUBREE, Paris, we have received a fine specimen of the meteoric iron from Deesa, Chili, peculiarly interesting, not only for the breccia-form structure which it presents (recalling the Tula fall), but for the occurrence in it of very well marked crystals of *Enstatite, colourless and transparent* and of a purity not hitherto met with, also crystals of *Peridot*, of *Schreibersite*, and of a lamellar substance closely allied to *Hypersthene*. And also a second smaller specimen of the Kernouve (or Cleguerec) fall of the 23rd May 1869. These were all in exchange for specimens of Indian falls.

T. O.

DONATIONS TO MUSEUM.

From COLONEL H. C. JOHNSTONE we have received a box of fossils collected by him in the Sulyman Range. There has not been time as yet to examine these in detail.

ACCESSIONS TO LIBRARY

FROM 1ST JULY TO 30TH SEPTEMBER 1870.

Titles of Books. *Donors.*

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RECORDS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

VOL. IV.

PUBLISHED BY ORDER OF HIS EXCELLENCY THE GOVERNOR GENERAL OF INDIA IN COUNCIL,

UNDER THE DIRECTION OF

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1871. [February.

Annual Report of the Geological Survey of India and of the Museum of Geology, Calcutta, for the year 1870.

Since the publication of the last annual report, the year now just passed has enabled the Geological Survey of India to make considerable progress in the careful examination of the country.

Taking the several districts in succession, I shall briefly refer to the progress made in each.

In the first place, it is necessary to notice the numbers with which the survey has been carrying on its labors, as the area which can be examined very seriously depends upon this. The vacancy in our staff caused by the lamented death of Mr. C. Æ. Oldham in 1869 had not been filled up, as no qualified person could be obtained at the time. And the absence on leave of Messrs. King and Mallet, neither of whom returned till just at the close of the year, left the staff of the survey diminished by three of its most qualified members for the whole twelve-months. Early in the season also, Mr. Ormsby, who in the previous year had been obliged to proceed to Europe in consequence of the effects of sunstroke, but had returned apparently restored, again felt the serious effects of exposure, and was obliged to leave the field rather earlier than usual. He was able to do some work in office, but gradually sank and succumbed to the effects of the attack and exposure in June last. Since March also, Mr. Fryar, specially sent out for the compilation of the mineralogical statistics of the country, has been placed under the orders of the Central Provinces Government for mining purposes, and has not in any way contributed to the progress of the Geological Survey. We have thus in reality been working during the year with only three-fourths of the full sanctioned numbers on the staff of the survey. Mr. King was obliged to seek extension of leave from ill-health in England, and Mr. Mallet was authorized to proceed on special duty counting three months as service, in addition to his furlough. Thus, neither of these gentlemen was back until quite the end of the year. Dr. W. Waagen joined the survey, to fill the vacancy in our numbers caused by the death of Mr. Oldham in 1869, about the middle of December, and has since then been most zealously engaged in the preparation and examination of the fine collection of *Cephalopoda* made during the last two years in Kutch.

It has been my duty on many occasions to point out the great delay and loss of work which result from such changes in the staff. There is no source in this country from which properly qualified assistants can be obtained for the Geological Survey. In truth, Geology is nowhere taught in this country, and assistants must be sought for in Europe, where such sciences are cultivated. The numbers, however, from which they can be selected are small. Those who have proved themselves competent readily and rapidly find employment at home, where the terms of retiring allowances and of pay are much more favorable, under the circumstances, than are offered out here. And it is only possible occasionally to procure the

aid of really trained and qualified assistants, who, either from a desire to see the geology of countries they could not otherwise hope to be able to visit, or from other causes, will venture to face the difficulties, hardships, and perils of a geologist's life in this country. Such a description may appear to some highly coloured, and that geologists have no more reason than others to be anxious on the score of health. I have, however, often had occasion to point out some of the causes of this—that geologists are compelled not only to visit for an hour or two, but often to remain camped for days in the very wildest, most inaccessible, and most inhospitable parts of the country. These are precisely the places most likely to afford them sections, and thus to give a clue to the structure of the district; but they are also the most dangerous. The serious losses which the survey has experienced since its commencement amply prove the truth of this. But perhaps the most convincing proof, that we are not alone in this view, will be to quote the deliberate opinion of Assurance Offices, who have had the whole facts carefully enquired into by their medical officers, and who acknowledging that there is no objection on any other ground to accept insurances on the lives of officers of the survey offered to them, yet decline to do so, stating that "no premium whatever would cover the risk."

And, further, when new assistants have been obtained, a considerable time elapses before they acquire a knowledge of the languages of the country and an acquaintance with the peculiar arrangements necessary for tent-life and marching in this country, so that they must necessarily be for some time placed along with others, and cannot work independently.

Mr. H. B. Medlicott, Deputy Superintendent, devoted the early part of last year to the careful and detailed examination of the country near Mopani, the site of the Narbadda Coal and Iron Company's collieries. When this area was originally visited and mapped out (in 1856-57) there were no maps whatever on which to record the observations of the survey. A general compass-sketch was very successfully carried out by Mr. J. G. Medlicott, then engaged there, and on this, on the scale of four miles equal one inch, the structure of the country geologically was represented and published (Mem., Geol. Surv., India, Vol. II). No one could be more fully aware of the imperfections of this sketch than those who constructed it; and we, therefore, looked forward anxiously to the completion of the detailed and careful maps of the regular survey. The operations of the revenue survey under Colonel J. E. Gastrell had been extended to that part of the country, and at the close of 1869 we were enabled, by his kindness, to obtain maps of part of the district, even in anticipation of their publication. These were just sufficient to enable us to take up the re-examination of the field, which the progress of railway communication, the opening out of the line in the Narbadda valley, and the general increase in the demand for fuel, rendered so immediately important. This re-examination Mr. Medlicott personally commenced, and the results, so far as the Mopani field is concerned, have already been published (Records, Geol. Surv. of India, Vol. III, August 1870). It is intended to carry on the careful examination of all the country which affords the least prospect of yielding coal or other valuable minerals in that neighbourhood as the detailed topographical maps become available.

At the commencement of the present working season, Mr. Medlicott took up the revision of the geological maps of the Jhansi, Lullutpur, and Saugor districts, prepared by Mr. Willson and others, with a view to their publication. Completing this, Mr. Medlicott will return to the Narbadda valley.

Mr. W. L. Willson has been engaged during the whole of the year, and still is engaged in completing the examination of the country just referred to, and extending northwards to the Jumna, by Calpi.

Mr. Hacket has been examining the Jabalpur country, with the advantage of the recently completed detailed maps to record his observations, and I hope the present season will see this district completed.

Mr. Ball, as stated in last year's report, was deputed to revise the maps of the Rajmahal hills, which are now ready for publication, so soon as the copper plates of the sheets of the Indian Atlas can be obtained from England and the maps transferred to stone for the geological lines. In the present season Mr. Ball has proceeded to the south of the Chota Nágpúr country and Sirgujah, with a view to determine, at least approximately, the boundaries of the extensive spread of coal-bearing rocks which there occur. For a large portion of this country maps are now for the first season available. But there are still important gaps, for the plans of which we shall have to wait for some time. Still it is hoped that we will be able to fix the boundaries with, at least, approximate accuracy over a very considerable area. Progress in these districts is unavoidably slower than elsewhere. Much of the country is without a road at all, and much of it is accessible only with elephants.

In the early portion of the year, Mr. Ormsby had completed the revision of a large portion of the Bhaugulpore country. But his illness, and lamented death, prevented the final completion of the maps of that area.

Mr. Mallet, who rejoined the survey towards the end of the year, has resumed the area on which he was last engaged, *viz.*, the southern parts of Mirzapúr and the adjoining parts of Rewah, &c., in the same valley. These are said to be rich in mineral wealth; and we are now for the first time able to take advantage of the recently completed maps of Rewah, &c., and to use them as records for the geological observations. Mr. Mallet had, on his return from Europe, been ordered to stop at Aden, and examine Aden and the country lying to the north of it between the peninsula and the hills with a special view to determine whether the principle of Artesian wells could be applied there with any prospect of success, in order to increase the supply of good water to the cantonments. Mr. Mallet's report on the geological structure of this country will shortly appear in the Memoirs of the Survey.

In Madras, by the absence of Mr. King and the death of Mr. Oldham, the party of the survey was reduced to only one, Mr. Foote. He completed the geological mapping of a considerable area of country, stretching along the valley of the Upper Kistna and adjoining area. Here the chief object has at present been to determine, on the one side, the outline of the great Deccan trap rocks, which have overflowed all the earlier formations, and cover them with a thick and nearly continuous spread of old volcanic lavas and muds, and, on the other hand, to fix also the general boundary of the immense area of fundamental gneissic rocks which constitute the basement rocks of everything else. Between these two, various other series crop out irregularly, and it is important to determine what these may be. This is the position which the coal-bearing rocks of India, among others, occupy, and there seem no sufficient reasons, *a priori*, why detached portions of these should not occur along the boundary in its south-western corner, as well as on the north-eastern. Hitherto no trace of them has been found, but, of course, we can only speak with any certainty regarding that portion which has been examined. Mr. King, who has recently returned from leave, has now rejoined the Madras party, and has taken up the continuation of the same boundary lines to the north by east, and will, I trust, during the present season, be able to carry his geological examination at least as far as Koolburga, while Mr. Foote will more especially extend his enquiries by the south and west to the Belgaum area, so as to join his lines with those already mapped some years since by Mr. Wilkinson in the Kōkan and southwards to Goa.

At the commencement of the year, Mr. W. T. Blanford was actively engaged in the detailed examination of the Berars and of Chanda district, and had nearly completed the portions of the Berars lying north of the Pem or Pein river. He was then specially diverted from this to visit and obtain a general idea of the extent and value of the coal-fields which had been for more than thirty years known to exist in Bilaspur, near Korba, &c. No topographical maps of this country, excepting in small detached areas, had been published up to date, and a detailed examination was, therefore, impracticable. I believe it was the late Colonel Ouseley

who first announced the existence of coal near this place, (as 'discovered March 14th, 1840,') and the fact had been noticed in all maps issued subsequently. The place had also been visited by several Forest Department Officers and others, and it was well known that coal was visible in detached localities extending over a considerable area. And although not having survey maps to work with, the Geological Department could not, in obedience to the instructions they had received, take up the examination in detail, it was highly desirable to obtain a general idea, with some accuracy, of the extent and probable richness of these coal-fields. The vast importance of these fields, whenever a direct line of railway to connect Bombay and Calcutta might be brought into operation, had more than once been insisted on by myself and been most strongly urged. Mr. Blanford, therefore, proceeded there, and the results of his general examination have already been published. It is needless to enter here on the details, which will be found in the May number of the Records of Geological Survey of India, 1870. It will suffice to say that Mr. Blanford satisfied himself of the existence of very thick and extensive beds of coal, yielding fuel of fair quality in abundance, and covering a large area. He also traced out the continuance of the same rocks with coal far to the eastward, and in the country lying between Korba and Ranchi, in Oodeypore (Udipúr), Jushpúr, &c.

Mr. Blanford was also requested to take advantage of his being in that vicinity to examine the lead vein, reported, by Mr. Smart of the Revenue Survey, as occurring at Chicholi near Raipur. This would appear to hold out promise of being valuable. At least there is nothing in the appearances inconsistent with the occurrence of a good vein of lead and copper ore below the surface. But as the place has not been opened out, and no works have as yet been undertaken on the lode, it is impossible to determine accurately its value from surface examination (Records, Geol. Surv., India, 1870, pt. 2, p. 44). The yield of silver in the lead ore proved equal to 9 oz. 19 dwts. to the ton of lead. All this country is, however, at present so difficult of access and so entirely without the means of free inter-communication with adjoining districts that no extensive works for the economizing of these valuable mineral products could be undertaken with any prospect of success. There is an immense area here of country very rich both agriculturally and mineralogically which must remain unimproved until its communications be extended, and it be brought into contact with the ports of shipment and the more populous territories lying both east and west of it.

Mr. Hughes was, during the whole of the early part of the year, engaged in the careful examination of the coal-bearing rocks of East Berar and Chanda, and is still carrying out the same. After I had myself left these fields at the beginning of March, I entrusted the sole determination of the proper localities for boring operations in the Berars to Mr. Hughes, and with the aid of Mr. Bateman Smythe, who had the actual work under his control, most successful progress was made in tracing out the continuous extension of the thick beds of coal up close to the northern extremity of the East Berar district. The monsoon having put a stop to these borings for a time, as there was nowhere in the district where good shelter could be procured, the tools, &c., were all removed to Yeotmahal, all repaired and rendered useful again. And on the opening of the season, Mr. Smythe at once commenced other borings, and found the coal at or near the village of Pepra or Pipar in the north-west of the field, and subsequently near to the river Wurdha, close by the village of Suini, or Sewnee, which lies west by north of the town of Wurrora, about seven miles. This is the most northerly point at which the coal has been as yet proved in these fields. It is in a right line not more than 35 or 36 miles from the station of Wurdha, on the Great Indian Peninsula Railway. Under Mr. Hughes' direction, Mr. Smythe, having thus carried up the coal to the extreme north limit of the Berars at this part of the boundary, has since commenced testing the extension of the coal more to the west, and with a view to prove whether it continues under the overlying trap rocks, has commenced boring to the west and north of the former sinkings.

The continuance in almost unbroken extension and in thick beds, at no point more than 70 yards from the surface, of coal, easily accessible, and abundant throughout almost the entire length of the Wun district in East Berar along the valley of the Wurdha, has been thoroughly established by the Geological Survey in a portion of one season's work. Not a single boring has failed under Mr. Smythe's charge, or Mr. Heppel's, while so engaged. And sufficient is now known to justify the actual commencement of sinkings and establishment of collieries with a certainty that they can be conveniently placed for working. Mr. Hughes has shown much judgment and skill in fixing the localities for these borings since I left, and has been very successful in working out the geology of the district.

Mr. Fedden, during the same time, was mapping in the area covered by the trap rocks to the north, north-west, and west of the coal-field, so as to fix accurately their boundaries in the vicinity of the coal-measures. There is a very large area to the north which has not been yet visited. And this work is being continued in the present season.

More recently the recurrence of the coal-bearing rocks to the north of the area covered by the outlying portion of these great trappean flows near to Wurrora has been pointed out by Mr. Fedden and at once communicated to the Central Provinces Government, so that trial borings may be carried out in that locality. It is near Khandalla, a village about 5½ miles nearly due north of Wurrora. This area had escaped the notice of the party who have been boring all the season close to Wurrora town.

In the number of these Records for May 1870, I gave a brief sketch of the knowledge which had then been obtained of the structure of the coal-fields in that part of the country. Since then there has only been little more than a month's work, so that there has not been much addition to this knowledge. At the close of last April also, I am happy to say the charge of the actual trials and borings within the area of the Chanda district was transferred to the Government of the Central Provinces, and for any explorations made in that area since then the Geological Survey is not responsible. Before leaving the field for the monsoon recess, Mr. Hughes pointed out a proper locality for boring near the town of Wurrora, south of the trap rocks already spoken of, and coal has been found near there. I had also stated in the report alluded to, (Records, Geological Survey, India, 1870, No. II, p. 43,) that a boring would probably be required in the vicinity of that town. I am informed that some fourteen or sixteen borings have been undertaken there, and that coal has been proved in three or four. It proves to be, exactly as was anticipated, irregular and less abundant than in the adjoining territories.

As there would seem to have been some misapprehension as to our views, arising from a hasty reading of the expressions in the report referred to, it may be well here to refer again to the statements made. In calculating the area under which coal could fairly be estimated to extend, the portion of the district covered by the thick flows of the trappean or volcanic rocks was rejected from any present consideration, because it was said, "this "thickness of trappean rocks effectually conceals everything beneath them, and, looking to "the great irregularity with which the coal rocks are overlapped, and the impossibility of draw- "ing any sound conclusion either as to the place or depth below the surface at which coal might "be found, fully justifies our putting the entire of this area out of calculation in estimating "the extent or quantity of the coal in these Wurdha-river fields. A boring will be put down "to the north of this large area of trappean rocks, where the lower beds are again visible "over a small area near Panjoorni, a village about six miles north-west of Wurrora, and pro- "bably near Wurrora itself," (that is, to the south of the same area). "But with this exception, "there will be little use in testing the rocks further on that part of the field *at present*. It "is not at all intended to assert that the coal group does not extend under a considerable "part of this area, but if it does so extend, the chances of finding it are so uncertain, and "the depth at which it probably occurs so doubtful, and in any case so much greater than in

"adjoining areas, that *for the present* at least the coal, even if found, could not be worked "to the same advantage or economy as elsewhere." Nothing can be clearer than that it was anticipated that coal would be found near Wurrora to the south of this area of trappean rocks, and again possibly near Panjoorni to the north of the same area.

It is the more necessary to point these facts out, because geological maps of this part of the country have been published since then in public documents which entirely misrepresent the true state of the case, but for which the Geological Survey Department is in no way responsible. This area of trappean rocks, which is most obviously an outlying or separated portion of the immense extent of overflowing volcanic rocks, which cover some thousands of square miles of the Deccan, and close to the general boundary of which this area lies, is stated to be of "trap rocks coming up through the sandstone" in one case* and is represented as a "trap dyke" in another.† Any geologist will at once see the vastly important difference in the two views here alluded to. In the one there is not only a chance, but almost a certainty, that the coal will be found under a part at least of the area covered at the surface by these rocks, (though we still think this may better be put out of any calculation for the present,) while, in the other, everything would be cut off, and there would be no prospects of proving the extension of the coal-bearing rocks at all. The same maps, which are issued in a way that might lead to the supposition that they had been furnished by the Geological Survey of India, represent the structure of the country very erroneously more to the south. I am not aware of anything to justify the extension of the Tálchír rocks in a broad belt across the entire field up to the crystalline boundary on the east, and I believe there is no foundation for this representation. Certainly no such idea is held by the Geological Department, which is in the same paper stated to have been working out the structure of the field, and which might, therefore, be supposed to hold the views represented on these maps.

It had been my intention to prove the detached areas of sandstones near to Nágpúr during the past season. This could have been done without interfering with the real progress of other enquiries. I am not aware that anything has been done in this direction.

In the report referred to on the 'Wurdha river coal-fields,' I pointed out that so far as information had been obtained up to that date, there appeared to be no question that any line of railway to these fields, if laid out with the object of commanding the widest area and largest amount of traffic for a given outlay, ought certainly to be carried into the Berar country. And there has been nothing since discovered tending in any way to modify this opinion. There is coal, and enough to supply the demand, in the Chanda district. But it is neither so conveniently placed, nor so continuous, nor so economically workable, as in the Berar district. While the latter has the very great collateral advantage of opening out one of the richest cotton districts in India, whereas there is little or no cotton, comparatively, in Chanda, and the nature of the soil precludes any hope of much extension of its cultivation. It would certainly appear an *almost necessary* consequence of the geological structure of the country, that any line, intended to accommodate the largest amount of traffic in these two staples—coal and cotton—*must* be carried on the right bank of the Wurdha river, at least south of the junction of the river Wunna. Any tonnage of coal likely to be required from these fields would be common to either line, while the very large cotton trade of the rich districts of Berar, Edlabad, and all to the south, can only be accommodated to any useful extent by a line passing into, or through, East Berar.

In connection with the examination of these important fields, it is only a matter of justice to the officers of the Geological Survey to point out that, at the first, it was estimated that four years would be required to explore fairly and to determine properly the value of

* Report of Administration of Central Provinces, 1869-70, p. 70, Map. The workings of the Geological Survey Department have never been, as here stated, under the direction of Mr. M. Fryar.

† Mining Journal, London, October 8, 1870.

the coal-fields, with the full staff sanctioned for the purpose, while not more than one and a half years have already elapsed since a commencement was made. And during even this time those engaged have been diverted to other work. It seems to me not only rash, but positively obstructive, to hurry on to conclusions, which must be as imperfect as the data on which they are based. The topographical maps of all the field are not even yet published, and without these no good geological map can be constructed. Still the greater part, if not all, of East Berar has been examined, and a considerable portion of the west side of Chanda.

But much still remains. And this must just be worked out in the same way, steadily proceeding from the known to the unknown, following up the details of the rocks, and carefully putting together the isolated facts which are visible in this much covered country till the structure of the whole can be built up. It is simply nothing but the wildest speculation to think that you can safely leap to a conclusion, or expect to accomplish in five days or even five minutes what would take more nearly five years to do. Let us apply the consideration to other countries. Any one, no matter how ignorant himself, who would demand a detailed examination, report, borings, &c., of the country between Liverpool and London in a few weeks, would either be pitied as out of his senses, or laughed at as unworthy of a reply from his ignorance. And yet here, if the demand were perhaps met by a simple statement of the impossibility of complying with it, this determination not to attempt what was impracticable would very possibly be thought dilatory.

The discovery of this coal on the Wurdha river is of no recent date. It was publicly made known and exhibited more than forty years since. On the 19th August, in the year 1830, Mr. J. Prinsep, the Secretary to the Asiatic Society of Bengal, laid before the Society a specimen of bituminous coal from the banks of the Wurdha river near Chanda, (Gleanings in Science, Vol. II, p. 386,) and in the next year, Mr. Prinsep gave the results of analysis of this coal, stating then, as we have had to do since, that it contained more than 20 per cent. of ash, and also a larger proportion of volatile matter than usual, which, he adds, might enable the coal, though of little use as a fuel, to be turned to profit for the gas, which it gives out in great abundance (*ibid*, Vol. III, p. 381). This coal has since that time been noticed by several others; it was rejected as not coal at all by many, and it was, in late years, only first declared positively to be good coal by one of the officers of the Geological Survey (Mr. Blanford). A rough sketch outline map was that very season made. But no detailed examination *could* be taken up until the detailed plans were ready. The Geological Survey has since traced out the limits of the field, and has made considerable progress in the detailed examination of it. These seem to me to be the proper duties of that Survey, leaving the working of the coal to those more immediately interested in the success of the undertaking. And in doing this, the Survey only follow up the definite instructions they have received to confine their operations to such portions of the country as have been carefully mapped by the regular survey establishments of the country.

The coal-fields known to occur in the lower Godavery near Dumagudium, for the examination of which no funds were provided last year, have been taken in hand during the present season, and Mr. W. Blanford has proceeded there for the purpose of examining them and determining the best localities for actual borings. These are the most southerly localities in India at which coal is known to occur, and their geographical position renders them of high importance.

Among the many wild statements of the 'discovery' of coal and other minerals which constantly find their way into the columns of newspapers, and give rise to much speculation and excitement, one of the wildest seized on the public during the past year, and was urged officially on the Government of Madras. It was stated that coal, 'excellent steam coal,' 'very different from Indian coal,' &c., &c., had been found near Gooty within a very short distance of the railroad and most conveniently placed. I took no notice of the first announcement

I saw of this. But when it was circumstantially stated that not only coal, but numbers of fossils, both animals and plants, identical with those which characterized the coal-fields of Scotland and England, had been procured in the same place, these details almost made one doubt their own convictions. I should have given nothing for the stated occurrence of 'fossil ferns and beautiful specimens of coal plants,' because I had, years before, received from the same neighbourhood and sent by the same person as now announced the discovery, a large collection of what were then called 'beautiful coal plants,' but which on examination proved to be nothing but the dried and squeezed rootlets of common grasses which had inserted themselves between the cleavage planes of a true slate, and had been attached to the surfaces by a little very fine impalpable mud carried in by water. The slightest application of water washed off every trace or marking of these so-called beautiful fossils. I was therefore prepared for the assertion of 'coal plants,' but the production of a few shells said to be from rocks which had been carefully examined before, without yielding a single organism, was still to be explained. Mr. Foote was requested to visit the locality on his way to the season's work, and I purposely left him without the geological maps which had been constructed by his colleagues, desiring to leave him without a chance of having his own opinions influenced by the views of others. His results are given in a very clear and concise statement published in the first number of the 'Records,' 1871, and it will be seen that there was not to be found a single bed of rock agreeing either in colour or texture with that containing the fossils said to have been brought from that district, but which, it appears, had been previously lying unlabelled, mixed up with other fossils of all ages and localities, and picked out from this aggregate of confusion.

The coal, which certainly was, as described, 'good steam coal,' and "very different from most Indian coals," was found just in the line followed by carts which had drawn a large quantity of similar coal to a contractor's depôt not three miles off; and to test the extent of this coal, the Government were recommended to commence boring in the granite-gneiss on which these dropped fragments were found!! Anything evincing more lamentable ignorance of the very first elements of geological or mineralogical knowledge than the whole affair it would be impossible even to conceive.

This was an instance in which there could not be the slightest doubt that the gentleman who brought forward the matter did so in all sincerity of purpose and honesty of belief in its truth. But during the past year, it has been also our duty to expose a very deliberate but amusing fraud leading to the belief of the existence of coal where it might possibly have occurred, although it was highly improbable that it did, and where the sanguine anticipations of those who first made known the supposed discovery led them to picture in glowing colours future results of magnificent dimensions. These illusions led also to serious and costly practical results, which a little calmer consideration would probably have obviated.

At the commencement of the year, it was publicly stated that thick and valuable beds of coal had been unexpectedly found while boring for water within the precincts of the new Central Jail Buildings at Midnapore. This 'discovery' was widely published, and the most sanguine anticipations of results were put forward. Dr. Mouat, then Inspector General of Jails, took up the question very energetically. Such tools as could be procured here were obtained, and the borings were prosecuted with great vigour under the able charge of Major J. D. Swayne, the Executive Engineer in charge of the works of the jail. The matter did not come to the Geological Survey till some months later. In March, Dr. Stoliczka, then in temporary charge of this office during my absence, reported to the Government of Bengal that the specimens of coal which had been sent indicated a valuable fuel, but that as nothing whatever was then known of either the dip or strike or thickness of the bed, all of which were entirely concealed by a thick covering of laterite and lateritous clays, &c., no correct idea could be formed as to what quantity of coal might exist in the locality. Borings were, therefore, continued and others made. The specimens of coal sent up from time

to time were all of the same kind, and all in similar pieces. The value of this coal was tested by assay, but any opinion as to the real value of the 'discovery' was withheld until after actually visiting the place. In the middle of April I went to Midnapore, hoping to find that the boring (No. 4) then in progress would have reached the coal by the time of my arrival, and that I should be able to judge better of the nature of the bed from seeing how the fragments came up in the boring tools. I remained several days, but regret that I failed to see the coal, which was stated to have been reached some few days after my return.

However, I had the advantage of cross-questioning the man in charge of the borings, and I ascertained from him that no actual bed of coal had ever been cut, but that, as he stated, throughout a depth of nine to eleven feet, the fragments of coal had been brought up mixed with the soft slush of the red clay in which the tools were sinking. From the moment I first saw the specimens of coal said to have been brought up, I believed that they could not have been the result of the cutting of any solid bed. And it was on my stating this to the man that he at once explained the matter as I have said. His answers were clear and consistent, and the facts, if they were facts as stated, were easily reconcilable with a supposition that the tools had just struck the loose outcrop or top of a bed of coal, the detached and broken portions of which had become mixed up with the clays above. To test these statements, and to prove the continuity of the coal, if it existed, the boring rods were at once moved as far to the apparent dip of the supposed coal as the limits of the jail grounds permitted. A boring in this locality ought certainly to give, if the statements were correct, a sufficient covering of rock over the coal to preserve it from any such admixture with the clays as appeared to occur in the other borings, and would also give a satisfactory indication of the amount and direction of dip of the bed, if it proved continuous.

This boring (No. 5) was commenced, but owing to the soft nature of the clays and sands through which it passed and the want of tubing, combined with the bad boring tools at command, it was necessarily abandoned before it had reached the required depth. After a delay of nearly a couple of months tubing was procured, and another boring was put down close by. This was in September. I communicated my suspicions to Major Swayne, and asked him to take precautions to prevent the possibility of any repetition of the trick, which I suspected had been played, of putting coal down the bore holes that it might be brought up again. And this boring was carried down some 220 feet, but, as Major Swayne states, 'not a single trace of coal was found subsequently to the date on which these precautions were taken'. To satisfy himself more thoroughly, Major Swayne then very judiciously commenced a new boring close to (within a foot or two of) the first boring in which eleven feet yielding coal were stated to have been passed through. Before this was commenced, new and better tools had been procured from England, and the boring was rapidly and easily carried out.

The boring had, however, only reached about half the depth at which the coal was stated to occur, when the man in charge disappeared without leave and under very suspicious circumstances. After he had thus absconded, his house was searched under warrant from a Magistrate, and some coal was found partly in lumps and partly broken up. And on comparison of this with that said to have been brought up from the borings, they proved identical. This, however, although very strongly corroborative of the suspicions entertained, was not sufficient to establish the facts: so the boring was continued and carried right through the whole depth at which the coal was, in the first instance, stated to occur. But *not a trace of coal was found.*

These results appeared sufficient to justify stopping all further borings with a view to test the extent of the coal which was shown not to exist. One only will be continued to prove the actual thickness of the covering clays, sands, &c., in this part of the district.

Briefly then, four borings had been nearly completed before the Geological Survey had the matter brought before them, in all of which coal had been stated to occur at about the same depth from the surface. A fifth boring was necessarily abandoned from want of proper tools, and the sixth discovered the fraud. The last boring put down close by the first was simply put down as a confirmation of the results obtained from the others. And so far no evidence whatever has been obtained that coal occurs at all in this Midnapore locality.

The trick of putting coal down a bore hole so that the boring tools may again bring it up, is by no means an unknown one. It has frequently been practised in Europe, &c., and I believe this is not the first time it has been resorted to in India either. Some useful lessons may possibly be learnt from such a detection. One is the delay and doubt inevitably engendered by the use of inferior and unsuitable tools for such enquiries. Some months would have been saved had there been available proper boring tools and piping in the present case. And it was simply impracticable with the bad tools at command to keep the boring holes as clear and free as they ought to have been. It would also seem both injudicious and, therefore, costly to employ doubtful characters in matters when so much must be taken on their statements. And certainly, if men are put to such work, it would be wiser to pay them in proportion to the work they are called on to execute. The man in charge in the present case was at first a convict, and when released, he received only a wretched pittance, barely sufficient to keep him from starving and certainly not sufficient to place him above the temptation of trying to eke out his living in other ways. It is highly probable that better pay would not have kept him from attempting such frauds, but the chance of his indulging in them would unquestionably have been diminished if he had been placed above want.

But if such rogueries be sufficient to indicate the serious responsibility which attaches to those who without enquiry hurry before the public with highly coloured and exaggerated statements of such 'discoveries' and so mislead every one else, the time and money will have been well spent. If there were not a hasty and unthinking desire to gain a little fame and reward by the immediate announcement as a discovery of what was quite unproven, I have no hesitation in saying that similar tricks, even if once attempted, would certainly not be often repeated.

Major Swayne, the Executive Engineer in charge of the jail works, has throughout exhibited a very earnest and intelligent desire to test the truth of the statements made, and would certainly have proved the facts before publicly announcing them.

I refer more particularly to these considerations because as an immediate consequence of this much trumpeted discovery of coal at Midnapore came an urgent request from Madras, that a very large reward (two lakhs of rupees, £20,000, was first mentioned, afterwards reduced to one-half of a lakh,) should be offered for the discovery of a workable bed of coal south of the 17th parallel of latitude in India; the coal to be of a specified quality, and the seam of specified dimensions.

This recommendation was based distinctly and directly on the assumed fact that a bed of coal, 13 feet in thickness, had been found at Midnapore beneath a thick superficial deposit of laterite, where all the lower rocks cropping out in the neighbourhood were crystalline and much older than the coal-bearing deposits. It was urged that "the discovery of coal under such circumstances is without precedent," but that the precedent being once established other such discoveries might fairly be looked for elsewhere. And that as it was known that in the Madras Presidency vast tracts of country existed in which the geological formation of the surface agrees with the above description, no reason appeared why the discovery of coal should be a more improbable event there than at Midnapore.

It might suffice here to point out that as the coal has really not been found at Midnapore, all this reasoning, supposed to be safely based on that discovery, must fall to the ground.

But as the whole thing appeared to me to be a baseless illusion, I had to point out the reasons for this opinion. This may best be done by quoting the letter addressed to the Government of India on the matter; in this, after speaking of the terms on which it was proposed to offer such a reward for the finding of coal, and stating my belief that nothing was likely to result from such a procedure, but a useless waste of time and money, I went on to say,—"I am convinced of this not only by the general experience of the result of such offers, but even more by the grounds on which the offer is recommended. This recommendation appears to me to be based on an entire misconception of the facts regarding recent discoveries of coal, and it may, therefore, be well briefly to indicate, for the information of the Consulting Engineer for Railways in Madras, as well as others, how those facts really stand. Major S. Stewart refers to a generalized statement of mine as to the geographical limits within which the great development of coal-measures in India has been confined. That this was a very general statement he would have seen from the fact, that the coal of Assam, of Eastern Bengal, and of many other places were excluded; and so far as the argument that the productive coal-fields of India are confined to one belt across the peninsula, it was of exceedingly little importance whether the southern limits were given at the 20th degree or at the 18th degree of north latitude. In fact, if the map which accompanies the report referred to had been looked at, it would have been seen that the coal-bearing rocks were shown to extend below the 20th degree of latitude, and also that the country still further to the south was shown to be unknown geologically, regarding which, therefore, nothing was attempted to be asserted. The southern limit of the coal-bearing rocks has since then been carried further to the south than was then (1867) known, but only within the limits then indicated as unexamined."

"It is entirely correct to state that great difficulty presents itself when any attempt is made to form general conclusions regarding the mineral resources of so vast a country, But this difficulty only arises from the impracticability of actually seeing this vast area and the necessity of trusting to the information of others. There is no real difficulty in determining the facts wherever we can examine the country. Reports of mine are also quoted, stating that coal had been found in the borings in the Chanda district at places where its existence was entirely unknown or unsuspected. It was clearly not unknown or unsuspected by the Geological Surveyors, as they selected the points at which the borings were put down. But it was asserted that it could not possibly exist there by so-called practical engineers, the very class whose aid it is proposed now to invoke."

The letter goes on to argue, that because coal has been found at Midnapore under laterite, and because a considerable portion of the Madras Presidency presents a surface formation of laterite also, it cannot be seen that the discovery of coal should be a more improbable event there than at Midnapore.

"We are not in any way responsible for the statements or descriptions given in newspapers, but those quoted above certainly do not represent the facts correctly. The seam of coal (the thickness of which by the way is as yet quite unknown) does not underlie a thick superficial deposit of laterite in the ordinary or proper sense of the term. It occurs in a series of beds of sandstone, &c., of totally distinct age from the laterite, and which had been disturbed, broken up, and very largely denuded or worn away before the nearly horizontal beds of the laterite and lateritous clays were spread over them; that is, the continuity or position of one formation is not the slightest clue to the continuity or position of the other. The lower rocks also which crop up in the neighbourhood are not crystalline. The crystalline rocks show a long way to the west. But wherever there is any trace of other rocks under the laterite, those rocks are sandstones, which have become much impregnated with iron from the laterite above, and have, therefore, lost a good deal of their distinctive characters. It is

said, "so far as known, a discovery of coal under such circumstances is without precedent." But so far from this being really so, coal has not only been known, but worked for many years in the eastern end of the Ranigunj coal-field under exactly similar circumstances, the only difference being that the covering or thickness of the laterite is much less than at Midnapore. In other respects the cases are analogous."

Undoubtedly "similar discoveries may be looked for elsewhere under similar geological conditions." "But although there are in the Madras Presidency vast tracts of country in which the geological formation of the surface is laterite, there is not that I am aware of any single locality where there is the slightest reason to suppose that this laterite covers up and conceals coal-measures below. There is no place where such coal-measures appear in the adjoining country, or in any of the sections. At Midnapore there is at a limited distance to the north the extensive and rich field of Ranigunj, which is at its eastern limit all covered up with laterite. And again to the south, similar sandstones, &c., appear near Cuttack, rendering it beyond a question more probable that *if* any distinct formation did occur under the laterite and above the crystalline rocks, that formation would certainly be the coal-bearing rocks. * * But there is not as yet known a shadow of evidence that any similar conditions exist anywhere in the Madras Presidency."

PUBLICATIONS.—The "RECORDS of the Geological Survey" have regularly appeared at the fixed intervals of three months. This series has proved, as anticipated, most useful in giving early and timely notices of geological facts, which could not be given to the public for many months if it were necessary to wait for a tolerably complete report, such as could be published in the Memoirs of the Survey with maps, &c. In the four numbers for the year 1870 will be found, in addition to the annual report of the Geological Survey and of the Geological Museum, a general sketch of the geological structure of the neighbourhood of Madras; the alluvial deposits of the Irrawadi valley; geology of country around Gwalior; the Wurdha river coal-fields; the Mohpani coal-field in the Narbadda valley; geology of Mount Tilla, in the salt range, Punjab; full accounts of the copper deposits of Singbhúm; the coal near Korba, Bilaspúr, with brief notices of lead lodes at Chicholi in Raipúr; lead and copper in Manbhúm; lead ores near Sleemanabad in Jabalpur; on petroleum in Burmah, &c., and in the Punjab, &c., &c., with the customary lists of additions to our library during each quarter. The lead found in Manbhúm by Mr. Ball proved to be extraordinarily rich in silver, yielding more than 119 ounces to the ton of lead! We have had several very satisfactory testimonies to the value of this series of papers. And one of the best perhaps is the readiness with which our results are quoted in the Geological Journals of Europe, &c. The quick publication of results in this way renders it unnecessary to enter into the same detail in our annual report, for these records contain at full, or in full abstract, the descriptive reports, &c., of the officers of the survey for a large part of the year's work.

Of the larger publications, The MEMOIRS of the Geological Survey of India, we have, we regret to say, been able actually to issue only one part. Great progress has been made in the preparation of others. But it has not been possible to have the geological maps and sections prepared and ready for issue in time. A long and fully detailed report on the country lying between Madras and the Kistna river is actually printed, but cannot be issued until the map to accompany it be ready. Reports on the small coal-fields of Itkhuri (Eetcooree); of Daltongunj, or Palamaun; of Karanpúrí, south of Hazáríbágh, &c., are also ready for issue, with the exception of the maps which are to accompany them. These unavoidably take much time. They are useless unless prepared with considerable accuracy, and the colouring requires much care and special attention. This too is work which cannot be done in the ordinary way without the supervision of a geologist who understands the maps. A detailed and beautiful map of Kutch is also being printed off now. This is being printed

in colours, and will, I think, prove a very excellent and admirable record of the geological examination of the country. We are greatly indebted to Captain W. G. Murray, in charge of the Lithographic Department of the Surveyor General's Office, for the earnest and skilful attention he has given to this and other similar work, of which he has done much with his own hands, and for the friendly and zealous aid he has throughout afforded. Indeed this is only a continuation of the same earnest assistance we have invariably experienced from Colonel Thuillier and all of his valued department.

Of the PALÆONTOLOGIA INDICA, the regular issue has been punctually maintained, with only one difference. It was found by experience that the small fasciculi, which at first were issued every three months and distributed at once, were frequently lost or much injured in transmission, or were not cared for afterwards as larger books would be. And in consequence of several representations to this effect, the four fasciculi representing a twelve months' issue of these palæontological memoirs have been published as one part. The part or volume issued during 1870 contains the first portion of the bivalve mollusca of the Cretaceous rocks of Southern India (the *Pelecypoda*). These have been illustrated with the same accuracy of detail and fulness of research as were the volumes already published of the *Cephalopoda* and *Gastropoda*. And the series has elicited the very highest encomiums from the best palæontologists and geologists of Europe. Dr. Ferd. Stoliczka, Palæontologist to the Survey, has throughout maintained the same thorough and indefatigable devotion to the work he has undertaken as have hitherto distinguished his labors.

The preparation of the final geological maps to be issued on the basis of the sheets of the Atlas of India has made much progress. Two quarter sheets, including Madras Town and neighbourhood, are nearly ready (No. 78, north-east and south-east), and the copper plates of several others have been applied for, that the necessary transfers for geological purposes may be prepared.

Geological descriptions of various parts of the country have been furnished to local officers, and especially a general sketch of the Geology of Orissa to Dr. W. W. Hunter for his accounts of that province; of the Central Provinces, published in the Gazetteer of the Central Provinces; and of the Berars for the Gazetteer of those districts. Other similar sketches have been applied for, but in some cases too late to admit of their preparation in time. It ought to be borne in mind, that however brief such sketches may be,the very necessity for this condensation renders them more tedious and troublesome in preparation than a fuller report might be.

LIBRARY.—Seven hundred and thirty-seven volumes or parts of serials have been added to the Library of the Geological Survey during the twelve months under report. Of this number no less than five hundred and twenty-five have been received in exchange for the publications of the Geological Survey of India from Societies and other Institutions with which relations of exchange have been established. Of these accessions, a complete list for the three preceding months is given in each number of the Records, and to this report is added a list of all Societies or public Institutions from which, during the twelve months, donations or exchanges have been received.

We still labour under the great disadvantage of having this valuable collection of books so crowded from want of proper space for their preservation, &c., that much time is lost and great inconvenience incurred when references are necessary.

The Library of the Geological Survey has during the year been freely consulted by many besides the officers of the survey, and has proved very useful by affording access to many books not to be had elsewhere in Calcutta or in India.

MUSEUM.—The regular and systematic numbering, entering, and cataloguing of the numerous additions to our collections progresses. Always a tedious process, it is in our case rendered more than usually so by the necessity we are under, from want of space, to pack

away, after cataloguing, in boxes, a very large part of the series, and simply store them in the godowns; this difficulty which involves a very large share of additional work, whenever reference to, or comparison of, these specimens becomes necessary, will be unavoidable until the Museum obtains proper space for the exhibition of its collections and for rendering them accessible to those who desire to study them.

Mr. Tween, Curator, has been steadily progressing with the detailed examination of the coals of India in connection with the detailed experiments as to their actual 'duty', which are being carried out by Colonel H. Hyde, R. E., at the Mint Offices. When completed, it is hoped that these combined assays and actual trials will give a very much more trustworthy and accurate test of the relative values of the various coals of India, than has hitherto been obtainable. The specific gravity of each coal is carefully determined, and the general assay or composition; and then careful analysis of the ashes of the coal is made, showing the nature of their composition and the presence or absence of ingredients, which, though in small quantities, would exercise possibly a very seriously injurious effect on the results of the employment of these coals in manufactures, such as smelting of iron, &c.

METEORITES.—As stated in the Records of the Survey, 1870, pt. 4, p. 104, we have added to our large collection of Meteorites, during the past year, specimens of the fall at Hessle, near Upsala, on the 1st of January 1869; of that of Kernouve or Cleguerec, Morbihan, France, of the 23rd of May 1869; also a fine specimen of the iron of Deesa, Chili.

As customary, an index map on a small scale is appended, showing roughly the present state of the survey; as also a list of those Societies or public Institutions from which we have received publications during the twelve months in exchange for those of the Geological Survey of India.

The various collections are all in as good order and safe keeping as the nature of the accommodation at our command will permit.

T. OLDHAM,

GEOLOGICAL SURVEY OFFICE, *January*, 1871.

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

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 1870.

BELGIUM.—Academie Royale des Sciences, Bruxelles.
BERLIN.—Royal Academy of Science.
„ Deutsche Geologische Gesellschaft.
BOSTON.—Society of Natural History.
„ Museum of Comparative Zoölogy.
CALCUTTA.—Asiatic Society of Bengal.
„ Agri-Horticultural Society.
„ Public Library.
CAMBRIDGE U. S.—Museum of Comparative Zoölogy.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
DUBLIN.—Royal Society.
„ Royal Geological Society.
„ Royal Irish Academy.

EDINBURGH.—Royal Society.
„ Royal Scottish Society of Arts.
FLORENCE.—Geological Society of Italy.
GÖTTINGEN.—Königl. Gesellschaft der Wissenschaften.
LAUSANNE.—Société Vaudoise des Sciences Naturelles.
LONDON.—Royal Institution of Great Britain.
„ Royal Geographical Society.
„ Royal Society.
„ Royal Asiatic Society of Great Britain and Ireland.
„ Geological Society.
„ Geological Survey of Great Britain and Ireland.
„ Society of Arts.
MOSCOW.—Société Impériale de Naturalistes.
MÜNICH.—The Academy.
NEUCHATEL.—Society of Natural Science.
NEW YORK.—Museum of Natural History.
NORWAY.—Royal University of Christiania.
PALERMO —Consiglio di Perfezionamento di Palermo.
PARIS.—Comm. des Annales des Mines.
„ Société Géologique de France.
PHILADELPHIA.—American Philosophical Society.
„ Franklin Institute.
„ Academy of Natural Sciences.
PORTLAND.—Society of Natural History.
ROORKEE.—Thomason College of Civil Engineering.
SALEM.—Essex Institute.
„ Peabody Academy of Science.
STOCKHOLM.—Royal Academy of Science.
„ Bureau de la Rech. Geol. d. l. Suede.
ST. PETERSBURG.—Acad. Imp. des Sciences de St. Petersbourg.
TORONTO.—Canadian Institute.
TURIN.—Royal Academy of Sciences.
„ Academy of Turin.
VICTORIA.—Govt. Geological Survey of Victoria, Department of Mines.
VIENNA.—Kais. Akad. der Wissenschaften.
„ K. K. Geologische Reichs-Anstalt.
WASHINGTON.—Smithsonian Institute.
„ National Academy of Sciences.
ZÜRICH.—The Society.

Governments of India, Madras, Bombay, Bengal, N. W. Provinces, Punjab; Chief Commissioners of Oude, Central Provinces, and British Burmah; Surveyor General of India, &c., &c.

RESULTS OF AN ENQUIRY INTO AN ALLEGED DISCOVERY OF COAL NEAR GOOTY, AND OF INDICATIONS OF COAL IN CUDDAPAH DISTRICT, *by* R. BRUCE FOOTE, F. G. S., GEOLOGICAL SURVEY OF INDIA.

Dr. Hunter in his letter to the Madras Government which I perused by desire of the Hon'ble R. S. Ellis, C. B., the Chief Secretary, stated that he was led to examine a certain piece of ground lying west of the Adoni road, and about five miles from Gooty, by hearing from a Sergeant Fenner, stationed at that place, that he had picked up fragments of coal at the above spot.

Dr. Hunter himself picked up one or two more fragments of coal, lying loose on the surface, at the same place, and from this inferred the existence of coal below the surface, and recommended that a further search should be carried out by means of 'borings.'

In order that no possible mistake should arise in identifying the spot in question, I requested Sergeant Fenner to become my guide to it, and accordingly visited it under his guidance.

The place I was taken to proved to be situate among the metamorphic rocks, which, at that spot, consist of an extremely hard, massive and highly crystalline variety of granite-gneiss, forming a low rocky hill west of Yerragoody tank. This granite-gneiss, which weathers into great tors and rounded lumps, is of a pale, pinkish or greyish white color (when freshly broken) speckled with small crystals of black mica in considerable numbers. Both here and throughout the neighbourhood it is traversed by trap-dykes (generally of green stone) and small quartz veins.

It was very evident therefore the coal fragments collected here could not have been derived from the underlying rock, but must have come from elsewhere, but no younger rocks out of which they might have been washed, or weathered, occur anywhere in the immediate vicinity. The nearest place at which younger rocks occur is fully eight miles to the eastward, where beds of quartzite and limestone appear; these belong to the Cuddapah (Kadapáh) series which is nowhere known to contain coal or any carbonaceous mineral. That the fragments of coal found by Dr. Hunter and Sergeant Fenner could not have been washed there out of the Cuddapah rocks is quite clear, as no drift of any kind occurs at the level where the fragments in question were found, which cannot be less than from 30 to 50 feet above the nearest valley, that of the little stream which fills the Yerragoody tank. Furthermore the fragments of coal in question are perfectly angular, with an unweathered surface, never having been rolled by water.

No fragments of coal remained at the time of my visit to the Yerragoody hill.

Sergeant Fenner pointed out as "most favorable indications of coal" according to Dr. Hunter, what proved to be the rather decomposed surface of a small trap-dyke exposed in a ballast pit close to the road. A hummocky intrusion of coarse dioritic trap was, on the same authority, given as "iron ore."

In conclusion, I have no hesitation in believing that the fragments of coal found by Dr. Hunter and Sergeant Fenner had been brought to the spot where found by some human agency.

They were either brought from a coal depôt belonging to Mr. E. W. Barnett, C. E., the Railway Contractor, the remains of which may still be seen at the spot where the Gooty-Adoni road crosses the railway, a distance of only three miles from the Yerragoody hill, or else they may have been dropped from the carts in which Mr. Barnett carted a quantity of coal up to Adoni, previous to the time of Dr. Hunter's visit.

In the latter case the carts would have to pass within a few yards of Dr. Hunter's supposed coal-field.

Among the remains of Mr. Barnett's coal depôt at the crossing over the line, to which my attention was directed by Mr. Barefoot, the very obliging Locomotive Foreman at Gooty Station, I picked up various pieces of slaty north-of-England coal identical in appearance with the specimens from Yerragoody hill, which Dr. Hunter exhibited to His Excellency Lord Napier and the members of Council on the occasion on which I was desired to attend.

2.—*Indications of Coal near Cuddapah.*

Dr. Hunter's informant as to the existence of good indications of coal near Cuddapah was, I believe, a Mr. Adams, a *soi-disant* 'experienced coal miner from Chanda.'

The spot indicated as showing such promising indications of coal lies about five miles north-north-west from Cuddapah where the limestones (here belonging to the Kurnool (Karnúl) series) have been largely quarried in deep pits, a little to the east of the village of Chinna Mazapully. These pits at the time of my visit were quite full of water, but the waste heaps, which I went over carefully, showed not the faintest indication of coal or coal shale.

In addition to the negative evidence afforded by the waste heaps, I ascertained from Mr. Higginson, the Irrigation Company's Engineer at Cuddapah, who has worked the self-same quarries largely, and for weeks together been in the habit of constantly visiting them, that he has never seen the smallest trace of carbonaceous matter in any part of the rocks there exposed.

As Mr. Higginson is not only an experienced Civil Engineer, but also a careful and thoughtful observer of facts, his evidence may be very safely accepted as conclusive of the non-existence of coal or coaly matter at this place.

Dr. Hunter did not, I believe, visit this place personally, but merely brought Mr. Adams' supposed discovery to the notice of the Madras Government.

3.—*Fossil shells and petroleum near Ryalcheroo.*

In his letter to the Madras Government above referred to, Dr. Hunter further stated that he believed coal occurred in the rocks lying between Ryalcheroo (in Bellary District, fifteen miles south-east of Gooty) and Cuddapah, and advanced three reasons especially for such belief; firstly, the presence of fossil shells '*Terebratulæ*' in the limestone near Ryalcheroo; secondly, the presence of petroleum in limestones at Khona Oopalapad, six miles north-east of Ryalcherroo; and thirdly, the black color of some of the limestones occurring between Tadputri (Taudapurtee) and Cuddapah!

Dr. Hunter produced before the Council two fossil shells (*Terebratulæ* of a species somewhat resembling *T. hastata*) which he stated came from Ryalcheroo, where they had been found some years ago by Major Bissett (since deceased, I believe), and added that the late Mr. Robert Cole, Inspector General of the Indian Medical Department, Madras, had also collected similar fossils at the same place.

As Dr. Hunter could give me no information as to the exact locality near Ryalcheroo whence the fossils came, and I had not the maps of that neighbourhood, prepared by my colleagues, a great deal more time was required to investigate this point than would have been otherwise necessary.

I examined a very large number of beds of limestone with intercalated slates, shales, quartzites, &c., &c., without finding the slightest trace of any organic form, some very doubtful worm-tracks excepted.

None of the limestones agree in color or texture with that which yielded Dr. Hunter's specimens, and I cannot help having the strongest doubts as to the correctness of Dr. Hunter's statement that the *Terebratulæ* in question came from Ryalcheroo, or any other place in that neighbourhood, as the statement in question rests only on the authority of his memory, which in this instance has, I firmly believe, played him false.

When Dr. Hunter showed me those *Terebratulæ* some days before the meeting of the Council, they were *unlabelled* in a drawer containing many other fossils from Europe, equally unlabelled, and mixed up together regardless of geological age, or natural orders. Whatever Major Bissett's specimens may have been, I cannot but think that, from trusting too much to his memory, and from keeping his collections in a state of utter disorder, Dr. Hunter has made a mistake, and unintentionally taken some European specimens for Major Bissett's.

The presence of petroleum in the limestones at Khona Oopalapad might offer some little support to Dr. Hunter's expectations of finding coal in the Cuddapah rock series, if proved, but unfortunately no petroleum can be found there.

The only substance which, following his directions, could be found at Khona Oopalapad, either by Mr. Kelsall, the Acting Sub-Collector of Bellary, or by myself, was a dark brown, glistening, fœtid substance which has dribbled out of numerous small caves in the face of the cliff overhanging the Khona Ramaswamy Pagoda.

This substance, though somewhat resembling petroleum in color, differs very markedly by refusing to burn. Before the blow pipe it volatilized without any appearance of flame.

The small caves out of which this brown substance dribbles are tenanted by numerous bats and blue pigeons whose excrementa are, by percolation of water in wet weather, converted into a species of guano retaining a very unpleasant bat-like odour.

The limestone cliffs in which this 'bat-guano' occurs do not belong to the Cuddapah rock series, but are formed of a recent travertin deposited on the scarp of those older rocks by streams flowing from a more elevated plateau of limestone (of the Kurnool (Karnúl) series), which lies unconformably on them.

The small caves are mostly spaces left between numerous large stalactites in the travertin, others are of artificial origin. The travertin is still being formed, but probably in far less quantity than in former periods when the country was less arid. Numerous organisms, such as land-shells, and leaves of trees of living species, have been encrusted by the travertin, and their impressions are beautifully clear.

The 'bat-guano,' I find, had been pronounced by my colleagues, the late C. Æ. Oldham and W. King, Junr., not to be petroleum. I was not aware of this till after my visit to Khona Oopalapad.

In reply to a letter in which I drew his attention to the fact that the supposed petroleum refused to burn, Dr. Hunter informs me that the specimen he received from Mr. Smart, late Chief Engineer of the Madras Railway, burnt with a strong flame, dropping and giving off much gas, but he does not know exactly from where Mr. Smart got it. I intend writing to Mr. Smart on this subject as soon as I can ascertain his present address.

It thus appears that none of Dr. Hunter's statements have been substantiated, while the most important have proved to be entirely without foundation. These statements were no doubt made by Dr. Hunter in a sincere belief in the correctness of his deductions, but the latter, unfortunately, were based on a series of hasty, crude, and in some cases utterly incorrect, observations evidencing such a want of practical knowledge of geology and several other sciences that in future his 'geological discoveries' should be received with extreme caution.

MINERALOGICAL STATISTICS OF KUMAON DIVISION, collected under instructions from THE COMMISSIONER, COLONEL H. RAMSAY, C. B., by A. W. LAWDER, Civil Divisional Engineer.

While submitting these mineralogical returns for the past year (1869-70), I would call attention to the statement commencing my last year's report, and to the remarks now made by Captain Garstin. While every care has been taken to check as far as possible the correctness of the details, still too much reliance cannot be placed upon them. It is not the special duty of any native officials in the several parts of the districts to collect the information required, and those from whom it is asked not understanding the object for which it is sought, or seeing any direct advantage to be derived therefrom, are liable not to be overcareful in making their calculations; and it should therefore be remembered that the figures entered are merely approximations and not actuals. Specimens from most of the mines mentioned in the returns having been received by me, I have endeavoured to give a description of their character and species, so far as I can determine them by the ordinary rough tests.

DETAIL OF LOCALITIES.

KUMAON DISTRICT.

IRON.—*Agar Puttí—Lúsgani mine.*—The specimens are rich in metal, of a laminated structure, black colour, are slightly micaceous, and influence the magnetic needle. They may possibly contain Manganese.

Agar Puttí—Nutthúa Khan mine.—A micaceous ore rich in metal, laminated, affects the needle slightly.

Agar Puttí—Sutbúnga mine.—A rich hæmatite, influences the needle.

Agar Puttí—Gulla mine.—Ore similar to that of the Nutthúa Khan mine.

Lukhunpúr Puttí—Munia mine.—The ore is seemingly an earthy red hæmatite, minute particles of yellow metal appear here and there, of which I have no means of testing the nature.

Darún Puttí—Diguria mine.—This specimen is also an earthy red hæmatite.

Rungourh Puttí—Diguria mine.—Ore possibly a clay ironstone. In parts affected by acid similarly to spathic iron.

Rungourh Puttí—Julal mine.—This resembles micaceous iron schist.

Kharai Puttí—Lobe mine.—This ore is apparently a brown hæmatite.

Mulla Kutyoor Puttí—Lugthan mine.—Similar to the last named specimen.

Burâon Puttí (Gangúlí).—A black micaceous ore apparently rich; laminated, and influences the magnetic needle.

COPPER.—*Bâel Puttí* (Gangúlí)—*Bujúl mine.*—This ore is a copper pyrites. The matrix is composed of steatite and felspar.

Bâel Puttí—Rethayat mine.—Specimen similar to the last mentioned.

Gungúlí Puttí—Tamba Khan.—This ore is pyrites, and is apparently rich in metal, talcose rocks form the gangue.

Athagâon Puttí (Gangúlí)—*Fudialí mine.*—Specimens from this mine do not seem very rich in copper. In a matrix of talcose schist pyrites is disseminated in small particles.

GURHWAL DISTRICT.

IRON.—*Pykunda Puttí.*—These specimens exhibit granular iron pyrites imbedded in veins of quartz which occur in a dark greyish talcose schist. They are apparently not very rich in ore.

Sílí Chandpúr Puttí—Rajbúnga mine.—This is a hæmatite, rich in quality. It is slightly attracted by the magnet.

Sílí Chandpúr Puttí—Khúsh mine.—This is evidently a micaceous ore, scaling off easily, minute crystals, resembling garnets, can be observed on the sides of the specimens. The adjacent beds seem to be chlorite schist. The ore affects the needle.

Putti Bichla Nagpúr—Búkhunda mine.—Specimens from these mines are also of a micaceous nature, and seem to contain in parts, minute crystals of quartz, pyrites, &c., otherwise it much resembles graphite, and leaves minute particles upon the fingers when touched. It does not influence the compass needle.

Puttí Bichla Nagpúr—Jakhtolí mine.—This ore is probably a clay ironstone. It is of a light coffee colour, and of little specific gravity.

Puttí Bichla Nagpúr—Gílet mine.—This ore is similar to that of the Bukhunda mine.

Puttí Mulla Dussolí—Mok mine.—The specimens appear to be magnetic iron ore rich in mineral; colour black, structure crystalline, and laminated. It possesses highly magnetic properties.

Puttí Mulla Dussolí—Churbung mine.—This corresponds to that of the Mok mine, one fragment is a natural loadstone and exhibits its polarity in the direction of the planes of lamination. (?) It seems very rich in iron.

Puttí Buckursyun—Dúgura mine.—It is difficult to define of what nature these specimens may be: possibly an earthy hydrated oxide of iron. Its colour varies from yellowish-brown to dusky black, streak the same. It is of little specific gravity, the clay seemingly predominating.

Puttí Idyakote—Pípulí mine.—Probably a hydrous form of sesquioxide of iron, clay largely predominates.

Puttí Idyakote—Danda Tolí mine.—The ore from this mine seems an argillaceous variety of brown hæmatite.

Puttí Painú—Chulya mine.—Very similar to the last mentioned.

A specimen of iron ore brought from the neighbourhood of Milum, called by the natives of Mulla Johar '*Buldúnga*', seems a crystalline variety of red hæmatite. It is used there for a red dye, the colour being extracted by rubbing the stone on a hard surface while wet.

SULPHUR.—This occurs frequently in the clay shale, and argillaceous rocks in the lower ranges. A stream running down beside the suspension bridge at Katgodam contains it in solution. A stream near Nurgolí village (new Thul Road) Puttí Athagaon is strongly impregnated with sulphur, and deposits it freely upon twigs, leaves, &c.

SALAJIT.—With reference to my remarks upon this substance in my last report, and a note by Dr. Oldham thereon, I would mention that I was led to form my opinion from a substance called Salajit and sold as such, which was brought to me from Gurhwal as the

pure mineral. I have since forwarded some of this to Mr. Tween, who has been kind enough to analyse it. Here is what he says:—

"It contains nothing but a very sandy clay, mixed with some strong bituminous matter. It burns vigorously for a short time like a coal, but soon ceases, and leaves without diminishing in bulk, nothing but the clay behind;" thus I was not much in error in naming it as bitumen.

On further enquiry, however, I find that this is *not* the pure mineral, it may contain a small amount of it, but is otherwise largely adulterated. I have not as yet been able to visit the place from whence salajit is collected, but from intelligence obtained from several *Hakims*, I am led to believe that the pure mineral here known as salajit is in all probability similar to that of Nepal, which Dr. Oldham states is a native sulphate of alumina.

Salajit is used as a medicine. It is said to be a specific in colds or influenza; to ease pains in the heart and lungs; in rheumatism, taken internally and externally; it is given with nitre in affections of the kidneys; to cure Impotency, and is used as a Tonic; and also as a lotion to wounds, &c.; it is valued at 4 annas to Re. 1 per tola, according to quality.

Sulphate of alumina is also to be found on some of the aluminous shales in the lower ranges in Kumaon. It can be seen on the road between Naini Tal and Khyrna, near Jak village. The shale contains minute particles of pyrites disseminated throughout its mass which decomposing promotes the formation of alum. The infiltration of water causes lixiviation, and the alum is left as an encrustation on the outside of the rock.

TALC.—A kind of dark-coloured Talc called *Jalposhe* seems also to be used as a medicine, either alone, or combined with other substances after it has been very finely pulverized. It is said to have cooling and tonic properties, is given in fevers, and in expectoration of blood from the lungs. These properties possibly arise from the amount of magnesia and iron it may contain.

SLATES.—Two specimens (in addition to those mentioned before) of clay slate have come under observation this year, one from Dhāree village, Puttí Baêl, (Gangúlí,) and the other from Bora Rao Puttí. They are apparently much inferior to the Chitélí slate in every respect.

IMPORTS AND EXPORTS.

From the annexed tables prepared from information obtained from the respective Tehsils and Thannas, and from the statement from Gurhwal, the amount of borax altogether imported through the ghats of Darma, Milum, and Nití, including some from the Byanse and Choudans ghats, was maunds 31,473, or much less than shown in last year's returns. The amount entered in the return from Chumphawut is taken by me as a portion of the amount entered in the Petwa return, as it passes through Chumphawut *en route* for Burmdeo and Píleebheet. A large quantity of borax direct from Choudans, Byanse and Darma finds its way into Nipal. The Tibetan authorities exact a tax in kind upon the export of borax to British territory of one load of grain for every ten loads of borax. It is carried by goats and sheep in a sort of pack with a pair of pockets slung over the back, one on each side. The pockets are covered with leather to keep out wet and damp when piled on the ground. This pack is girthed underneath the body, a band round the chest and another under the animal's tail render it perfectly safe. Each goat is supposed to be able to carry eight seers (or 16 lbs), and the pockets are made sufficiently capacious to hold that weight of grain.*

* It is marvellous to observe the business-like way in which these little beasts of burden carry their loads! Coming upon them on the very narrowest, steepest and slippiest ascent on the brink of a precipice they seem intent only upon pursuing their way, not turning aside for any one or anything, their obstinacy often causing the traveller uneasiness and teaching him patience. And not the less curious is it to observe flocks of them numbering many hundred each meeting, each going the contrary way, and yet none make a mistake, but persist in following their own leader and patiently overcome all obstacles to their doing so.—A. W. L.

The salt returns show a greater total amount than those of last year and would seem to be—

	Mds.
Salt imported *vid* the Johar (Milum) Pass in 1869-70 about	3,000
" " Nití and Mana Passes in 1869-70 about ...	3,521
" " Darma and Byanse Passes in 1869-70 about ...	4,000
Total ...	10,521

It is sold at Bagesur at about Rs. 5 per maund, and by Almorah bunyas at Rs. 7 per maund. The Bhotias generally barter all their salt for grain.

Salt is also imported from the Punjab and Sambhur Lakes. Lahorí (Punjab) salt is generally most esteemed, and is considerably whiter than the other two. It averages from 2 to 3½ seers per rupee in the Almorah bazaar, whereas the Bhotia and Sambhur salts (of similar value) sell at from 4 to 6 seers per rupee, the fluctuations depending upon the amount available. The total amount of Indian salt imported appears from the accompanying statements to have been about 21,000 maunds, but this is probably below the mark, as no mention of it is made in the Gurhwal returns.

GOLD.—The amount of gold brought from Tibet and disposed of at Bagesur during the year appears to have been about Rs. 10,000 worth. It averaged Rs. 14 per tolah. It is collected in grains and dust from many of the Tibetan rivers, the authorities taking a percentage upon the amount realized.

SILVER.—Silver was brought down to these provinces from Tibet in former times. It was imported into that country from those surrounding it (probably China), and does not seem to be found in Tibet itself in any quantity. It was sent into Tibet in a crude state in lumps called *Doja* or *Thukka* of a general value of Rupees 165 each. Importations from that source have, I believe, ceased for some time, owing possibly to the great and growing influx of silver in the shape of rupees from British territory. Formerly all borax, salt, &c., was bartered for grain, cloth, &c., but now while a large amount is still disposed of in that way (probably to procure actual necessaries), still, whether it proceed from the increase of trade, and the portability of coin for hoarding purposes, or from the existence of a greater demand for silver in Tibet, by far the largest amount of borax is disposed of here for British money. And I may mention that the Bhotias state that our coin is largely current in Gurtok and the other large towns, and is preferred by the inhabitants there to the coinage of other countries. They ask for the Cheharádár Rupayá or face-printed money.

The Bhotia traders are only allowed to go as far north as Gurtok and Durchín. Further progress is impeded by the Tibetan authorities.

COPPER.—A large quantity of copper seems to be imported from the plains.

IRON.—The import returns seem to be 2,000 maunds from, against 155 maunds exported to, the plains.

LIME.—The returns show 1,00,000 maunds of lime sent to the plains from Ramnugger and Chorgullia only.

I forward herewith a return sent to me from Gurhwal by Captain Garstin together with some remarks by him thereon.

24th August 1870. A. W. LAWDER.

IMPORTS. *Chumphawut and Burmdeo.*

NAME OF MINERAL.	Number of Maunds.	From whence.	Value at Chumphawut.	Ultimate destination.	Value there.	REMARKS.
			Rs.			
Brass	...	The Plains ...	1,000	The Hills.		
Kansa (alloy of copper and zinc.)	...	Ditto ...	400	Ditto.		
Borax	9,000	Tibet ...	80,000	Pileebheet ...	1,25,000	
Coarse Salt (common)* ...	...	The Plains ...	10,000	The Hills ...	...	* Villagers purchase at Burmdeo and take to their houses in the Hills.
Ditto (common)† ...	4,000	Tibet ...	20,000	Petora, Chumphawut, and Burmdeo.	...	† Consumed in the Hills.
Salajit	...	Khurkdes and Nepal	10	The Plains.		

Petoragurh.

NAME OF MINERAL.	Number of Maunds.	From whence.	Value at Petora.	Ultimate destination.	REMARKS.
			Rs.		
Brass	...	The Plains ..	8,000	The Hills ...	Sold at the New Thul Fair.
Salt	4,000	Tibet ...	20,000	The Hills.	
Borax	16,000	Do. ...	1,60,000	Burmdeo and Pileebheet.	
Salajit	...	District ...	15	District.	

Ramnagar.

NAME OF MINERAL.	Number of Maunds.	From whence imported.	Value at Ramnagar.	Ultimate destination.	REMARKS.
Iron	55	The Hills ...	Rs. 10 per md.	Sold at Ramnuggur.	
Ditto	1,000	„ Plains ..	„ 8 „	Ditto.	
Copper	5	„ Hills ...	„ 70 „	The Hills.	
Ditto	300	„ Plains ...	„ 70 „	Ditto.	
Lead	10	Do. ...	„ 12 „	Ditto.	
Gold	...	Do. ...	„ 1,000	Ditto.	
Ditto Mohurs ...	...	Do. ...	„ 10,000	Ditto.	
Borax*	15,000	Tibet ...	.....	The Plains.	* Sold at Bagesur for Rs. 11 per maund, and at Ramnagar, when cleaned, at Rs. 22 to 24 per maund.
Salt (common) ...	15,000	„ Plains ...	„ 67,500	„ Hills.	
Salajit	2	„ Hills ...	Re. 1 per tola.	1 seer sold at Ramnagar, remainder to the Plains	
Lime (Stone and Tufa) ...	90,000	Do. ...	Rs. 18 per 100 maunds.	The Plains.	

Huldwani.

NAME OF MINERAL.	Number of Maunds.	From whence imported.	Value at Huldwani.	Ultimate destination.	REMARKS.
			Rs.		
Iron	100	The Hills ...	1,000	Sold at Huldwani.	
Ditto	1,250	The Plains ...	10,000	The Hills.	
Copper	...	Ditto ...	2,000	Ditto	
Lead	...	Ditto ...	500	Ditto	
Gold	...	Ditto ...	10,000	Ditto	In gold mohurs.
Sulphur	...	Ditto ...	50	Ditto	
Borax	7	Tibet ...	98	The Plains.	
Salt	...	The Plains ...	20,000	„ Hills.	
Salajit	...	„ Hills ...	25	„ Plains.	
Lime	...	Chorgullia, Bhabur.	10,000	Ditto ...	Sold at the foot of the Hills at Rs. 18 per 100 maunds.

Return of amount and value of all kinds of mineral produce brought

Name of Putti.	Name of Mine.	Description of ore.	How worked.	Probable number of persons employed during the year.	Amount raised for private use.	Amount of ore sold.	Amount of metal sold after smelting ore.
					Maunds.	Maunds.	Maunds.
Kutowlee	Suyalbarree	Iron ...	By digging rock ...	700	3	55	8
Ramgurh	Dusoula	„ ...	„ ...	4,300	160	500	200
„	Buna	„ ...	„ ...	2,000	90	200	65
„	Palee, &c.	„ ...	„ ...	2,200	120	150	72
Agar	Putbara	„ ...	„ ...	4,100	144	225	150
„	Mujera	„ ...	„ ...	4,300	112	330	130
„	Losgyanee	„ ...	„ ...	4,000	130	450	220
„	Nuthúakhan	„ ...	„ ...	4,300	135	525	235
„	Gulla	„ ...	„ ...	200	20	24	5
„	Súnkea	„ ...	„ ...	120	19	40	10
„	Chowkhoota	„ ...	„ ...	124	40	39	18
Lukhunpore ...	Munia	„ ..	„ ...	600	220	60	31
„	Chanee	„ ...	„ ...	500	32	18	12
„	Beena	„ ...	„ ...	300	16	22	12
„	Kanchoola	„ ...	„ ...	300	15	17	4
Darún	Ludholee	„ ...	„ ...	660	60	150	130
„	Madum	„ ...	„ ...	700	70	144	120
„	Ghoorkúnda	„ ...	„ ...	900	75	130	125
„	Mutkadria	„ ...	„ ...	750	52	126	132
Bungourh	Buna	„ ...	„ ...	5,000	300	800	400
„	Ookhulgara	„ ...	„ ...	6,000	230	600	300
„	Jirtolee	„ ...	„ ...	250	30	125	134
Gewarh	Khetsaree	„ ...	„ ...	9,000	80	600	300
„	Godee, Sirolee, &c. ...	„ ...	„ ...	8,300	65	700	250
Mulla Kutyoor ...	Lugthán	„ ...	„ ...	400	25	40	4
Tulla Johar ...	Mulla Mainskote ...	„ ...	„ ...	450	25	33	7
Kharaí	Lob	„ ...	„ ...	525	35	35	4
„	Goul	Copper	Deep shaft ...	4,000	1	13	9
Buraôn	Rai	„ ...	„	3,700	3	14	2
„	Belarh	„ ...	„	2,550	2	3	1
„	Lettee	„ ...	„	550	2	2	2
Tullee Row ...	Nace, Boree, &c.... ...	Iron ...	By digging rock ...	1,000	2	14	7
Seera	Agar	Copper	Deep shaft ...	100	.....	15	15

KUMAON;
CIVIL DIVNL. ENGR.'s OFFICE,
The 25th August 1870.

to market or raised for private use in Zillah Kumaon for the year 1869.

Amount of metal exported and to what direction.	Amount of metal imported and from what direction.	Mines of lead.	Mines of slates.	Mines of lime.	Remarks.
Maunds.					
10					Partly sold in the neighbourhood and partly sent to Almorah, Huldwani and Nynee Tal.
200					Ditto ditto.
75					Ditto ditto.
82					Ditto ditto.
125					Ditto ditto.
225					Ditto Ramnagar and to ditto.
192					Ditto
244					Ditto Huldwani ditto ditto.
7					Ditto ditto
12					Ditto ditto
16					Ditto ditto
12					Ditto Thul, Ramesur, Bagesur and Almorah.
12					Ditto ditto ditto.
7					Ditto ditto ditto.
3					Ditto ditto ditto.
70					Ditto ditto ditto.
60					Ditto ditto ditto.
50					Ditto ditto ditto.
48					Ditto ditto ditto.
400					Ditto ditto ditto.
300					Ditto ditto ditto.
125					Ditto ditto ditto.
300					Ditto Gurhwal.
400					Ditto ditto.
8					Ditto Bagesur.
12					Ditto ditto.
3					Ditto ditto and Almorah.
10					Ditto ditto ditto.
4					Ditto ditto and Thul.
4					Ditto ditto ditto.
3					Ditto ditto ditto.
7					Ditto Burmdeo.
.....					Ditto Thul.
	Salt, borax, gold, imported from Bhoot, north of Kumaon; copper, brass, lead, zinc and iron chiefly imported from the plains.	There is one mine of lead in Patti Kharal which is lying unworked.	There are many mines of slates in the District.	Limestone is plentifully found close by in almost every part of the District, except in the neighbourhood of Almorah and within a radius of about 15 miles therefrom.	

A. W. LAWDER,
Civil Divisional Engineer, Kumaon.

Return of amount and value of all kinds of mineral produce brought to market or raised for private use in Zillah Gurhwal for the year 1869.

Name of Putti.	Name of Mine.	Description of ore.	How worked.	Probable number of persons employed during the year.	Amount raised for private use.	Amount of ore sold.	Amount of metal sold after smelting ore.	Amount of metal exported and to what direction.	Amount of metal imported and from what direction.	Mines of sulphur.	Mines of slates.	Amount of Bhotia salt imported.	Amount of borax imported.	Amount of gundabiroja exported.	Remarks.
					Mds.		Mds.	Mds.							
Dhunpoor	Dhunpoor	Copper	Deep shaft ...	1,201	16	...	10	...							* Salt is brought from Tibet; its original cost is about 16 seers per rupee, but when sold in this District it averages about 8 seers, and Bunnyas sell at 5½ seers this year.
Ditto	Tachoda	Lead...	Ditto ...	100	1	...	1	...							† Borax is also purchased in Tibet. This year it has realized Rs. 22 per maund.
Mulla Nagpoor ...	Hat Jaisal	Iron...	Ditto ...	750	10	...	4	...							‡ The export of gundabiroja has been stopped, owing to the destruction caused to the Cheer forests by extracting it. It used to sell at about 5 seers per rupee.
Bichla Nagpoor ...	Agur Jakhtolee ...	Do. ...	Ditto ...	720	20	...	14	...							
Ditto ...	Goolet	Do. ...	Ditto ...	720	15	...	15	...							
Ditto ...	Bhookunda ...	Do. ...	Ditto ...	360	14	...	8	...							
Boongee	Buwanee Mudaoo Charn	Do. ...	By digging earth	100	7	...	4	...							
Lohba	Simulkhet	Do. ...	Deep shaft ...	700	50	...	50	30							
Mulla Dusolee ...	Churbung	Do. ...	By digging earth	100	25	...	50	...							
Nundak	Mokh	Do. ...	Ditto ditto ...	300	50	...	50	...							
Painoo	Chulya	Do. ...	Collected from different parts.	280	50	...	12	...							
Iriakote	Dandatolee... ...	Do. ...	Ditto ...	120	32	...	8	...							
Ditto	Pipulee	Do. ...	Ditto ...	60	6	...	3	...							
Seelee Chandpore ...	Rajboonga	Do. ...	Deep shaft ...	300	60	...	35	...							
Kurakote	Koos	Do. ...	Ditto ...	200	60	...	20	...							
Buchunsyoon ...	Doongra	Do. ...	Ditto ...	960	100	...	90	90							
										Unknown.					
										There are two mines of sulphur in Mulla Nagpoor and one in Mulla Dusolee which are all lying unworked.					
											There are many mines of slates in Puttees Goojroo, Chundkot, Gugwarsyoon, Khatsyoon, Iriakote, Dewulgurh, Bijlot, Khatlee, Choprakot and Lohba.				
												3,521 Maunds.*			
													473 Maunds.†		
														1,677 Maunds.‡	

GURHWAL;
SENIOR ASSTT. COMMR.'S OFFICE, PAORI,
The 18th July 1870.

C. J. GARSTIN,
Offg. Sr. Asstt. Commr.

Captain Garstin, in forwarding the Gurhwal returns, says (18th July, 1870):—

I have the honor to forward the annual statement regarding produce of mines, &c., in Gurhwal.

2. There is a considerable difference between the figures now shewn and those of last year. This will be the case for some years to come, till the Putwarees, who have to compile the returns, and the miners who give the information, understand better what is required. At present the latter suspect that there is some ulterior reason for the information being called for, and are therefore chary of giving it.

3. It is quite impossible to find out to what parts of the country the metals extracted are sent, or in what quantities, as they are not sold at fairs, in this district: indeed there are no large fairs, where sales take place usually. Those wishing to purchase go themselves to the miners and do so, and unless some person to register sales were appointed for each mine, it is quite out of the question to attempt any compilation of this kind of information.

4. Iron usually sells at 3 seers per Rupee, but if made up into vessels its price is $2\frac{1}{2}$ seers. Copper sells at Re. 1-8, or Rs. 2 per seer, if made into vessels.

5. As regards the statistics of salt, borax, and gunda-biroja since asked for by you, the return shews pretty nearly the quantities imported and sold and the prices prevailing. The latter article used to be exported in considerable quantities, but owing to the destruction caused to the Cheer forests in extracting it, this traffic has been put a stop to.

6. In conclusion, I would add that for the reasons given in my 2nd paragraph, too much reliance must not be placed on these statistics, all they are worth is to show approximately the quantities of metal, &c., produced.

7. This return would have been sent in before, but further information was lately called for, which had to be collected, and hence the delay.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1871. [May.

The Axial group in Western Prome, British Burmah, by W. Theobald, Esq., Geological Survey of India.

When examining the southern portion of the Arakan range, I applied the term 'axials' to a group of rocks which seemed everywhere to comprise the central region or axis of the range, but the relations of which to the newer or nummulitic group were not there very clearly displayed, partly from the nature of the ground and partly from the character of the beds which, though of great thickness, were very deficient in any salient points for arrangement and sub-division. In Western Prome, however, there is a great improvement in these respects, and the axial group is so well displayed that we obtain, not only a good insight into its relation with the newer group which adjoins it, but, from a few good sections, a tolerable conception of its own principal stratigraphical sub-divisions. The best and most illustrative sections are met with near the frontier, particularly in the Hlowa stream, where an enormous thickness of beds dips with much regularity and at a high angle, the section comprehending beds of both the axial and nummulitic groups.

As we go south the breadth of country covered by this group increases materially, and with this increase in breadth, there is a proportionate change in the arrangement of the beds, the high steady dip observable to the north there becoming replaced by a variable, and often extremely low, one.

At the frontier, these beds are 13 miles in breadth measured from the crest of the range at right angles to its general strike, which breadth is diminished to 7 miles at Shuedoung, a remarkable hill thirteen and a half miles south-west by south from Mendoon. From this point the 'axials' gradually expand till they attain their greatest breadth of twenty miles at Thabie Sukan, a halting place on the Arakan road.* The relations of the axial and nummulitic groups are nowhere better seen than along the frontier, proceeding west from the village of Sangyi. The road from Sangyi to Yebile (Yua-ba-lay in map) lies over an undulating and in part hilly country of the ordinary character seen within the outer ranges of hills composed of nummulitic strata. The forest is moderately thick and the low vallies rather well supplied with water, (considering that the previous rainy season had been very scanty, and most of the streams were unusually low in consequence). From many points along this line of road, the bolder character and denser forest of the main Arakan range formed a prominent and

* It would seem to have been no fortuitous circumstance that dictated the adoption by the Burmese of the line along which the Padoung and Tonghoop road (Arakan road) now runs, and which is the line along which the Burmese formerly transported, at great cost and toil, a colossal image of brass of Gaudama as a trophy of their prowess, from Arakan to their own capital. The road traverses the indurated rocks at the point where they are actually broadest, and where, in place of having to traverse ridges of highly inclined rocks, the road undulates over a series of spurs, whose ultimate origin must be looked for in the geological structure of the region.

grateful feature in the landscape. The village of Yebile, on the Moo-choung *(choung* or stream) is reached after a pretty sharp descent, and the same rocks as constitute the country traversed are alone to be seen in the bed of the stream.

No sooner, however, is the Moo-choung crossed in a westerly direction than we find ourselves among rocks of an entirely different aspect. These rocks (axials) are not only exceedingly disturbed, and along the boundary especially faulted and crushed, but are also indurated to a considerable extent, and often seamed with calcite. An excellent section of these beds is seen between Yebile and Kondaingzu (near Kondaingkeng of map), and again above that village still going west, in the direction of Pathi, situated on a considerable feeder of the Mahton stream two and a quarter miles from the frontier. The scenery hereabouts is very beautiful, and I know no more wild or picturesque part of Pegu than the Mahton valley near the frontier with its rapid and flashing waters winding between rocky hills clad in virgin forest. From Yebile to Kondaingzu the road lies up the valley and continues up it after passing that village as far as Kyoungtha, where it somewhat abruptly commences to ascend the lofty ridge east of Pathi. From the top of this ridge whose eastern slope is partly cleared for cultivation a magnificent *coup d'œil* is obtained displaying in panoramic order the lower ranges to the eastward and the more imposing and densely wooded ranges with their grassy peaks, west of Pathi. Of these the most conspicuous are Kyeedoung and Bomadoung which respectively mark the culminant points of the eastern and western Arakan range, though, strictly speaking, Bomadoung stands a little out of the general line of the range on a lofty spur, which stretches towards the Kyeedoung or eastern range, but separated from it by the deep gorge-like valley of the Mahton. The Arakan range in fact here bifurcates some four miles south of Bomadoung which is given off to the eastward, and of which the Kyeedoung range may be regarded as the continuation across the Mahton valley, whilst the westerly branch, or main range, after curving back a little runs north through the lofty peak of Myeen-ma-toung above the frontier. On the frontier the eastern and western branches of the range are eight and three quarters miles apart measuring from the Kyeedoung peak to the triple boundary of Birma, Arakan and Pegu. The Kyeedoung and Bomadoung ranges are not only higher than those to the eastward, but unquestionably more densely wooded on their slopes,—and more so I think than is usually the case even on the main range further to the south,—though their summits are in many places covered with tall grass, which gives them rather a tame appearance. I do not think that this great contrast between the vegetation and forest of these hills and of the outer ranges depends to any appreciable extent on the rocks composing them, but results from the injurious influence of hill cultivation as practised in Pegu, the initial step in which is the extirpation, as far as practicable, of all vegetable life over large tracts of hill side from which only a few crops of cereals or other produce will be derived, when the same process will be repeated over some neighbouring area. In the ridge east of Pathi we find an example of the incipient effects of the above process, which has as yet not gone the length necessary to produce the arid and meagre jungles of the outer ranges; but even here, there is an unfavorable contrast with the more westerly slopes of Kyeedoung and Bomadoung, where, I believe, no cultivation whatever has been attempted, and which consequently retain their virgin freshness, and whose slopes are still refreshed with those perennial rills which disappear before the system of hill cultivation as surely as the clouds of morning before the rising sun. Where water is deficient the character of the vegetation will be largely modified by peculiarities of the soil, especially its hygrometric ones, but under more favorable climatal or atmospheric conditions the influence of the soil is, with perhaps certain exceptions, less perceptible. An instance in point seems to be this very range east of Pathi which is well clad in forest, but consists of harsh grits which *primâ facie* would not seem so favorable to vegetation as the beds of the newer group to the eastward where, for the reason above given, the forests are sparse and arid.

At the village of Kondaingzu an enormous thickness of beds is displayed vertical in places, or with a high dip west by north. The grits and shales are very regularly intercalated, the grits varying in thickness from an inch to a foot. They are hard and of a prevailing grey or bluish color. The coarser beds are white-speckled,—which white-speckling is quite *characteristic of the upper portion of the group;*—and a few of the conglomerates are coarse enough to be termed pudding-stones. The shales are grey, rarely dark and often purplish brown, with a few beds creamy or whitish. The section of these beds continues well displayed in the stream as far as Kyoungtha, with no material reversal of dip, which is generally upwards of 70°, varying between east-by-north and east-by-south. Before reaching Kyoungtha, the dip becomes much less and the beds are seen dipping at low angles in the opposite direction, forming small anticlinal folds, but these excepted, the sequence of beds seems uninterrupted, though the great thickness would render it probable that a fault or two brings in the same beds over again. In this stream I noticed many blocks of limestone well rounded, but too large to have travelled very far, but I could not find the outcrop, neither was it known to the natives. It did not seem to contain fossils, and though at the time I was in doubt as to what group to assign it, a more extended examination of the 'axials' removed all doubt as to its belonging to them. At Kyoungtha the road ascends the Pathi range, but the rocks are not well seen. The prevailing dip is east-by-north, though in some places it is reversed. The prevailing beds are grits, thick bedded with rather glazed and rusty looking surfaces, especially where the rock is coarse and conglomeratic. The whole of the group thus far is much indurated and seamed with calcite, though nowhere displaying metamorphism proper. Directly, however, we cross the stream on which Pathi is situated and ascend the slopes of the range leading up to Kyeedoung, we find ourselves passing over a different description of rock, much of which is of a distinctly metamorphic character. Whilst, however, in places the schistose character is plainly developed, the general impress of metamorphism is essentially feeble, and the result ill-defined, and, so to say, spurious. In these softer schistose beds, however, quartz veins have replaced those of calcite, which occur in the grits of the opposite hill; a peculiarity one would hardly have anticipated, *viz.*, that the silicious grits be veined and seamed with calcite and the more argillaceous ones with silica, but I could not satisfy myself of any definite relation between either description of veins and any particular zone of rocks. A more extended knowledge of the axials, however, shows that, whilst a more perfect exhibition of metamorphism than any here seen occurs locally in these beds, such portions do not constitute or belong to another group, how dissimilar soever in character they may be, and this is nowhere more indubitably manifest, than where the metamorphism has been most marked. Such a case, for instance, occurs in the Hlowa stream above Yuathit, where a dyke of serpentine crosses the stream, and in contact with which several beds of the axial group assume quite the aspect of a hornblendic schist. A similar case on a somewhat larger scale is seen on the outer or eastern flank of Bidoung,— a huge hill of serpentine a few miles from the frontier,—the protrusion of which seems not only to have affected the axials in its vicinity, converting them into chloritic and diallagic slates, but by its mechanical action to have caused the great outcurving or deflection which the axial boundary here displays. Metamorphism, however, of this distinct character is always very circumscribed in its range and not so likely to mislead as the more subdued type, affecting a great thickness of strata as in the Kyeedoung range for instance; but whilst only speaking of this metamorphism as differing in degree, I do not consider it by any means established that the cause in either case is one and the same; and whilst referring the more local and exceptional action to the direct and immediate agency of the serpentine, I think it very questionable if that rock has been more than indirectly connected with the feebler and wider spread alteration to which the whole group may be said to have been subjected: the serpentine itself possibly being nothing more than the extreme product of the very forces which have induced the feebler but more widely spread alteration in the beds of this group.

The following section in the Hlowa stream above Yuathit will give a good idea of the general character of the upper portion of this group, though its upper limit is rather doubtful:—

Section of the axial group in the Hlowa stream above Yuathit (ascending)—

Lower Axials.

Dark and greenish flaggy shales.
Sandstones and shales.
Dark thin bedded shales with carbonaceous markings.

Upper Axials.

a.

	Ft.	In.
Thick bedded shales, passing into dark massive arenaceous shales with hard nodules interspersed, with *Cardita* (?), &c.	10	0

b.

Dark blue shale with a few sandstone bands	17	0	
Rubbly limestone conglomerate with a little blue shale, bedding rather indistinct	10	6	
Hard coarse conglomerate with a little fine sandstone	5	9	
			33

c.

Shales and sandstones in thick and thin beds	188	0	
Fine thin bedded grey argillaceous sandstones with shaly partings ...	34	0	
Do. thicker bedded	4	6	
Thick bedded sandstone in one and two feet beds with shaly partings	63	0	
Coarse hard sub-porcellanous grit	5	0	
Thin bedded shales and sandstones and one six-inch bed	68	0	
Conglomerate	3	0	
Shaly beds	21	0	
Hard argillaceous sub-porcellanous sandstones	102	0	
Shaly beds	102	0	
Massive argillaceous sub-porcellanous sandstones	34	0	
Shaly beds	21	0	
Hard sub-porcellanous sandstones	3	0	
Shaly beds	5	0	
Massive thick bedded grey, white speckled grits	25	0	
Do. but in thinner beds	129	0	
Shaly beds	25	0	
Thick bedded sub-porcellanous white speckled grits	43	0	
Do. but thinner bedded	12	0	
Dark shales and sandstone	51	0	
Bluish grey sub-porcellanous sandstones	21	0	
Dark sandstone and shales	129	0	
Dark shales	45	0	
Creamy blue sub-porcellanous sandstone	5	0	
Sandstone and shales (ill seen)	215	0	
Massive white speckled grit	11	0	
			1,364 6

d.

Shales and sandstones in from 6- to 18-inch beds	475	0	
Massive greenish grey sandstone	4	0	
Shales with a few thin sandstone beds	172	0	
Shales with a few thick beds of sandstone	475	0	
Sandstone with a few shaly partings	43	0	
Very massive blue and grey sandstone	52	0	
			1,221 0
			2,728 9

	Brought forward ...		2,728 9
e.			
Dark harsh shales and dark thin bedded grey sandstones, none over 4 inches in thickness	154 0		
Massive argillaceous sandstone	5 0		
Dark harsh shale and sandstones (as above)	319 0		
Do. but thicker bedded	25 0		
Do. but thinner bedded (as above)	129 0		
Shales and sandstones	344 0		
			976 0
f.			
Pale massive sandstones gritty and in places finely conglomeratic ...	103 0		
Pale sandstones gritty, grey and creamy and thin bedded	12 0		
Do. very massive	6 0		
Hard grey sandstone	26 0		
			147 0
TOTAL			3,851 9

At or near this point the junction of the nummulitics seems to come in, but this is not very clear, and it may be in reality a few hundred feet higher. A measured thickness of nummulitics now offers of ... ... 1,810 feet.
followed by an estimated section of ... ... 2,307 „
or fully 4,000 feet of nummulitics ... ... 4,117 feet.

The following epitomises this section :—

	Ascending.	Ft.	In.
Lower 'axials' (shales, &c.) seen, more than		300	0
	a.—*Cardita* (?) shales	110	0
	b.—Limestone shales, &c.	33	3
Upper 'axials.'	*c.*—Freckled grits, &c....	1,364	6
	d.—Shales and sandstones	1,221	0
	e.— Do. do.	976	0
	f.—Sandstones and conglomerates	147	0
		3,851	9

The Nummulitic section I shall give elsewhere, but as the upper beds of the group are not represented in it, the entire thickness of this group cannot be safely placed at less than 6,500 feet, and as the lower axials are, I think, thicker than the upper, 8,500 will hardly be an overestimate for that group, giving a total thickness of about 15,000 feet of beds throughout which fossils are so rare as to be practically of no use in sub-dividing so unmanageable a mass of strata or correlating even neighbouring sections. In spite of these drawbacks, however, the above section is valuable from the great thickness of beds exhibited without any reversal* of dip, and by its seeming to embrace the greater part

* My colleague, Mr. Fedden, in noticing this section, speaks of "something very like a fault," but his account is too meagre to be of much use in fixing the spot, and his section only embraces 800 feet of beds in all. He also speaks of the beds "rolling and dipping in various directions," which, I consider, conveys an inaccurate idea, if thereby any reversal of dip is implied, and again where he continues "doubtless these are a repetition of the former beds." It is true that the great thickness of beds here seen dipping with very general regularity, a little troubled in places, but nowhere reversed, would suggest the idea of faulted repetition of the same beds, but there is nothing in the beds themselves to countenance this. I do not think there are any faults cutting through the beds of the section given by me, and they alone could affect the question. Reversal of dip there is none also, and there only remains the question of obliquely folded beds. For this the group seems to me too thick. It is possible to conceive such a cause for the excessive thickness here displayed by some of the groups of shales, but then they appear to be in perfect sequence with beds which certainly have not been thus folded, such as the characteristic white speckled grits. It will be noticed that I have grouped the section into divisions; now, each division taken by itself presents a certain uniformity of facies and type, which in some instances might possibly result from the excessive plication of a comparatively small group of beds, but where these large groups of varied character follow one another, such a supposition is no longer tenable, and the only result is the conclusion that the entire section is a *bond fide* display of thickness,—a conclusion borne out by our knowledge and observation of the entire group elsewhere.

of the upper divisions of the axials, which is better defined than the other by the mineral peculiarities and appearance of some of its beds.

The section commences in what I have termed the 'lower axials,' an arbitrary division, but useful in dealing with so vast a group. These lower beds are entirely unfossiliferous as far as my knowledge extends, excepting perhaps obscure carbonaceous markings, or what may be annelid tracks, in some of the shales; at the same time, however, I cannot but think that they may yield some organic remains when more closely studied, and perhaps their lower beds brought to light, for at present I am ignorant of what constitutes the base of this group. They consist of shales and sandstones devoid of any marked character or distinctive beds and usually more or less harsh and indurated. The shales are mostly dark, grey, harsh, and meagre and comminuted or splintery from the pressure they have been subjected to; and it is along lines of crushing and faults, brine springs seem to rise accompanied often by an increased amount of induration of the beds in the neighbourhood. I cannot offer any estimate of the thickness of this division, but as it is nowhere cut through on any of the heavy sections in the Arakan range, its thickness must surpass that of the upper division, so that between 4,000 and 5,000 feet may be provisionally adopted.

The bed, or rather group of beds, which I have made the base of the upper division of the axials, has the advantage of affording what few fossils have hitherto been noticed in them, and of containing a limestone which serves over a great stretch of country as an unfailing indication of a particular horizon, whereby we are greatly aided in determining the relations of other beds also. Many other beds of this division likewise are very well-marked lithologically, so that where the limestone is not seen, we are still able to recognize the upper axials from some of these beds. Such, for instance, are the white speckled grits and pale or creamy sub-porcellanous grits and conglomerates, which form a strong contrast to any rocks either below them or in the upper or nummulitic group against which they occur. At the base of the upper group (just below the mouth of the Thayet stream in the Hlowa section) lies a considerable bed of dark shales, massive and arenaceous, characterised by a *Cardita* (?) which occurs in it rather plentifully, not unfrequently both valves being united. A few small and not well preserved *gastropoda* also occur, but the prevailing and characteristic fossil is the *Cardita;* a little above this occurs the limestone above referred to. It is here a rubbly rock mingled with conglomerate and shale, and forming a sort of composite bed, part limestone and part conglomerate and shale. From this spot (Hlowa stream) I extracted the first *Echinoderm*, and here I could find no other specimens; elsewhere, however, where the limestone was better developed, the species was not rare. Where well-developed this limestone is a homogeneous fine-grained rock, with a conchoidal fracture, and usually of some pale, or dark grey, or bluish, hue. In some spots (as south of Nattoung in feeders of the Thannee Choung) it occurs of various shades of pink and yellow, and I have noticed it converted into a coarsely crystalline white marble. In the Hlowa section I only noticed one bed of this rock, but to the south several minor beds seem to be developed about this horizon, whilst the bed in question itself assumes more important proportions.* This limestone can be traced at intervals along the outer or eastern edge of the group as far as it has been examined. Commencing near the frontier, loose blocks occur in the stream near Kondaingzu, though I did not detect the outcrop. It is again met with near the Mahton about one

* After the experience of the axial group acquired during the past season's work, I think there is little doubt that the Gwa limestone and associated conglomerate and much of the other limestone towards the southern extremity of the range will prove identical with this bed. This will be interesting, though its occurrence on the western slopes of the range materially diminishes the probability of our perfecting our knowledge of the lower portion of the group, as it would seem to indicate that the whole range forms a sort of huge anticlinal in its ensemble, and that the base of this group is nowhere exposed.

mile north-west of Lepangaing where it seems to strike west-south-west. Three miles north-east of this spot is a large patch of limestone forming a low ridge, and two and a half miles south of the first locality is another large mass forming the summit of a hill. The relations of this limestone are not seen, but the ascent to it lies over typical upper axial grits and shales with a high dip east-by-north to east-north-east. These three outcrops are, I think, all disconnected portions of the same bed, the great disturbance of the beds hereabouts being probably produced by the presence of the great serpentine mass of Bidoung hill six miles to the north-west.

Six and a half miles south of Lepangaing, the limestone is again seen in the section above given, where it appears to be unusually thin and poorly developed, but thickens again to the south in the Pemyouk stream and on the ascent to Shue-doung, and in two or three places in the Made (Mudday) stream where it is much disturbed.

(North of Nattoung, and about one and a half mile south-west from Thabiegaing, a limestone is seen on the crest of a low hill, very similar to, though differing from, any of the beds in the neighbouring series. From this spot I obtained a single ill-preserved valve of a *Halobia*, which is very closely allied to, if not identical with, *Halobia Lommeli*, as determined by Dr. Stoliczka. This would indicate a triassic age for the rock in which it occurs, but the relations of this could not be satisfactorily traced.)

Still going south, the limestones referred to above occur at intervals, and display a distinct tendency to approach the boundary of the group. At one and a half mile south-south-east of Nioung-jadouk, it occurs on a hill top very close to the boundary, and still closer to it, above the village of Quienhla (Kwenghla) five miles west-south-west of Akouktoung. In a word, as we proceed south, the Nummulitic boundary cuts back into the axial group, until a little below the parallel of Akouktoung the great and characteristic series of upper axials has almost entirely disappeared, very gradually certainly, from the oblique angle at which the boundary intersects the strike of the beds. The complete elision of this upper group to the south is well seen at Chinuagi (Kyeng-yua-gyee) three miles south-by-west from Quienhla. The stream above Chinuagi seems to display mostly shales of the lower group, and just south of the village in the bed of the stream highly altered sandstones come in of the usual harsh character of so many beds belonging to this portion of the group. Not thirty yards below them comes in quite unaltered a calcareous sandstone profusely charged with Nummulites. The boundary is here fixed within a few yards and strikes through the centre of Chinuagi village, and at this point would seem to completely cut out the whole upper group.

Above the limestone occurs an enormous series of sandstones and shales, which in the section previously given, I have sub-divided into small groups. The lowest of these (*c*) is over 1,300 feet in thickness, and contains a number of very characteristic beds, such as white freckled grits* and conglomerates, not usually very coarse, though now and then coarse beds, almost breccias, are seen, and cream-colored argillaceous sandstones sub-porcellanous, and sometimes offering a 'lithographic' look. Small white quartz pebbles abound in the finer conglomerates, but the coarser conglomerates are mainly composed of fragments of argillaceous subschistose rocks which suggest the idea of their derivation from beds of the lower group. The coarsest beds I anywhere noticed occur in the Shu (Shoo) Choung above

* My colleague, Mr. Fedden, in describing these rocks in the Made valley, on the ascent to Shuedoung and elsewhere, has given emphasis to this peculiar character of *white speckling* in some of these beds by terming them 'a porphyry or altered grit.' The term "porphyry" is of course inadmissible, though the beds often greatly resemble a porphyritic trachyte, and it is clearly to their external aspect only that Mr. Fedden refers when using the term.

Sabatan. In the lower part of the Shu an enormous thickness of beds is fairly exposed, but greatly disturbed and faulted; hence the junction of the Axial and Nummulitic group is not clear. Higher up the stream the dip is more regular, varying from north-east by east to east-north-east, but always high. Some of the sandstones are hard and have strings of quartz pebbles irregularly disseminated through them, and sometimes the pebbles constitute bands through the rock. In one instance I noticed a quartz boulder in one of these conglomeratic sandstones, 6 inches in length, among the finer constituents, but such a case is rare. Some of the coarser beds, however, on this stream tax my power of describing adequately. The most remarkable was a little below a spot where a wall of rock makes the channel almost impassable, a sandstone, with here and there huge angular schistose fragments embedded in it. I satisfied myself that the fragments were really derivative and not the result of any segregative process in the rock itself. Some of these angular pieces very little worn by attrition were more than a cubic foot in content. I have not noticed any similar bed elsewhere, and it is probably local as respects the peculiarity of its included fragments. The general variety of coarse conglomerate is that of a rock mainly composed of partially rounded or well-rounded fragments with very little matrix, in some instances verging on a breccia in aspect and origin, but these beds are local and exceptional, though perhaps belonging to the upper group and characteristic of it.

Above the last group (*c*) occurs a vast thickness of beds which I have sub-divided into three groups (*d*, *e*, *f*), all of which occur in uninterrupted sequence, but each possessing a certain appearance which distinguishes it from the other. In the aggregate the thickness of these groups is over 2,300 feet. But though it is tolerably certain that the whole of these belong to the Axial group, it is not equally certain that none of the beds included in the Nummulitics do not belong to the former group, as from their disturbed condition the beds themselves do not give very precise ground for drawing the line between the groups with exactness.

I shall now pass to the consideration of the imposing hill of Shuedoung at the head of the Hlowa valley, returning to the remainder of the Hlowa section when describing the Nummulitic group.

Shuedoung or Shuaylounggyee, situated fourteen miles south-west from Mendoon, is one of the most conspicuous and picturesque hills in Pegu, not so much from its actual height as from the abrupt way in which it rises from among the lower hills which encircle it, and from the exceedingly rugged and precipitous character of its outlines.

It is situated between the sources of the Hlowa and Pemyouk streams, and marks a remarkable change in the Arakan range, of which in some respects it is the culminant peak. Instead, however, of the range continuing its course northward past Shuedoung, it here takes a sharp sigmoid curve to the westward, before again trending north; giving thereby the appearance to Shuedoung of standing out from the main range like a promontory round which the sources of the Hlowa wind, so that the drainage pertaining to the Pegu side of the mountain, received by the Hlowa and Pemyouk streams, represents an arc of no less than 300 degrees at least, with the hill as a centre. The hill itself is a ridge of 'axial' shales and grits, much indurated and culminating in a serrated cluster of rugged pinnacles. The prevailing strike of the ridge corresponds with the normal strike of the axials, and is about north-north-west, and viewed from the north the bedded structure of the rocks composing the hill is plainly perceptible, but from an easterly view the hill presents all the appearance of being composed of some granitic mass, so sharply curved and defiant are its tor-like crags. The ascent is effected over two long spurs, one to the north, running down into the Hlowa stream, the other to the south into the Pemyouk, my colleague selecting the latter whilst I ascended by the former route. From my colleague's account of his ascent from the south, it is abundantly clear that the beds on that side are higher in the series than those on the

other, and that a local change in the direction of the beds has occurred, as his account reveals, circumstantially enough, the characteristic beds of the upper axials, whilst to the north these beds are replaced by shales of the lower group. A great deal of disturbance here occurs, resulting no doubt from the sharp bend and dislocation as regards its general bearing which the range has here undergone, but the mineral character of the rocks sufficiently indicate their general relations. On the south side, my colleague records, 'shales, and a bed of argillaceous impure limestone,' also 'fine grained speckly white, and green, rock,' and on the summit a porphyritic or altered grit. On the ascent from the north by the Hlowa stream, we find none of these beds, which, however, are seen in the Hlowa, lower down where my section is taken, but in their place at the point where we quit the stream bed, indurated shales, dark and harsh, such as mark the lower group. Higher up the ascent, softer shales are passed over, and at the highest point gained by me, a sort of ridge running down from and in the line of strike of the northern extremity of the hill, indurated grits not very well characterised. There was throughout these beds a somewhat notable scarcity of quartz veins, which, in such a focus of disturbance, I should have expected to find more developed. My colleague found serpentine in profusion, but on the Hlowa spur there was none excepting a very insignificant patch, like a dying out vein, on the summit. No trace of serpentine is seen in the Hlowa where the ascent commences, so that no considerable development of this rock occurs on the northern flanks of the hill, how common soever to the south; and this distribution of the serpentine tallies with many observations elsewhere, that the serpentine seems to affect a certain geological horizon, namely, that of the upper axials, but occupying a low position in them. It would convey an erroneous view to describe Shuedoung as the culmination of the line of serpentine outbursts running up from the south-south-east, since, waiving the remark that Shuedoung is not a serpentine outburst at all, I would observe that though Shuedoung may be described as a somewhat abnormal culminating peak of the Arakan range, yet it, from that very fact, does not lie within the 'line of serpentine outbursts' properly so called, which generally occur within the outer ranges. Serpentine occurs in Shuedoung, and this is the only instance yet known to me of that rock occurring on the actual watershed of the range, the line of serpentine outbursts usually traversing the outer hills. This deviation from its usual position in the hills seems accounted for in part by the fact before alluded to, that it seems to follow not so much a geographical zone of country as a certain geological horizon. This horizon, a low one in the upper axials, very exceptionally crosses Shuedoung; the main range more usually being solely composed of beds far lower in the series; hence, the presence of serpentine on Shuedoung is not at variance with its relations elsewhere to the surrounding rocks, though not on the 'line of serpentine outbursts,' (if we generalize these phenomena,) the general strike of which line corresponds with the general strike of the adjoining beds.

In strong contrast with the Hlowa section is that seen along the line of the Arakan road. The breadth of the axial group at Shuedoung is barely seven miles, and most of the beds on this line belong to the upper division of the group. At Thabie Sukan on the Arakan road, the breadth of the group is over 20 miles, of which not a fifth belongs to the upper division. Here then, we might expect a fine section of the lower group, but the value of this section is inversely in proportion to the length of ground it covers, and we see great complexity of dip and undulations of strata without the instructive section displayed in the Hlowa. In addition to which must be added the absence of any fossiliferous bed or marked mineral group in those lower axials to enable us to divide or classify them.

I will here describe the mode of occurrence of the serpentine and its relation to the rocks I am now treating of. Serpentine, though widely distributed, nowhere occurs in patches of very large extent, if we perhaps except the Bidoung hill. It occurs in two ways, which may be conveniently considered separately (though perhaps the main

distinction between them is merely one of degree) that is, in detached outbursts assuming the proportions of low hills, and as veins or dykes traversing the 'axial' strata. The most important development of this rock, throughout the country north of the parallel of Akouktoung, is the Bidoung hill, five miles south by east of Pathi. This serpentine area is five miles in length by from two to two and a half in breadth and is divided by the Mahton: Bidoung standing on the west side, faced on the east by a hill of hardly less height. These two hills indicate the great bulk of the serpentine along an axis stretching north by east, but from the easterly hill a small range runs nearly due south impinging on the Mahton at Keinggye, though the serpentine stops just short and is not seen here in the river. This most important development of serpentine illustrates the remark I have before made of that rock affecting the outer rather than the central hills. Descending the Mahton from the north, Bidoung hill is seen straight ahead of the river channel, and so distinctly is the bulk of Bidoung dissociated from the spurs of the main range, that without reference to the map, it is doubtful which side of the hill the Mahton is about to flow, but on reaching the hill it flows round its east flank through one of the prettiest gorges conceivable. The character of the rock is proclaimed by the stunted vegetation covering it, but where cracks have allowed the retention of moisture, trees, especially the Thitsi (*Melanorrhœa usitatissima*), have taken hold, favored of course by the generally cooler and moister air of the country close to the densely wooded main range. Large surfaces of rock, however, are absolutely and in the most literal sense bare of all verdure and impart a distinctive character which, once seen, cannot be mistaken. I have already remarked on the metamorphism developed among the 'axials' on the flanks of Bidoung, but the intrusion of this mass of serpentine seems to have produced even a greater mechanical result, in the deflection of the axial boundary here to the eastward. The boundary is not perhaps so sharply defined as in some spots, but I regard the channel of the Moo stream as very nearly coinciding with it, or in fact resulting from it. South of Lepangain, too, the boundary seems to find physical expression in the conformation of the surface, but for a few miles east of Lepangain the boundary is obscure, and few rocks are seen through the jungly undulating country which intervenes. The fact of the general outward deflection of the boundary is not, however, in the main affected by a little ambiguity in detail, and the *curve so corresponds to the great mass of Bidoung serpentine*, that taken together with the excessively disturbed condition of the rocks hereabouts, we are forced to regard the cause of these appearances as nothing more nor less than the mechanical intrusion of that hill mass.

The next considerable development of serpentine occurs as a low narrow ridge of some three miles in length intersected by the Made stream, and situated on the junction of the axial and nummulitic groups. This ridge, which must often be less than the third of a mile in breadth, seems as though it were a huge dyke or wall of rock occupying at this spot the boundary itself. Above it very considerable disturbance exists among the axials, and enormous masses of the limestone are seen in the bed of the stream, much affected both chemically and mechanically. This action is not so well, if at all, noticed in the nummulitic group, and whereas the upper axials are repeatedly seen thus altered, I do not remember any similar amount of metamorphism in the nummulitic group, though here it is contiguous to a very considerable mass of serpentine which has characteristically affected the lower group.

The next considerable mass of serpentine is that which constitutes Nattoung a prominent hill between the Made and Thanni streams. The rock here rises into two peaks, that of Shinbaian to the north-west and the somewhat higher one of Nattoung to the south-east, giving a length of about three and a half miles in its long axis.

Two miles west of Laidi on the Thanni channel occur two small patches of serpentine forming the twin peaks of Thitsidoung and Huordoung. These patches are separated by

'axial' strata, but midway between them like a link is a very minute patch of serpentine of a few yards in diameter, probably a dyke. Thitsi hill is in fact a miniature of Nattoung, as Nattoung is of Bidoung, and no other similar outbursts are known to me within the area under review. All the other localities seem to fall under the category of veins subordinate to the axials they traverse, but be they all connected or not, the rock throughout is one and the same whether occurring in veins or developed in masses like Bidoung. Serpentine veins are far from infrequent in the upper axial zone, and I rather think they are confined to it, or to within a short distance of it. Certain it is that I can recall no instance of their occurrence in the older division of the group, or where the upper group is not present likewise. The horizon indeed which these veins seem to affect is one near the bottom of the upper axials, and we are pretty certain to find the characteristic limestone of this division not very far from the outcrop of serpentine. The limestone is frequently altered and sometimes only occurs sparingly, but it is usually to be seen, or some other of the equally characteristic beds of this horizon. The veins are always small and usually associated with a species of steatite from which the Burmese manufacture pencils for writing on black boards. I cannot affirm that this steatite is always associated with serpentine, but such is the case usually. This steatite is called 'kangu' and is largely imported from Upper Burmah. There are, however, numerous places in Western Prome where it occurs and where it is extracted for local use. It usually occurs in small pieces lying loose in the decaying rock and not commonly in pieces larger than a hen's egg. It occurs in shale (and also far to the south, as noticed in a previous report, in sandstone) and appears to be the result of a segregative metamorphism. It is not an intrusive rock or mineral and yet its component atoms must have enjoyed complete mobility, and its formation seems due to the re-arrangement of the constituents of certain beds of the axial group, through an influence which may have resulted from the presence of serpentine veins in the vicinity, for there seems a decided connexion between the two.

A curious variety of this rock is sometimes seen closely simulating a conglomerate. The dark steatite occurs in various sized nodules or amygdala, from the size of a hemp-seed or less to that of a small egg. These nodules are smooth and burnished and impacted in a matrix of white fibrous quartz, in just sufficient quantity to separate the nodules of steatite, but still forming a very inconsiderable proportion of the rock. Excellent samples of this variety occur on Shinbaian hill, and here I could detect no instance of the steatite enveloping any portion of quartz, but where the two minerals are more equally proportioned I believe either indifferently envelopes the other. The mineral occurs of various tints from pale grey to black, the paler varieties being esteemed the purest and most suitable for writing. The very dark varieties approach a shale in character, and may be regarded as peculiarly altered shale: some pieces display very distinct fissures or shrinkage cracks, and all the appearance of having been once in a plastic state.

At Shinbaian hill just on the flanks of the serpentine, or before that rock is quite reached, a considerable quantity of the above varieties is developed on the hill side and also a more massive or compact variety than is usually seen. This variety occurred in regular strata of from 6 inches to a foot in thickness, but unequally developed. The more massive portions broke with a clean but earthy fracture, and dull surface, and much resembled in general appearance a claystone; but this dull variety passes into the ordinary sort with highly lustrous surface planes and the quasi foliated structure as seen in pure spermaceti; and the association of the two suggests that the latter merely consists of the finer portions eliminated by segregation from the other. The common shape for the finer sort to spontaneously break up into or arrange itself is that of rudely amygdaloidal pieces, with curved ends, either the result of pressure, or of some modified form of crystallization. The highly

burnished surfaces which traverse the rock might seem to indicate the former cause and in appearance certainly resemble the 'slicken sides' in a coal shale, but the peculiar arrangement of the steatite amygdala and their enveloping layers of quartz strongly contra indicates this idea, as there is no crushing or subsequent re-cementing of these brittle quartz layers, as would be seen if the burnished surface of the included nodules were due to pressure. Pressure has then nothing to do with the production of the smooth surfaces traversing the finer sorts of the steatite and displayed on the surface of its nodules, and the phenomenon is due to some peculiar form of segregative action whereby the nodules themselves originated from the finer portions of the adjacent rock. I think I am warranted in regarding this steatite as a mineral species, although it sometimes exhibits a passage into a form to which that term might be less applicable. Some of the largest lumps of the compacter variety of the mineral are pale grey distinctly tinged with pale yellowish or leek-green, or perhaps rather green than grey, lustre rather waxy, and decidedly tough, especially in a direction across the polished foliation planes which are rarely absent in the mass.

The serpentine is everywhere very uniform in appearance, but in some spots, as west of Laidi, a rock is associated with it like an ordinary greenstone. I think it not quite certain that this rock is not an altered one, or if not a bedded rock or shale altered, I should regard it as a variety of serpentine produced by the reaction of the bedded rocks on it; my reason for so judging being the trifling and insignificant development of it, its obscure relations and the unlikelihood of a mere patch of rock of this character appearing here and there in the merest indications, if not a part of, and subordinate to, the general serpentine effusion in the neighbourhood. Nowhere else does this trap rock appear as an independent formation, but merely here as a very feebly developed satellite of the widely diffused Serpentine.

Sketch of Geological structure of the Southern Konkan, *by* C. J. Wilkinson, Esq., *late of the* Geological Survey of India.

The South Konkan is in its northern part composed of trap rocks, covered to a varying distance from the sea by laterite. Where the latter rock is present it gives a monotonous aspect to the country, forming an undulating and in some places quite flat plateau, the surface of which is a sheet of rock, black and slag-like externally. This laterite plateau, which has a general elevation of between two and three hundred feet, has a bare black appearance, supporting no vegetation, except scanty grass and stunted trees here and there. There are places where the rock has been denuded, and here owing to the presence of thicker soil, the ground can be cultivated.

It is cut through by numerous rivers, the largest of which rise in the ghâts, and after flowing through comparatively open trap country, enter the laterite through deep ravines, which widen towards the sea, the rivers becoming broad tidal creeks. In these ravines, along the banks of the rivers, villages are generally situated, and every available spot of the rich alluvial soil is cultivated for the production of rice and other grain. At the sea coast the laterite forms bluff cliffs, in the lower part of which trap is disclosed.

At Rutnagherry, &c., in well and other sections, the trap is found to be overlaid by a thickness of a few feet of white clay, imbedding fruits and containing thin carbonaceous seams composed for the most part of leaves. This is separated from the soft laterite above by a ferruginous band about an inch thick, having much the appearance of Hæmatite. It

is vesicular, the cavities being filled by quartz, &c. The soft laterite soil above hardens on exposure and this rapidly. It is very thick here and along the sea coast, trap only becoming disclosed in the deep sections and at the base of the cliffs. In proceeding inland, however, it is found higher up in the hills, which seems to show that it has a westerly dip, though it is very difficult to determine the amount, as all the sections are so covered by the detritus from the laterite. East of Rutnagherry, the latter rock extends for about fifteen or twenty miles; beyond this the trap hills are more irregular in outline and increase gradually in height towards the ghâts. The eastern boundary of the laterite runs west of Lanje in a south-east direction, passing east of Rajapur to Khareputtun. South of the latter place its direction has been more correctly determined.

About Phonda it is found nearer to the ghâts than in other places, it then bears to the south-west, meeting low trap hills which run out from the ghâts at the north of the Sawunt Waree state. The lower beds of this pass under it about half way between the ghâts and the sea. South of this the width of the formation becomes much less, and it extends as a band ten or fifteen miles wide along the western boundary of the state and in the narrow strip of British territory by Vingorla, &c.

It occurs in great quantity in the Goa territory. In speaking of the laterite boundary, I refer to that of the plateau which has a very constant elevation, and consists, as I have mentioned, of a series of flat-topped or slightly undulating hills separated from one another by deep ravines, which have been excavated by the rivers which drain the country.

There are numerous instances where this rock occurs further east, forming patches which in many cases may be outliers of the great mass, though oftener occurring at a lower level, being the products of the denudation of the older laterite. These often have the appearance of true laterite, but are more generally found as gravel, sandstone, conglomerate, &c.

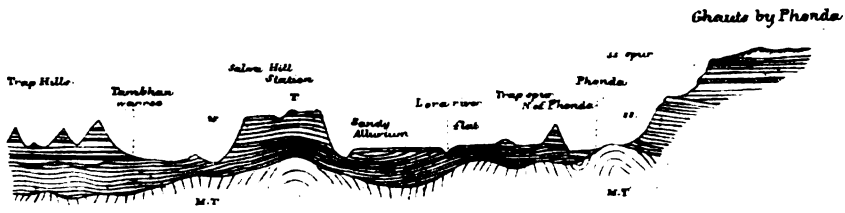
The country east of the laterite boundary is more varied in aspect. The rivers rising in the ghâts run westward between lofty spurs for some miles, and then emerge into lower and more open country, which continues up to the scarped edge of the laterite hills. These spurs in the northern part of the district consist entirely of trap, the lines of flow of the beds in them being generally easily traceable, and merging at their eastern extremity into the main range of the ghâts. These beds having been irregularly denuded, the result is, that conical peaks have been left, which vary the otherwise even outline of the hills. These peaks are generally surmounted by a sharp black point of rock. A good example of this occurs in a spur south of Phonda which runs out westward from the ghâts. In the peaks on this, portions of a thick bed of black columnar basalt are seen, the bed of which these are outliers being very conspicuous in the ghâts themselves.

The metamorphics, &c., skirting the southern boundary of the trap are at a low level generally. The rock immediately under the trap is a white, yellow or pink altered sandstone, associated with shales and lying unconformably on the older metamorphic rocks.

The evidence tends to show that this sandstone formation was originally much thicker, but it was much reduced by denudation before the outpouring of the trap, and this thinning has subsequently been carried on still further by other denudation affecting both it and the overlying rock.

About Phonda and the country to the west, this sandstone (quartzite) is well seen, forming an open patch of country about ten square miles in area and enclosed within the trap boundary, this rock with the exception of one or two isolated masses having been entirely denuded.

In the north-west corner of this sandstone area there is a group of hills, of which one, Salwa hill, is about eight or nine hundred feet high. The arrangement of the beds in the main mass of the hill is difficult to determine, as the sides are thickly covered with detritus



Sketch Section of Salwa and adjoining hills in Southern Konkan.

and jungle, but at the western base shales generally associated with this sandstone occur, dipping slightly to the west and passing under the trap at its boundary, whilst the summit of the hill is formed by a thick bed of sandstone pink in colour, and either horizontal or perhaps with a very slight dip westward. There are other high hills or spurs on the edge of the ghâts formed of sandstone lying on metamorphics which are partially disclosed and capped by the same thick bed of sandstone, here dipping eastward, the two portions of the beds on the respective hills being apparently the remains of a low anticlinal axis. The parts of these beds which intervened have been swept away, possibly before the trap covered up the country. The first flows of trap poured into the hollows between the hills, for at the boundary of this patch of sandstone the trap is generally found at their bases. As the successive flows of trap surrounded them, the highest ones remained probably as islands in a sea of trap. Finally they became covered up by some of the higher beds, which are now only seen in the scarped sides of the ghâts a few miles eastward. As I have mentioned, this trap with the exception of one or two patches, has since been denuded. The effects of denudation on the trap west of Salwa hill are rather curious, for side by side with this hill, their bases almost touching, is another hill quite conical in shape, and formed entirely of successive beds of trap. The two are nearly equal in height and present a strong contrast to each other, the trap hill conical in shape and almost devoid of vegetation with the lines of flow of the trap showing black and strong, and the sandstone hill, long, flat-topped and thickly wooded.

The country south of this patch of sandstone is covered by a band of trap about ten miles wide. The lowest beds of this are approximately at the same elevation as the laterite plateau to the west under which they pass, but there are lofty spurs running out on them formed of higher beds. When the trap passes under the laterite, it no longer influences the aspect of the country which is now a slightly undulating plateau intersected by deep ravines, in which trap, sandstone, and often the older metamorphics, are disclosed.

The southernmost boundary of the trap bears in a direction west by south along the north side of the valley formed by the Usya Mut (or Kimkaoli) river. From Ramgurh it bears more north-west, and is found down to the sea at Kunkeshwar just south of Deogurh.

In the Usya Mut valley, which is the northern boundary of the Sawunt Waree state, the older metamorphics are disclosed, and from this southward the denudation of the country before the outpouring of the trap appears to have removed most of the sandstone, which conceals the older metamorphics almost entirely more to the north. The metamorphics only

attain a very slight elevation about this part of the country, and outlying trap is found capping them to the south of the valley forming low comparatively flat-topped hills, varied by higher spurs to the east of Kolsooli. This trap also becomes concealed under the laterite, south of Kunkooli (Usya Mut), the edges of the bed (for it seems as if only one bed extended far) being seen in the scarped sides of the laterite hills not far from their summits. Still further south-west and extending almost to Malwun, outliers of trap are found overlying the metamorphics and under the laterite.

South of the trap hills and spurs which are found in the northern part of the Sawunt Waree state, the metamorphic rocks attain a greater elevation, forming lofty spurs in the neighbourhood of the ghâts. The earlier trap flows abutted against these hills, but it was only the higher beds which could have concealed their summits, and as you go south outlying patches are still found capping the great metamorphic ridges, even as far westward as the town of Sawunt Waree, on the hills which surround that place.

In the ghâts the older rocks attain a greater and greater height, and are only covered by two or three beds of a very inconsiderable thickness.

There is a curious example of outlying patches of the highest beds of the ghâts in the shape of small slab-like masses of trap rock left on the most elevated parts of the spurs. These from their almost inaccessible position were long ago chosen as sites on which hill forts were constructed. They are generally separated from the ghâts by a deep gorge. As examples of these forts in the Sawunt Waree state may be instanced those of Rangna, Monohur, Hummutgur, Pargurh, Suda, &c.

The Sawunt Waree state is composed for the most part of metamorphic rocks, but there is at the northern part, as I have mentioned, a considerable quantity of trap, and on the west the narrow band of laterite. These with the ghâts on the east form physical features which serve as a sort of natural boundary to the country. The great metamorphic spurs which run out west from under the mural termination of the Deccan trap at the ghâts, extend to varying distances, and either end abruptly or break into clusters of lower hills. The intervening country is low and covered with thicker soil than is usually the case in the Konkan: this renders the Sawunt Waree state more open to cultivation than the barren laterite plateau to the west and north.

The soil is obtained from the disintegration of the metamorphic rocks, and is light coloured and clayey, though fine sandy soil occurs as frequently, being derived from the quartzite and altered sandstone so abundant in the district.

Along the alluvial banks of the rivers, rice is extensively cultivated during all the fine season, a system of irrigation being established by means of Persian wheels and other contrivances. By these water is constantly raised from the beds of the rivers, and distributed by channels to the different plots of rice ground in the neighbourhood, these fields having been previously prepared. They consist of rich alluvial mud traversed by numerous little channels for the water, crossing each other at right angles. When the country cultivated is inclined at any angle, an arrangement of step-like embankments is constructed, each surrounded by a little mud parapet, a few inches high. The water after thoroughly saturating one field is allowed to escape into the next below, through an orifice cut in the parapet. This system of irrigation is very generally made use of throughout the Konkan.

On the supposed occurrence of Native Antimony in the Straits Settlements, by T. Oldham, *Supdt., Geological Survey of India.*

About the middle of December last, a specimen of a beautiful silvery metallic substance was forwarded to this office from the Home Department, with a request that it might be analysed and reported on. It was stated to have been discovered in the Straits Settlements, but no locality was given.

On examination it proved to be Native Antimony, of great purity, yielding no trace of arsenic or of silver, and only a slight trace of iron and also of sulphur. This was reported to Government, and it was stated that if it occurred in any quantity, the discovery was a very valuable one. A nearly pure mineral like that forwarded would always command a market, and would realize about seventy-five pounds (£75) per ton in England. Enquiry was made as to the locality where found, &c., and a more recent letter from the Secretary to the Straits Government, states, "that it was found on Pulo Obin or Ubin, an island lying at the east end of Silat Tambran, the strait dividing Singapore from the mainland; that a careful search had been made, and a reward offered to any person finding more of the same, but that up to the present time (15th February 1871) no more had been discovered, and that it seemed probable that the specimen received by the Government must have been introduced into the island from some other place as yet unknown."

Native Antimony also occurs in Borneo, Sarawak, &c.

On the composition of a deposit in the boilers of Steam Engines at Ranigunj, by T. Oldham, *Supdt., Geological Survey of India.*

During a recent visit to the Ranigunj collieries, I was struck with the amount and character of the deposit in some of the boilers of the Engines in use there: and was desirous of ascertaining the true composition. By the kindness of A. Stuart, Esq., the General Manager of the Bengal Coal Company, I obtained specimens. The specimen examined by Mr. Tween, Curator of the Geological Museum, was taken from the boiler at a deep pit near Ranigunj known as No. 36. The water, which feeds the boilers here, is all derived from the mine itself, passing from the pump heads through a filtering wall of fine sand, and received in a masonry tank, where a certain amount of fine matter is deposited on settling. This water, as it passes to the boilers, looks bright, clear and pure, has no taste, is hard, but not unpleasant, and altogether looks clear good water. From its use, however, a large amount of deposit results. This is thrown down in a fine almost impalpable powder, which, when dried in the air, is of a light ash-grey tint. Some of this was carefully dried by exposure for five hours at a temperature of 212° Ft., and the dried powder then analysed.

It gave a percentage composition as follows:—

Water	7·2
Organic matter	2·1
Insoluble clay	8·8
Iron and alumina	1·23
Carbonate of lime	47·67
„ of magnesia	33·00
	100·00

This shows that the deposit consists chiefly of carbonates of lime and magnesia, which, doubtless, have been taken up from the calcareous and dolomitic sandstones, so frequent in the upper series of the Ranigunj field, by the surface water when passing through these rocks to the bottom of the mine.

The organic matter showed as a slimy dark substance separated on the filtering paper.

As the water comes from the mines, the principal apparent impurities are minute particles of coal-dust, and shale mechanically mixed with it, while it is certain that a portion, at least, of the iron will have been derived from the rusting of the pumps, &c. But it will be seen that more than three-fourths of the whole consists of the carbonates of lime and of magnesia held in solution in the water.

NOTE ON THE PLANT-BEARING SANDSTONES OF THE GODAVERY VALLEY, ON THE SOUTHERN EXTENSION OF ROCKS BELONGING TO THE KÁMTHI GROUP TO THE NEIGHBOURHOOD OF ELLORE AND RÁJÁMANDRI, AND ON THE POSSIBLE OCCURRENCE OF COAL IN THE SAME DIRECTION, BY WILLIAM T. BLANFORD, Deputy Superintendent, Geological Survey, India.

Recent explorations in the Godavery valley below Sironcha, and in parts of the adjoining country, have enabled me to ascertain that a very large area is occupied by representatives of the various formations which have been described in Bengal and the Central Provinces under the names of Panchet, Damúda, and Tálchir. The occurrence of sandstone in the bed of the Godavery and along its banks throughout a large portion of the river's course below Sironcha was, I believe, first made known by Mr. Wall in the Madras Journal of Literature and Science, New Series, Vol. II. It now appears that sedimentary beds belonging to the Damúda group and its associates extend, apparently without a single break* from the neighbourhood of Mánglí and Phizdúra, 34 miles in a direct line north-north-west of Chánda, to Lingálá on the Godavery, just above the top of the first barrier and 14 miles above Dúmagúdiam, or throughout a distance of 200 miles. A break then occurs which extends along the river for about 25 miles. The sandstones re-appear at Raigúdiam, about 6 miles below Bhadráchallam, and thence continue along the south or right bank of the river with one brief interruption for about 15 miles, terminating a little below the village of Mádaváram. These beds, as will presently be shown, extend far to the southwards.

Metamorphic and Vindhyan rocks occupy the bed of the river at the second and third barriers and for some miles below them, the remaining portion of the Pranhita and Godavery are in the soft sandstones and the associated beds, and at both barriers a continuous belt of the later sedimentary formations on the right bank of the river, though at a distance from its course, unites the areas occupied by the same rocks in the river's bed.

Throughout the whole valley of the Pranhita and Godavery† below the third barrier at the spot where the Wardhá and Waingangá unite to form the first named stream, the area occupied by the plant-bearing sandstones on the left (north and east) bank of the river is but trifling, whilst from the right bank these beds extend for a great, but hitherto unascertained, distance into the little known tracts of the Nizam's territories belonging to the Rámghir and Kamarmet Sircars, and perhaps into Warangal.

In the same manner the sandstones below Bhadráchallam occupy an area not exceeding 8 or 10 square miles north of the Godavery, while to the south they cover a tract of country 25 miles in breadth from east to west near the river, and gradually becoming broader till it is at least 50 miles across. It extends from the Godavery near Bhadráchallam till it is lost, 60 miles further to the south, beneath the coast alluvium in the neighbourhood of Ellore. To the south-east it stretches nearly to Rájámandri, extending to the banks of the Godavery

* This cannot be stated positively as yet, some portions of the ground not having been examined. But no break exists exceeding a very few miles in extent.

† The valley of the Godavery proper above the junction of the Pranhita is geologically almost unknown. It is only certain that the greater portion consists of trap.

near Polaváram, below the great gorge in the metamorphic rocks through which the river runs. At Pangadi near Rájámandri the sandstones are covered up by the bedded dolerites of the Deccan trap, just as, 300 miles in a direct line to the north-west, the same sandstones, in the districts of Chanda and South-east Berar, disappear beneath the same traps on the eastern verge of the great basaltic area of the Deccan.

The proportion of the enormous extent of sedimentary rocks in the valley of the Godavery and its neighbourhood, which is occupied by the valuable coal-bearing beds of the Damúda group, appears, so far as research has hitherto extended, to be extremely small. Here and there along the boundary of the sandstone tract, beds are found with the mineral character of the Barákar group of Bengal. Such is the case near Chandá, and the same beds occur at Lingálá, above the first barrier, and at Mádaváram below it; and in each case where these rocks have been observed, coal beds, sometimes of little or no value it is true, have been found associated with them. It is highly probable that further examination will show the presence of these valuable beds in several places where they have not hitherto been detected, but the search is difficult, because the surface of the country in which the sandstones are found is greatly concealed by a thick covering of sandy clay and sand, derived from the disintegration of the soft argillaceous sandstones.

The lower Panchets of Bengal, to which the name Panchet should perhaps be restricted, appear to be represented by rocks of similar mineral character in the Godavery valley, but further examination of these beds is necessary in order to determine their position in the series and their relations to the limestones containing fish remains, which are met with in several places near Sironcha.

The Tálchirs, at the base of the great series, precisely resemble their representatives elsewhere, but the unconformity between them and the Damúdas appears to be greater than usual.

These formations, the Barákars, Panchets, and Tálchirs, together do not take up a tenth part of the area occupied by the sandstones. The great bulk of these consist of coarse argillaceous sandstones and grits of no very marked character, with hard ferruginous bands. The few fossils found in them, chiefly. *Vertebraria*, *Calamites*, and *Glossopteris*, are identical with Damúda forms, but the mineral character of the beds taken as a whole is always slightly and sometimes remarkably different from that of any true Damúda beds, as found elsewhere, while the fossil plants seem to preclude the idea of associating these rocks with the Panchets, the flora of which, so far as it is known, is very different. One of the most striking distinctions between these beds and the Damúdas proper is the absence of coal and of any carbonaceous matter in the former, even the plant remains having lost their carbon and existing as mere impressions. It appears, therefore, desirable, both for scientific and economic reasons, to apply a distinctive term to these beds, restricting the name Damúda to the group or groups which usually contain coal. For these reasons, I proposed some years since the name of *Kámthi* beds for some rocks near Nágpúr which belong to this group. The name has since come into more general use on the Survey, and it has become necessary briefly to repeat the reasons for first adopting it. The Kámthi group is intermediate in position between the Barákar and Panchet groups.

So far as their geological examination has progressed, the immense mass of argillaceous sandstones which occupy so large a proportion of the country in Chánda and South-east Berar appears to belong to the Kámthi group. The same is probably the case with the sandstones of Sironcha and those on the right bank of the Godavery, which have, however, hitherto remained unexplored. The beds extending south of the Godavery towards Ellore and Rájámandri appear to me to differ in no important respect from the rocks in Chánda.

Sections, except on the sides of hills, are unusually rare, precisely as in the more northern area, and the great mass of the rocks consists of white and brown argillaceous sandstones, grit, and conglomerate, with so little marked mineral character that they might be either Barákar, Kámthi, or Panchet. On the Godavery, below Bhadráchallam, it is very difficult to draw a line between the Damúda and Kámthi groups.

But in the neighbourhood of Ellore and Rájámandri the sandstones are frequently variegated in a peculiar and characteristic manner. They are associated with numerous hard bands of ferruginous grit and compact red and yellow shale. In one instance sandstone was found with a peculiar semi-vitreous texture, which is very characteristic of some beds in Chánda and Berar. All these characters lead unmistakeably to the conclusion that these rocks are the representatives of the Kámthi beds of Nágpúr and Chánda.

Let it not be supposed that this conclusion is a mere abstract scientific matter, interesting perhaps to geologists, but of no importance to the world in general. In reality it involves a most serious economic question. It is quite unnecessary to remark that the discovery of coal in the Madras Presidency is a great desideratum. Hitherto, despite much research, neither coal nor the rocks with which coal is associated in India have been met with in any part of the country south of the Godavery. The tracing, therefore, into the Madras Presidency of sandstones belonging to the great series of which the coal-bearing beds of Bengal form a portion is of great interest and importance, because there is a possibility of the coal-bearing beds being associated with them.* The greater part of the working season of 1870-71 has been devoted to the very important borings for coal on the Godavery, and I have been unable to give nearly sufficient time to the examination of the Ellore and Rájámandri country to enable me to ascertain with certainty the presence or absence of Damúda beds. Indeed, the surface of the rocks, although much better exposed than is the case a little further to the north, is so far concealed that it will probably be necessary to bore in order to determine this question. But although there is fair possibility of coal-bearing rocks being found, I could not positively detect their presence anywhere, and in one or two places, the base of the Kámthis was seen resting upon the metamorphic rocks, all beds of the Damúda group being wanting.

In conclusion I may briefly describe the limits of the Kámthi sandstone area near Ellore and Rájámandri. The northern boundary runs nearly east and west from Raigúdiam on the Godavery to Palúncha. There it turns sharply to the south, and the eastern boundary extends thence at first south, then south-east to Chintalpúdi, 20 miles north-by-west of Ellore. Thence, after making a sweep to the westward, the boundary runs to the south, passing just east of the large town of Núzed (Noozeid or Noozudoo), whence it turns south-west, and finally reaches the alluvial plain of Ellore near a village called Krishnawáram, at a spot nearly 20 miles east-by-north of Bezwárá, and 16 miles west-by-south of Ellore.

Along the southern part of this boundary, near Núzed, the base of the sandstones is well exposed in several places, and, so far as I was able to examine, there was no trace of Damúda rocks. Still, further and closer examination is desirable before the same conclusion can be arrived at for the whole country.

The Kámthi beds stretch along the edge of the alluvium from the point already mentioned east-by-south of Ellore to the Godavery, trap intervening near the latter river at Pangadi, as already mentioned. The beds are in general flat, or dip at low angles.

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* So far as I am aware,—I am writing without means of reference, and may be mistaken—the occurrence of these sandstones near Ellore and Rájámandri has not before been noticed.

The eastern or rather north-eastern limit of the sandstone area extends from the Godavery at Pondigúl, 12 miles below Bhadráchallam, through the western portion of the mass of hills which culminate at the trigonometrical station of Rájgota. The boundary passes a few miles east of Ashráopetta, and thence trends nearly due east in the direction of a point on the Godavery a little south of Polaváram. Whether it crosses the river has not been ascertained.

This boundary also has only been most cursorily examined, and it is impossible at present even to guess whether Damúda beds occur along it or not. They are found on the north close to the Godavery, but they appear to be wanting in the hills a few miles further south. Some sandstones were seen near Ashráopetta which had the appearance of Barákars, but it should be repeated that after much experience of the two formations Barákar and Kámthi, I confess myself often unable to distinguish between the sandstones which usually form the bulk of both groups. I can only conclude that further examination of both boundaries, first geological and afterwards by boring, is requisite. This is especially a case in which research, to have any chance of success, must proceed on purely geological principles.

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Specimen of coal from new workings at Kasta, by F. R. REED, ESQ., Soory.

Fossils from the Chittagong country, by C. BROWNLOW, ESQ., Cachar. These contained very well preserved molars of *Cervus? Sus* or *Chærotherium*, teeth of squaloid fishes *(Odontapsis? Lamna?), Conus, Cerithium, Fusus, Cladocora.* All tertiary.

Specimens of rocks and fossils from the limestone ridges north of the Linzithang plain, from DR. CAYLEY.

Specimens of rough jade, and of a rude stone-mortar, small wooden wedges, &c., found in the now abandoned jade quarries opposite Gulbasha, from DR. CAYLEY.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1871. [August.

Report on the progress and results of borings for coal in the Godávarí Valley near Dúmagúdem and Bhadráchalam, *by* W. T. Blanford, F. G. S., *Deputy Superintendent, Geological Survey of India.*

The occurrence of fragments of shaly coal in the bed of the Godávarí close to the spot where the Tál river joins it from the north, about twelve miles above Dúmagúdem, has been known for several years. It was noticed by Mr. Wall in his report of his journey to Kota near Sironchá in 1857, and the coal was by him supposed to be derived from the Tál river. An examination of the Tál for a considerable distance above its junction with the Godávarí, however, having proved fruitless, Colonel Haig, the Superintending Engineer of the Godávarí Navigation Works, asked me to examine the spot when I was marching down the valley in May 1867. I found that in the Tál, near its junction with the Godávarí, the only rocks exposed belonged to the Tálchír group, whilst the Damúdá shales and sandstones, which alone have been hitherto found in the Indian Peninsula to contain coal, appeared at the spot where the smaller stream joined the Godávarí, and I suggested that the coal probably came from a seam buried beneath the sand of the river, and advised exploration by digging away the sand and closely examining the rocks. This was done by Mr. Vanstavern, Executive Engineer, and resulted in the discovery of coal in four places, all a little lower down the river than the mouth of the Tál, so that the bed from which the fragments first found were derived has not yet been detected, but as a large quantity of silt and sand has been accumulated near the mouth of the Tál of late years, it is probably now covered to a considerable depth. The quality was inferior. Of the seams found, two, neither of them exceeding 2 feet in thickness, were detected close to the left bank of the river, opposite the village of Lingálá. The quality of the coal is rather inferior, and both seams thin out and disappear within a few yards; moreover, as the dip of the rocks at Lingálá is towards the river bed, or south-west, and the outcrop exactly parallel with the bank, it is clear that the beds, even if of good quality, could not be easily worked at this spot, as the whole of them within any reasonable depth must be beneath the bed of the river.

The third seam found crops out in the middle of the river bed; it is about 5 feet thick, and the quality appears better than in the other seams. The reef of sandstone resting on this coal can be fairly traced at intervals for some distance, and after running along the river for about a mile, it turns in towards the right or south-west bank. Here its course becomes obscure. Borings were put down by Mr. Vanstavern near the spot where the coal would probably crop out on the bank, but without success. Another thin seam, only 2 feet thick, has also been detected by Mr. Vanstavern on the right bank of the river. This, like the two first met with, thins out within a few yards in one direction.

I reached Dúmagúdem on the 25th December 1870, and learned from Colonel Haig that besides the coal at Lingálá near the mouth of the Tál, some had been reported farther down the river at a village named Madaváram below Bhadráchalam. This place is below the first barrier on the Godávarí, and is consequently at all times in free communication by water with the coast, whilst Lingálá is above the first barrier, and although communication is now possible during the greater part of the year, it is not easy for laden boats except for a few months. At the spot where coal was said to have been found, I could detect nothing except some shaly dark coloured sandstone, but the rocks around were unmistakeably Damúdás and there was every reason to hope for success in the search.

An examination of the ground showed that the Damúdá rocks extend for a short distance on both banks of the river, but that sections are very few and imperfect. On the left bank which belongs to the Upper Godávarí* districts, there are scarcely any rocks visible except at the hills near Daorpali, and these are probably of a higher group, nearly the whole surface elsewhere being covered with alluvium. The beds appear to extend about six miles along the river from Gogubáká to Nándigúr, but not more than from a mile to a mile and a half from the bank. On the right (south) bank of the river they extend about five miles from Paláram to the bend below Madaváram, stretching for a mile and a half to two miles inland. Above Paláram there is a break occupied by metamorphic rocks for a mile and a half; above this, again, at Pundigúl the Damúdás re-appear and occur for about one and a half miles to a little above Amraváram, then they are covered apparently by the Kámthís, but the two groups here resemble each other so much in mineral character that their limits are difficult to define, especially as nearly the whole surface of the country is thickly covered with alluvial deposit. The Damúdás near Amraváram cannot be traced more than about a mile and a half from the river's banks, beyond this limit they are entirely overlapped by the Kámthís.

Along the right (or south) bank of the Godávarí a tolerable section of the Damúdás is exposed, consisting of conglomerate, sandstone, shale and clay, but no coal. There are, however, many breaks in the section, and it is evident that an examination of these by boring would prove conclusively the presence or absence of any bed of coal extending over the whole field. Local beds, of course, might be found elsewhere, but their value must be comparatively small. It is also manifest that a thorough exploration can only be made south of the river, as to the north the beds are so much concealed that, except in a few spots, all borings must be put down at haphazard.

The general dip seen in the river's bank near Madaváram is to the westward, the rocks at the village being inclined at a high angle and much broken and disturbed; a short distance to the east down the river there is an anticlinal, at the spot where a small stream enters the river. From this point eastwards to the bend of the river, a distance of less than a quarter of a mile, the rocks either have a low dip to the east or are horizontal, and the prevalence of conglomerate shows them to be in all probability near the base or limit of the formation.

It is evident that the anticlinal exposes the lowest rocks to be seen on the river bank, and that a boring at this spot must penetrate beds lower in the series than any exposed elsewhere. On the arrival of the boring tools, I arranged with Mr. Vanstavern for a borehole to be begun at this spot. This was commenced on January 17th and carried on until April 12th, up to which time 192 feet had been penetrated; the borehole was then stopped in

* I do not know who bestowed this name on the districts, but it is an absurd misnomer. The Upper Godávarí can only be that portion of the river's course above its junction with the Pranhítá, if not higher still, where it traverses the Bombay Presidency. Sironchá at the upper extremity of these "Upper Godávarí districts" is 210 miles as the crow flies from the mouth of the river and 400 miles from its source!

consequence of the tools being required to prove the coal discovered on the opposite side of the river. The section passed through was—

		Ft.	In.
1.	Brown sandstone	24	6
2.	Shale and clay of various colours, mostly dark-grey	21	1
3.	Coal and shale mixed	0	6
	Dark-grey shale	0	7
	Ditto ditto with fragments of coal	0	8
	Ditto ditto	18	9
4.	White sandstone, conglomeratic in places, with thin beds of shale towards the base	53	9
5.	Shale and clay with a little sandstone	37	2
6.	Coal	0	8
	Black shale and coal	1	4
7.	Dark-grey shale with a few fragments of coal in two places	26	1
8.	White sandstone	8	4
		193	5

I next arranged for a series of fourteen borings to explore the portions of the section not exposed in the river banks to the west of Madaváram between that village and Damarcherla. These varied in depth from 6 to 200 feet, according to the extent of the breaks in the section, and the plan proposed was that all the smaller boreholes not exceeding 35 feet in depth, nine in number, should be made by jumpers with extra lengths of light rods to screw on. The remaining five boreholes alone would require the use of the heavier boring rods. In the ground opposite Madaváram no boreholes were put, because the breaks in the section are trifling, and the disturbance so great that there is reason to believe that a repetition of beds takes place.

To the west of Damarcherla one or two additional boreholes might have been required, but a little beyond the village the beds turn up, dipping east, and then roll over again, and just beyond the small anticlinal, very unpromising conglomerates, perhaps belonging to a higher group, come in, in which there is no break of section which could conceal a coal seam. Two or three small jumper holes were put down to the east of Madaváram.

Of the holes proposed six were carried out, *viz.*, four jumper holes and two boreholes, when peremptory orders were received from the Government of India to discontinue all boring operations in the Nizam's dominions. It is doubtful whether the boreholes in the bed of the river were in the Nizam's dominions, but pending a reference to the Government of the Central Provinces, one set of boring tools was moved across the river into British territory in order to test some ground near the boundary of the field, and close to the base of the measures, on a horizon which did not appear to have been proved by the borings on the opposite bank.

It should be stated that the borings, so far as they had been carried out on the right bank, had shown the existence of sandstones and shales similar in every respect to those seen in the bank of the river, except that in two or three instances small fragments of coal, proving the existence of very thin seams, probably not exceeding two or three inches in thickness, had been brought up by the borer. These little seams, although absolutely worthless in themselves, are of importance, as indicating that the mineral does occur in the beds, and that hopes may be entertained of larger seams being found.

The place selected for a boring on the north or British bank of the Godávarí was on the right or west bank of a stream called the Ganár, rather less than half a mile from the Godávarí, and about the same distance east of the village of Tátpali, at a spot where some brown sandstone, dipping to the south, is seen on the bank of the watercourse. A little more sandstone of the same kind is seen up the stream to the north, and then metamorphics crop out, the latter appearing about 500 yards north of the spot selected for boring. For

some distance east and west all is alluvium. It was hoped that a borehole at the spot selected would afford a section of the lowest Damúdá beds; lower than any passed through in the boring east of Madaváram. The borehole was commenced on the 12th April, and the section traversed was—

(No. 1).

		Ft.	In.
	Soil and gravel	8	6
*1.	—Brown and yellow sandstone	25	6
2.	Shale, pale above, darker below	7	0
	Coal	3	0
	Do. mixed with shale	1	0
	Dark carbonaceous shale	5	0
	Coal	3	0
	Dark shale with 2 inches coal	6	0
3.	—White sandstone	27	0
		86	0

The higher 3 feet of coal appears to be of better quality than the lower; an analysis of the small fragments washed from the samples brought up from the borehole gave the following (average of three samples from three different levels)—

Volatile	37·7
Carbon	42·7
Ash	19·6
	100·0

The volatile portion comprised 10·8 per cent. of water. This is by no means a good result, but still some use could be made of such coal, and it should be remembered that analyses of such samples as are obtained from borings are only approximations, although they are usually not far from the true composition.

When I heard of the discovery of coal I was about forty miles from the spot. I marched to it at once, but before I reached it, Mr. Heppel, who was carrying on the borings, had commenced a second borehole on some sandstone in the bed of the Ganár stream below No. 1 borehole at a distance from the first of 125 yards south-east by east. This (No. 2) gave the following remarkable section:—

(No. 2).

		Ft.	In.
1.	—Yellow and brown sandstone	28	0
2.	Shale, partly dark-grey, partly buff	1	6
	Coal	2	0
	Shale	2	2
	Coal	0	6
	Shale	0	6
	Coal	1	4
	Shale	1	4
	Coal	1	0
	Shale	1	2
	Coal	1	8
	Shale	1	2
	Coal	1	
	Shale	0	10
	Coal	1	0
	Shale	2	8
	Coal (shaly)	1	9
	Shale	1	4
	Coal	0	8
	Black shale	5	0
3.	—White sandstone	3	2
		60	8

* The numbers 1, 2, 3, before the several beds in the sections indicate those which are supposed to be representative of the same part of the series in each.

Altogether the combined bed of shale and coal measures 29 feet 6 inches, of which 11 feet 8 inches is coal, but the bands of coal and shale are intermixed in a way which would much increase the cost of working the seam. The astonishing change, however, in so short a distance as 125 yards from a bed 25 feet thick containing 7 feet of coal in two well defined seams exceeds anything usual even in India, amongst the very variable seams sometimes met with in the Barákár group, and this amount of change within so short a distance rendered it doubtful whether the seam could be traced to any distance.

It was now desirable, 1st, to ascertain the extent of the seam, and 2nd, its quality. For the extent two boreholes were put down, one to the east, the other to the west, at a distance of about one-third of a mile from No. 1, on the supposed strike of the coal seam. All the ground east and west for a considerable distance being completely covered by alluvium, the true strike could only be inferred from the line of outcrop of the metamorphic rocks to the northward. To the east the borehole (No. 4) was a complete failure. It was put down in an open plain north of the village of Ganára. It passed through 34 feet of earth and 18 feet of quicksand, in which no further progress could be made, as the sand filled the tube faster than it could be removed by the "pump" or mineral lifter. A second borehole 200 yards farther south (No. 5) was equally unsuccessful. After passing through 22 feet of soil and 24 feet of quicksand it also had to be abandoned. There was not time for more attempts in this direction.

The boring to the west (No. 3) was on higher ground, just south of the village of Tátpali. It gave—

(No. 3).			Ft.	In.
		Soil and gravel	3	7
	1?	Sandstone, yellow, brown, and red	29	9
	2?	Pale coloured shale	10	0
		Red and yellow sandstone with some shale	7	0
		Shale, pale and dark	13	0
	3?	White sandstone with a little shale and brown sandstone ...	24	8
			88	0

In my absence this borehole was stopped by Mr. Heppel, and another (No. 6) started 250 yards to the south-east. This was on somewhat lower ground, and as the beds dip south at a low angle the section is probably that of the same beds—

(No. 6).			Ft.	In.
		Soil	11	0
	1?	Brown sandstone	13	10
	2?	Buff shale	6	0
		Red sandstone	2	0
		Dark shale	6	0
	3?	White sandstone with darker bands	46	0
			84	10

These sections I am strongly inclined to believe are in the same beds as Nos. 1 and 2. We have the same general succession, brown and yellow sandstone above, then a thick bed of shale, and then white sandstone. I have recommended that one of the boreholes should be carried out to a greater depth on the possibility of these beds belonging to a higher horizon, but I cannot think this at all probable. The evidence afforded by these boreholes appears to indicate that the coal thins out and disappears to the westward within a short distance.

Meantime a locality for a small pit had been selected up the Ganár stream 350 yards north-east of No. 1 borehole, at a spot where some yellow sandstone, just like that immediately over the coal, crops out in the bank of the nala, in the expectation that this would be close to the

outcrop of the coal, and that a sinking of a few feet would produce abundance of coal to enable the quality to be fairly tested. A jumper hole, subsequently deepened by boring (No. 7), was put down in order to ascertain the presence of the coal. This gave—

(No. 7).			Ft.	In.
	1.—Yellow sandstone		29	6
	2.	Buff shale	24	0
		Dark shale	6	0
		Coal	1	3
		Dark shale	26	3
			87	0

showing that the beds are nearly flat, and that a great increase of thickness in the shale has been accompanied by a diminution in the coal. A pit was therefore commenced close to No. 2, but when it was only 13 feet deep, the quantity of water met with retarded progress so much that it was considered advisable to commence another on the high ground 30 yards west of No. 1, as, although it would be a little deeper, it would not be equally liable to flooding, and might be used for the extraction of coal. A borehole has shown that the section is the same as at No. 1. This pit is now in progress.

Meantime one more boring (No. 8) was made only 200 yards west-by-north from No. 1. The section was—

(No. 8).			Ft.	In.
		Soil and gravel	10	5
	1.—Coarse brown sandstone		4	0
	2.	Light coloured and buff shale	9	0
		Red sandstone	3	0
		Light blue shale	2	9
		Red sandy clay	14	3
		Variegated clay	13	0
		Dark shale	21	7
			78	0

This boring was in progress when I had to leave at the end of May, and I have not yet received accounts of its completion. The enormous thickness of shale recalls the section in No. 7, and both sections may possibly be below the white sandstone which underlies the coal. But it is more probable that the shale represents the shale and coal found in the two first boreholes.

Lastly, as the absence of coal had been proved to the north-east and west, and no borings had been found practicable to the east, while the ground to the south appeared equally unfavorable for boring, except at a place on the bed in the Godávarí where operations might at any moment, at the season now reached (June), have been stopped by a rise in the river, a borehole was recommended 500 yards south of No. 8 and south-south-west of No. 1. This (No. 9) has given the following section, sent to me by Mr. Vanstavern since my arrival in Calcutta—

(No. 9).			Ft.	In.
		Soil &c.	39	0
	1.—Brown sandstone and conglomerate		23	0
	2.	Dark shale	3	0
		Ironstone	2	6
		Shale	2	0
		Coal	1	6
		Shale	2	0
			73	0

		Ft.	In.
		73	0
2.	*Coal*	2	1
	Shale, carbonaceous	2	0
	Coal	1	6
	Shale, carbonaceous	1	6
	Coal	1	6
	Shale, carbonaceous	1	0
	Coal	1	0
	Shale, carbonaceous	2	0
	Coal	1	0
	Shale, carbonaceous	1	0
	Coal	2	0
	Shale	23	0
		112	7

The section is remarkably like that at No. 2. It decidedly strengthens the evidence in favor of all the boreholes having passed through the continuation of the same beds, for we have in this case a great thickness of shale as in Nos. 7 and 8, with the coal as in No. 2. The total thickness of coal as yet proved in this last borehole is 10 feet 7 inches.

To sum up the evidence: the presence of coal has been proved over a small area which contains probably 25,000 tons, or rather more, of which quantity it is as well not to assume that more than one-half can be profitably extracted, owing to the great admixture of shale. It is probable that the seam may be traced for some distance to the south, because the amount of coal, so far as is known, increases in that direction, but it is hardly likely that a seam which thins out and disappears within so short a distance as 200 yards can be depended upon for any long distance. The quality has not yet been accurately ascertained. If on cutting into the coal it is found to burn fairly, a considerable quantity may be extracted, far more than sufficient to well repay the expenditure incurred in boring, but, except in the improbable case of the coal continuing for a distance to the south and east, no permanent supply can be depended upon from this locality. The great admixture of shale and the variation in the seam will render it necessary to mine a large quantity of useless rock, and this will increase the cost of the coal, but in a country where no other supply exists, this alone should not prevent the coal being worked.

The locality is most favorable. The river is within half a mile when full, and about a mile during the dry season, and so soon as the coast canals are completed, it will be in constant water communication with Madras.

In conclusion, I would recommend that the remainder of this small tract of coal-bearing beds be thoroughly explored, as, even if no extensive seam of coal be found, a considerable quantity of useful fuel might be discovered, which would be available on an emergency. North of the river a borehole should be put down below the high bank at Rajgúmpa, at a spot where conglomerate is seen in the river bed, in order to test if the coal continues so far to the south-east. A boring might also be made where sandstone occurs in the stream north-east of Gaoriopeta, and another south of the large tank near Egerpeta, west of Tátpali, and one of the boreholes already sunk, for preference No. 1, should be continued until the metamorphics or Tálchírs are reached. There is little chance of good from any further exploration on the north bank. On the south or right side of the river, the series of borings planned west of Madaváram should be carried out. The small breaks in the section near Amraváram might be explored in the same manner, and especially a spot above the mouth of the large stream which enters the Godávarí just above the village, as small fragments of shale and coal are hereabouts scattered along the edge of the river, and may indicate a coal seam below the sandstone exposed at a place where there are some bushes beneath the bank.

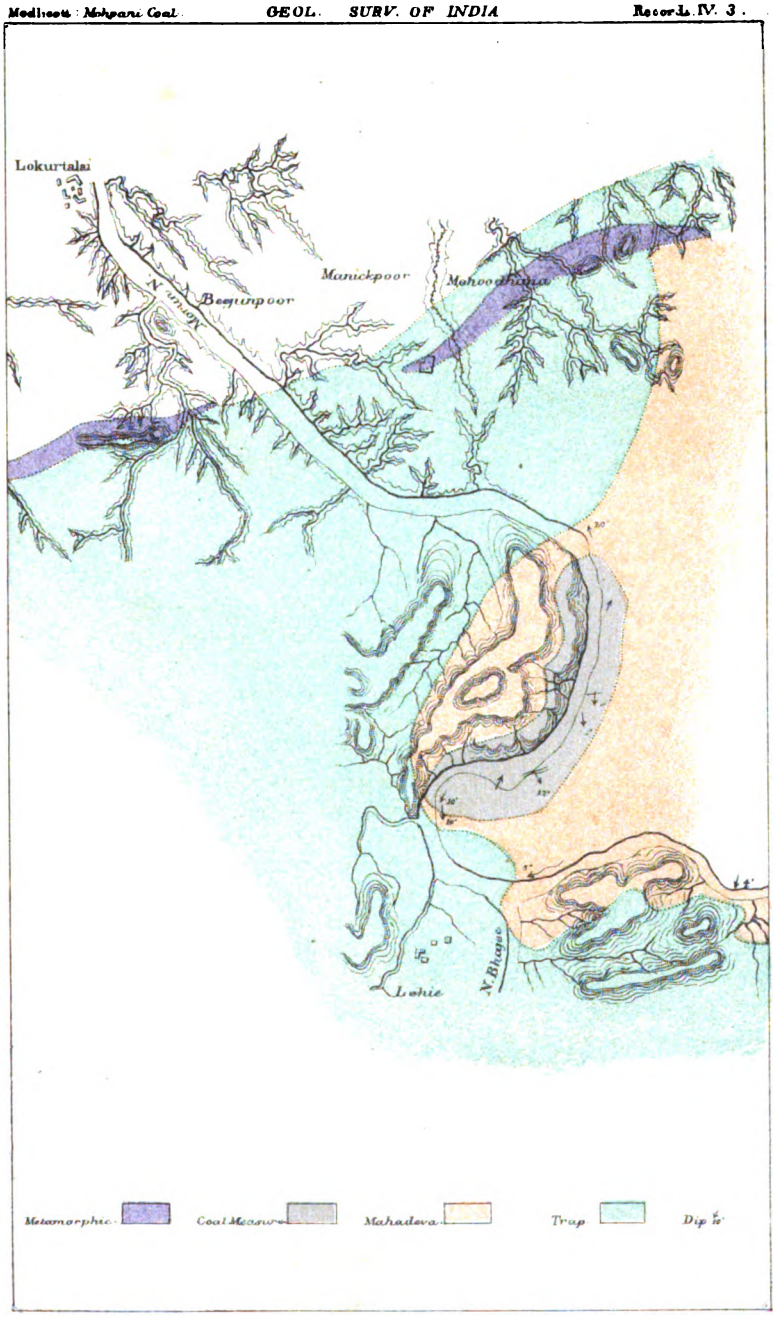
If all endeavours to find a permanent coal supply in this locality fail, an eventuality for which we must be prepared, the next chance is near Lingálá. Here I consider further exploration in British territory as almost hopeless, the Tálchírs must crop out everywhere below the mouth of the Tál close to the river bank, so that the Damúdás are confined, or nearly so, to the bed of the river and the country on the opposite side. Above the mouth of the Tál for some distance it is simply impossible to say what exists, for the whole country is covered with thick alluvium as far as Cherla, where the only rocks that are known to occur appear to me undoubtedly Kámthís, and all the Damúdás and Tálchírs are overlapped. The only plan by which any good can be done is an exploration of all the breaks in the section exposed above the top of the Tálchírs at Sangáram on the right bank of the river in the same manner as I have recommended near Madaváram. The dip varies from 10° to about 20°, and the depth to which the boring in each case must be sunk will be found by multiplying the length of the break by the tangent of the angle of dip.

I am under great obligation to Mr. Vanstavern for the very thorough manner in which he has aided me, and for his readiness to carry out every suggestion I made. Mr. Heppel's services in charge of the boreholes were invaluable; it is mainly due to his thorough knowledge of boring and to his hard work, in an intensely hot season and despite many difficulties, that so much has been accomplished in a short time.

CALCUTTA,
July 6th, 1871.

NOTE ON THE NARBADÁ COAL-BASIN, *by* H. B. MEDLICOTT, A.M., F.G.S., *Deputy Superintendent, Geological Survey of India.*

From the point of view of uncertainty and of expectancy the Narbadá coal-fields are at present the most important in India. They are the nearest known source of coal for the great region of North-Western India, where so many miles of railway are either open, under construction, or projected. Even as communications now stand, with the circuit through Jabalpúr and Allahabad, these fields are much nearer than those of Bengal to the Panjáb. When the rails are laid through Malwa and Gwalior the length of carriage will be greatly reduced. Yet less is known regarding the resources of the Narbadá area than of almost any other. The Wardá fields have been comparatively recently brought to notice; but their value and extent have been so well established by systematic boring experiments that the working of them is now only a question of time and convenience. Until similar trials are made in the Narbadá fields the prospect of a supply of coal there must remain uncertain, the naturally exposed sections of the rocks being so very obscure. There is an immense area beneath which it is possible, or even probable, that coal exists; but its presence and the depth at which it must be sought are still unknown. In connection with this there is an interesting question of stratigraphy to be discussed, and which would be out of place in this brief notice of practical objects; the more so that I believe no amount of discussion upon surface observations could in this case finally settle the point or remove the necessity for actual exploration. The occurrence of a fine outcrop of coal in a convenient position at the northern edge of the basin, and the formation of an efficient mining establishment to work it, have, no doubt, contributed with other causes, such as the want of proper maps, to keep in temporary abeyance the further exploration of the field; but it is evident that this should no longer be deferred. My brief report of last year (Records, Geological Survey, Vol. III, Pt. 3,) showed how much need there was for information regarding even the seams on the Sitárivá (at Mohpáni); how limited their known extension; how broken, crushed, and even locally destroyed they are within those small limits; how urgent it was



Lithographed in Colors at the Surveyor General's Office, Calcutta. July 1871.

to ascertain their extension beneath the younger rocks to the south. Although little information has been gained within the last twelve months, and that little not very encouraging, the importance of the case makes it worth noting. The following notes, in continuation of my last year's report, refer only to the northern side of the coal region: every endeavour should be made to find the coal there before attempting to work the distant outcrops of the Upper Tawa valley, on the south side of the basin. The localities to be mentioned in this paper may be followed upon the small map attached to the report of last year, or upon the large sketch map of 1859.

During part of the past season I examined a number of sections along the northern side of the area of sedimentary rocks from end to end, but without discovering an outcrop of the coal-measure rocks (the Barákar group). This direct evidence failing, the fact that has most encouraged hope of the proximity of coal has been the occurrence in several places of Tálchír rocks, which so constantly underlie the coal-measures. The outcrop in the glen south of Futtehpúr was mentioned in last year's report. A much larger spread of the same rock is seen at the edge of the plains south of Dhábká, eight miles east-south-east of Sohágpúr: again, to east of the Sitárivá, half way between Chungaon and Hatnápúr, close on the west of Nibhora village. But even this evidence is open to doubt: in all cases the rock in question is indeed the lowest seen, and is identical with the well known Tálchír boulder clay; but except for the boulders (which are not of large size) an identical clay is common in the adjoining Máhádévá rocks, alternating with the more common mottled red clays. Thus, the identification of this boulder bed as Tálchír rests largely on the assumption that there is no such bed in the Máhádévás; it is certainly very different from the ordinary conglomerates of this series. It is moreover noteworthy that in the undoubted Tálchírs of the Sitárivá section *sandy* rocks prevail: even the boulder-bed is principally a sandstone, the clay being subordinate. I am, however, decidedly of opinion that the rock in the localities noticed belongs to the Tálchírs. The presumption thus gained in favor of the proximity of the coal-measures along this edge of the field is, no doubt, an uncertain one; but it is something; the Barákur and Tálchír groups being about the two most constant companions of all the groups of the great plant-bearing series. It will probably be advisable at some early date to make one or more deep borings through the Máhádévá rocks at some little distance from the edge of the basin; but, as was urged last year, it would be unwise to attempt this until it be seen what can be learned from the exploration of the Sitárivá field as to the conditions of the formations in passing southwards.

Very little has been added during the past year to our knowledge of the seams in the Sitárivá (Mohpáni) field. What explorations have been made only bring into clearer view the greatly disturbed condition of rocks within the area exposed, and the corresponding deterioration of the coal. In the pits on the vertical seams at the north edge of the field the coal has become greatly squeezed-out at a depth of 100 feet, and along the strike westwards, being at the same time reduced to an useless paste. Some shallow excavations on the outcrops in the ravine to the north of the Narbadá Company's mine show the coal to be tremendously crushed and mixed with the associated rock; two strong trap-dykes here passing within a hundred yards of each other right through the measures. The trial boring at Pukuhi was carried to a depth of 110 feet. The result was inconclusive and, in a measure, unexpected. The sandstone, which from its position and general appearance it was thought might be the top-rock of the coal-measures, proved to be only a band in the Máhádévás; the bore having gone through some 60 feet of the typical red clay beneath it. Below this, however, the bore passed through dark-brown and dark-grey, slightly carbonaceous, clay. Such a rock would be very unusual in the Máhádévás in this position; and would, on the contrary, fairly represent the top of the coal-measures in the

northern section on the Sitárivá; the two being, moreover, on the same general strike. Regarding the southern extension of the seams, where, it may be hoped, they become steadier and farther from trap, no result has as yet been attained. The small trial-shaft and boring close to Benár on the north-west not having proved coal within 50 feet, Mr. Taylor shifted his operations to a point south-east of the village, and well in on the Máhádévá rocks where he is now boldly sinking a shaft. He could not, within his limits, have chosen a better position for making a thorough trial of the ground. According to the nearest dip seen (25°), and supposing no intervening fault, the shaft may have to be sunk 235 feet before striking the measures; but there is hope that the dip flattens, so as to lessen the depth. The shaft is now 98 feet deep, 92 feet of which were through an unbroken mass of mottled red clay, locally silicified and very hard, but all requiring to be cased up. The bottom 6 feet are in a firm, clear gray, sandstone-conglomerate. The plane of junction, which (Mr. Taylor informs me) seemed regular, thus affording a fair observation of the dip, sloped at 18° to the south-south-east. The prospects are so far improving. The spirited enterprize of Mr. Jones, the present proprietor, deserves every success.

In my small map of last year I marked some Tálchír rocks, with a query, on the south of Puwaria village. A re-examination of that obscure section, later in the season, when the ground is less concealed, has convinced me that the rocks are Máhádévá; thus making the suppression of the older rocks to the westward of the Sitárivá much more rapid than was at first apparent. But there is no deciding as to the manner of this suppression; it may be altogether due to faulting or to folding of the strata. The alternative supposition to that of disturbance to account for this so sudden disappearance of the coal-measures would be that there is strong denudation-unconformity between the two rock-series. There are some puzzling sections about the mines seeming to corroborate this view of the case; still it is hard to get over the fact first adduced against it—that in the best exposed sections the succession of the rocks seems regular. And there certainly can be no objection now to the supposition of disturbance. The unpromising nature of the ground in this position, at the edge of the basin, is further displayed in this section at Puwaria by the discovery of four strong trap-dykes, or at least outcrops (the section is so flat one cannot positively say how the trap occurs), in a length of about three quarters of a mile.

Several new outcrops of the lignite-coal in the Upper Máhádévá rocks have been examined during the past field season in the hills east of the Sitárivá. They all bear out the opinion already given on the subject.

There remains to notice the coal near Lokartálai at the extreme west end of the basin, so far as exposed at the surface; the whole sedimentary series there passing beneath the trap. The coal-band here seems different to any yet noticed. It occurs (see small map annexed) at some distance from the boundary of the metamorphic rocks, being exposed in a trench cut by the Moran across a flat anticlinal fold of the strata. The upper rock is a strong pebbly Máhádévá sandstone, but on what exact horizon has not been determined, immediately beneath which come the earthy coal-bearing beds. There is the usual appearance of complete conformity; the upper rocks dipping at the same angles as the lower; and the same beds of shale being identifiable on both sides of the anticlinal; a thick bed of nodular and shaly, micaceous and carbonaceous clay is recognizable at a few feet below the sandstone on either side. There are altogether about 80 feet of the lower rocks: 40 to 50 feet at top are earthy, some of the layers of shale containing strings of bright coal. These are best exposed in the southerly elbow formed by the river. They rest upon a thick mass of fine sandstones, between which and a similar mass below occurs the principal seam. It is about 4 feet thick. What coal there is in it is very bright; but shale predominates in the mass, and there is a great deal of pyrites. Some explorer had last year cut a short drift into the seam and evidently abandoned it as worthless. This seam is about the lowest

bed exposed on the back of the anticlinal. I do not think that this band of coal-bearing rocks belongs to the Barákar group. I rather think it belongs to those younger beds of the Damúdá series so largely exposed along the south base of the Pachmari range, and in which as yet no coal-outcrops of any promise have been found. Or, it may possibly belong to the Máhádévá series. I was not fortunate enough to find any fossils to determine this point; and owing to the isolated position it will be a very tedious matter, if even possible, to work out the question stratigraphically.

CAMP,
May 1871.

SKETCH OF THE GEOLOGY OF THE CENTRAL PROVINCES, *by* T. OLDHAM, F. R. S., *Supdt., Geological Survey of India.*

[In connection with the valuable series of Gazetteers which are now in course of publication under the authority of Government, the Geological Survey have from time to time afforded information to the officers charged with their compilation. This has frequently been on isolated points, but we have also been urged to give general and sketchy outlines of the geology of the various provinces viewed more as a whole. Such sketches are necessarily brief, being very limited in the space intended for them, but they may be useful to others as giving a more general outline than separate reports could do. It is, therefore, in contemplation to reprint these in the present series of records. Of those which have been already furnished, that of the Central Provinces has appeared soonest. It is now given here. It was written entirely without a single map or record for reference, and very hurriedly under great pressure for time. Others of Orissa, North-Western Provinces, Bombay, &c., will follow.] T. O.

Diversity of the geological character of the country.

To give a general description of the geological structure of the Central Provinces in any detail would involve the necessity of entering upon a discussion of the geology of India at large, as these provinces contain representatives of almost all the formations known to occur within Indian limits, although frequently these are much better seen in other districts, and ought, therefore, more correctly to be described in connection with the locality where the most typical sections occur. In the very brief notice which follows I am therefore compelled to presuppose a certain amount of acquaintance with Indian rocks, and the classification of them. It is only necessary to state that the few descriptions which follow have been drawn up under great pressure as to time, and while actively engaged in field work of an important and intricate nature, and away from all maps and records.

General correspondence of geological and physical areas.

The Central Provinces, divided into nineteen districts, naturally group themselves into separate areas, corresponding to well-marked physical features. These again have in a similar way a general agreement with the geological structure. To the north the districts of Ságar and Damoh are altogether on the Vindhyan plateau, and a large part of their surface is formed of the deposits to which the name *Vindhyan* has been given. These are, however, concealed over considerable areas by the overflowing volcanic rocks of the great Deccan trap area. Physically also these districts (as is all the Vindhyan plateau) are connected with the country to the north, all the drainage of the area being into the Ganges valley. Immediately to the south of the Vindhyan escarpment, along the marked depression of the Narbadá valley, lie the four districts of Jabalpúr, Narsinghpúr, Hoshangábád, and

Nimár (taking them in order from east to west), which are in great part on alluvial and tertiary deposits, with a narrow belt of older rocks along the southern side of the valley. South of the Narbadá valley rise the extensive highlands constituting the Sátpurá range, or its continuation, which are in great part formed of the Deccan traps resting upon crystalline rocks, or upon sandstone and other rocks of later date. Of this region Mandla occupies the extreme eastern end, bounded by the steep escarpment of the trappean plateau, near to the edge of which the Narbadá river has its source at Amarkantak. Along this same range to the west lie parts of Bálághát, Seoní, Chhindwárá, and Betúl. South and south-east of the Sátpurá ranges lie the remaining districts. Biláspúr, Ráípúr, and Sambalpúr lie in the great drainage basin of the Mahánadí. The two former occupy the low plain country of Chhattísgarh, formed principally on rocks believed to belong to the *Vindhyan* series, with a part of their area covered by coal-bearing rocks. Sambalpúr is in a rugged jungly country composed of crystalline and metamorphic rocks. The great drainage basin of the Godávarí, on the other hand, includes Nágpúr, Bhandára, Wardhá, Chándá and Sironchá. These districts have no very considerable elevation. The two first are principally on gneissose rocks, with much trap in Nágpúr: Wardhá is almost entirely on trap-rocks; Chándá and Sironchá have a very varied structure, including more or less of all the formations that have been named.

Geological groups.

Crystalline and metamorphic rocks.

These formations may be noticed in ascending order. The crystalline and metamorphic rocks have not as yet been described in any great detail. Gneiss of different varieties, often highly granitoid, predominates. The frequency with which these rocks appear shows how closely to the surface they form the substratum of the whole area. They are found at intervals all round the irregular boundary or border of the trappean rocks, rising in several places nearly to the full height of the plateau. The principal areas occupied by them are in Nágpúr and Bhandára and in Betúl. Also in Sambalpúr a very large area is formed of these rocks; but this is naturally connected with, and belongs to the great Gneissic area of Bengal. In obscure relation to the gneiss there occasionally appear sub-metamorphic rocks, schists, slates, and quartzites. These may be seen at many points along the borders of the Narbadá valley, from the north-east of Jabalpúr into Nimár.

Sub-metamorphic rocks.

Vindhyan series.

The great *Vindhyan* series of strata which form so prominent and important a feature in the geology of Hindustán are the next deposits in succession of age found in the Central Provinces. There is, however, a wide and complete separation of these from the gneissose rocks. They are universally unconformable to the latter, and they exhibit little or no mineral alteration, and only very locally any marked mechanical disturbance. The range or escarpment, from which the name of the series has been adopted, forms the northern boundary of the Narbadá valley, and the districts of Ságar and Damoh are occupied by the upper member of the series—the *Bhánrer* and *Rewá* groups. Each of these groups consists of a strong band of sandstone resting upon shales with subordinate limestone—an arrangement which, coupled with the nearly horizontal position of the beds, has, through the operation of denudation, produced the peculiar surface features of the country, namely, local plateaus bounded by precipitous scarps, overlooking broadly undulating valley-plains—features even better seen in the Rewá country. The Bijerághogarh *pargana* in the north-east corner of the Jabalpúr district lies within the geological region of the Son valley, where the *Lower Vindhyan* rocks are so well exposed: they consist of less uniform alternations of shales, sandstones, and banded limestones, with some peculiar compact silicious (cherty and jaspery) layers, very homogeneous and regularly bedded. Along the entire southern margin of the *Vindhyan*

area these rocks both '*Upper*' and '*Lower*' are much crushed and contorted, but they are only locally (in the south-west) penetrated by igneous rocks, probably of the same period as those of the great basaltic area. The extensive plains of Bilás pú r and Rái pú r are formed on rocks very similar in composition, arrangement, and external relations to those of the *Lower Vindhyan* formation as seen to the north, and these extend from here along the upper courses of the Mahánadí into very close proximity, if not actual continuity, with the similar deposits in the Chándá and Sironchá districts, and beyond the limits of the Central Provinces to the south, extend at intervals into the Madras Presidency, where they cover an immense area in the Kaddapá and Karnúl districts. Our knowledge of these detached areas is not as yet sufficient to justify an assertion that they were once continuous, although the striking identity in lithological character of the several deposits lends strong support to this view. Throughout all these widely-extended deposits there is constant physical evidence of their having been accumulated in comparatively shallow water, and so far under physical conditions favourable to life. The sandstones are false-bedded and beautifully rippled on their surfaces, each successive bed, often for hundreds of feet in thickness, showing its own ripple-marked surface. Nor is there anything in their mineralised condition to suggest the chance of subsequent obliteration of organic remains, had they ever been imbedded or become fossilised. Yet no success has hitherto rewarded our most careful searchings for such traces of early existences.

Coal-bearing rocks.

Passing upwards in the historical succession of rocks, we find in India a wide gap in the geological record between the *Vindhyan* rocks, just alluded to and the next succeeding series of deposits, in which are included the coal-bearing rocks. The whole face of the country wherever these occur must have been entirely remodelled by long-continued denudation and other causes before the commencement of the deposit of this great plant-bearing series of beds. This series has attracted much attention, both from its economic importance, and from the fact that it is in all its groups more or less fossiliferous. And the proper sub-division of it as represented at distant localities has been the subject of much study. Nor has the detailed examination of the country yet been sufficiently extended to admit of a final decision of this question.

Sub-divisions.

Three great groups have, however, been thoroughly established—the *Tálchír*, the *Damúdá*, and the *Panchet* rocks, and representatives of these three great groups have been found wherever the general series occurs. It is solely as to the exact limits of each that any question still exists, which can only be answered after more detailed examination. This question is, however, of high practical importance, because of the three series which I have mentioned only one is proved to contain workable beds of coal. The *Tálchír* rocks below contain no coal, and the *Panchet* rocks above are equally without any coals, the whole of the workable beds of coal of this geological epoch being found confined to the *Damúdá* rocks.

Sátpurá coal-fields.

The largest area occupied by the rocks of this great series within the Central Provinces lies in the hilly region to the south of Hoshangábád and Narsinghpúr, partly within the boundaries of these districts, but principally belonging to Chhindwárá, and embracing the Pachmarhí or Mahádeo hills. At the base of the series we find the characteristic deposits of the *Tálchír* group—greenish silt beds, breaking up into small splintery flakes and sharp fragments, and hence called 'needle shales,' and greenish brown or whitish earthy felspathic sandstones, in either of which pebbles and large boulders are often irregularly scattered. Often these are very numerous and form a distinct bed, to which, from its peculiar constitution, the name of "Boulder" Bed has been given. These rocks, generally speaking, are

found at the edges of the field, or weathered out in the deep valleys. The thickness of this group is variable, never very great, and it is locally altogether overlapped. In the Narbadá it covers by far the larger portion of the area. As noticed, no coal has ever been found in the *Tálchír* rocks, and very rarely any of the dark carbonaceous shales which are so frequent an accompaniment of coal, with the exception of a few thin and irregular streaks which invariably mark the transition of these *Tálchír* rocks into the *Damúdá (Barákar)* rocks above. This *Damúdá* series is chiefly made up of thick-bedded, often coarse felspathic sandstones, with subordinate beds of blue and carbonaceous shales and *coal*. In Bengal and towards the east this series is of great thickness, and is easily divisible into several distinct groups. But towards the west and the Central Provinces the series is of much diminished thickness, and the sub-divisions so well marked in Bengal are not recognisable. The beds of coal in the same way are much fewer and less important. These variations appear to have only a local development when viewed in detail, while on a general comparison the facts would seem to be expressed by saying that the *Panchet* series, which immediately succeeds the coal rocks, assumes towards the west a much greater thickness and importance than in the east, while the *Damúdá* series has been much less developed. In the Narbadá valley the latter series is represented by one group of beds only, which belong to the lowermost group recognised in Bengal (the *Barákar*), of no great thickness, and covered by an immense series of sandstones of varying age. No trace of any one of the sub-divisions of this great plant-bearing series—*Tálchír*, *Damúdá*, or *Panchets*—has been found to the west of about the parallel of Hoshangábád (Lokhartalai). The *Damúdá* rocks cover a wide spread of country round the bases of the noble Pachmarhí hills, and extend thence to Umréth and Barkoí, about sixteen miles from Chhindwárá. They rest in parts immediately on the gneissose rocks, and are frequently succeeded directly by the great trappean flows.

Western limit.

In Biláspúr (Chattísgarh) a large area of widely undulating country along the Hasdú—an affluent of the Mahánadí—is also formed of these rocks, and coal has long been known to exist there in some quantity. The district has not been examined as yet, and no trustworthy information exists as to the quantity or quality of this coal.*

Biláspúr coal-fields.

In the Chánda district again, and in Berár adjoining, similar *Barákar* rocks are found resting upon the characteristic *Tálchír* beds, and occupying a very small area in the large field of sandstones which there occur. At least one thick group of beds with coal is known in which the coal itself exhibits the same characters which distinguish the beds in the *Barákar* series elsewhere—that is, there is rapid and considerable variation in the thickness and quantity of the coal. Beds of great thickness have, however, been met with, and there is a very large supply therefore of useful fuel.

Wardhá River coal-fields.

Similar rocks extend down the valley of the Godávarí and the Pranhítá for a long distance, occurring in detached localities separated by wide ridges of the older formations. Near the mouth of the Tál river about fourteen miles above Dúmagúdem, both *Tálchír* and *Damúdá* rocks occur, the latter containing coal, which form the bed of the river Godávarí for some distance, and have probably a considerable extension; and coal is also known to occur about thirty-four miles to the south of the same town, visible on the banks of the river.

Godávarí and Pranhítá.

* See later information in Records Geological Survey of India, 1870, p. 71, also p. 54.

We are not as yet able to speak so certainly of the limits and relations of the beds which occur immediately above these coal-bearing rocks, so far at least as parts of the country under notice are concerned. In the Narbadá valley coarse conglomeratic sandstones with ferruginous bands, which are believed to be the representatives of the *Panchet* rocks of Bengal, come in immediate succession on the *Barákar* beds (Mohpání, &c.). And similar rocks occur in the same relation in the wide flats of Chhattísgarh, and probably at the intermediate locality of the Chhindwárá fields.

Kámthí sub-group.

But passing into the drainage basin of the Godávarí, a series of rocks of peculiar lithological character and locally abounding in fossil plants, is met with, no exact representatives of which are as yet known elsewhere. In their general mineral aspects they come very near to the ordinary *Panchet* rocks of Bengal, and they appear to pass upwards into undoubted representatives of these, but the prevailing form of fern of which they contain the fossilised fronds, is one *(Glossopteris browniana)* which is scarcely known to extend up to the *Panchet* horizon. These beds would therefore seem to indicate either a commencement in the basin of the Godávarí of the deposition of rocks having the peculiar mineral character of the *Panchet* beds at a much earlier period than in Bengal into which these ferns continued to exist: or the flora of the Godávarí basin had not been subjected to the same influencing causes, resulting in a marked change in its character, which in Bengal led to the well-defined separation as to fossils of the *Panchet* and upper groups of the *Damúdá* rocks *(Raníganj)*. I am disposed to think that, viewed in a very general way, it gives the truer representation of the facts to consider these local rocks, notwithstanding their contained plants, as belonging rather to the *Panchet* series than to the *Damúdá*. And there is one very important practical reason for this also, inasmuch as no workable coal has yet been found in either of these groups, while it has invariably been seen to occur where rocks of the undoubted *Damúdá* age are developed.

A local name was provisionally given to these rocks by Mr. W. Blanford, who first examined them, and as this has been published (although unintentionally), it may be retained as a useful sub-division. One of the largest areas of these rocks in the Nágpúr country is close to the important military station of Kámthí, and from this circumstance Mr. Blanford spoke of them as the *Kámthí* beds. They consist, lithologically, of hard compact gritty sandstones, fine variegated sandstones, coarse loose-textured sandstone, very fine-grained deep and bright red and buff argillaceous or argillaceo-silicious sandstones, and bands of hard very ferruginous pebbly grits.

These rocks cover an area of about twenty-five miles long from north-west to south-east near Kámthí (Kámthí to Kélod), and at the broadest parts (near Pátansáongí) about eight miles wide. Over a large portion of this area the rocks are concealed by thick alluvial deposits, but they are well seen at Kámthí, Silewárá, Bhokárá, and south and south-east of Pátansáongí, &c. A small area of the much older *Túlchír* rocks is seen north-east of Bhokárá, and a small hill north-east of Pátansáongí. Two other localities where these rocks are seen have been exposed within the area of the trap-rocks, these having been removed by denudation. One—the larger of the two—is close to Behár and Bázárgáon, about fifteen miles from Nágpúr on the road to Amráotí. The rocks here are of the same type, but become more conglomeratic towards the top than is seen near Nágpúr. The other inlier of these rocks is about thirty-six miles north-west of Nágpúr, near the village of Chorkherí. The rocks extend over an area of only about six and a half square miles in all. There is also another very small patch not a mile long near Khútkherí, about one mile south-east of the other.

Passing further southward similar rocks are more widely developed in the Chándá district, and cover a large area, concealing the underlying *Barákar* beds; there the rocks are, as a whole, less fine-grained than in the neighbourhood of Nágpúr, and the tendency to become more conglomeratic in the upper beds of the group is still more markedly exhibited than in the case already noticed. In this field also they appear to be closely connected with, and to pass up into a great thickness of bright red clays with thin-bedded sandstones, which belong undoubtedly to the *Panchet* series—well seen in the Wardhá about Porsá and in the country round, giving additional evidence of the connection of the two groups. These rocks—the *Kámthí* beds—yield in many of their beds admirable building stones, while others of a coarser texture are used as millstones or querns. Quarries exist at Kámthí, Silewárá, Bhokárá, &c., also in the Chándá district, but owing to the comparative poverty and sparseness of the population, they are here less worked than in the Nágpúr country. The white argillaceous band which is used near Chándá town, and which can be traced for miles along the country, is very even in texture, and can be carved into very minute forms of ornaments (a kind of work which is very skilfully done at Chándá), but it is rather soft. The beds, excepting the hard ferruginous pebbly grits, are not, generally speaking, very compact, and the surface of the ground becomes covered with loose sand resulting from their disintegration. The soil on these, except where they are covered by the alluvial deposits, is poor and little cultivated, almost the whole of this tract being covered with jungle.

The fossils found in these *Kámthí* beds have been noticed above. The fine sandstones of Kámthí, Silewárá, &c., have yielded very beautiful and numerous specimens of the large *Glossopteris Browniana*—a fossil-fern common in the coal-bearing rocks of Bengal and also in those of Australia. Similar fronds are found, but more rarely, in the finer beds of the vicinity of Chándá.

We have noticed these so-called *Kámthí* beds a little more in detail than their relative importance in a general sketch would justify, because of their local development, and of the interesting fossils which they contain.

Panchet series.

In ascending order the next important series of rocks is that to which the name of *Panchet* has been given. This, which is a very extensive formation in Bengal and in the country intervening between that and Jabalpúr, is not so largely developed in the Central Provinces. Indeed there is still much doubt as to the true limits and true parallel of many of the rocks which would probably at first be classed under this group. There is another peculiar feature: in the Bengal coal-fields, the so-called *Lower Panchet* group, consisting principally of red clays, with fine-grained, thin-bedded, often calcareous sandstones, both of red and greenish white colours, forms a set of beds of very considerable thickness and wide extent. But on passing to the west this group rapidly disappears and soon seems to be entirely wanting, while the *Upper Panchet* group, consisting chiefly of coarse red conglomerates, &c., with numerous ferruginous bands, becomes more largely developed, and constitutes almost the whole of the series. Still further to the west, however, as in the Chhindwárá fields near Umréth, these red-clays and thin-bedded fine-grained sandstones recur with a considerable development. And similar beds cover a large area on the south of the Chándá coal-field (Porsá and all the country around), and also appear in other minor patches throughout the Chándá field and in Berár. These pass upwards into coarser beds, pebbly and conglomeratic, and it is not an easy task to make out the exact relation of these to the adjoining rocks in a country so very much covered as is the greater part of the Chándá district. Similar rocks are seen again further south (Maledi), and here, as at Manglí to the north of Chándá, have yielded organic remains, which establish with tolerable accuracy their true position in the general European scale of geological formations.

Several forms of *Labyrinthodont* reptiles from the *Lower Panchet* rocks of Bengal remains of the very remarkable genus *Dicynodon*, previously only known from South Africa, and abundance of *Estheriæ* (small bivalved crustaceans) mark the fauna of the time in Eastern India. In the Central Provinces similar *Estheriæ* and a remarkable reptile *(Brachyops laticeps)* have been obtained from Manglí thirty miles north of Chándá, while the red clays of Maledi afford numerous remains of the very curious and interesting *Hyperodapedon*, *Belodon*, and some *Labyrinthodont* fragments also. There is a high probability that the rocks at these different localities are all truly on or about the same geological horizon (a fact which can only be satisfactorily established by detailed and careful observation), and that that horizon represents in Indian geological homotaxis the period of the *Trias* of Europe.

Jabalpúr beds.

In the vicinity of Jabálpúr and stretching down the valley of the Narbadá to the Sher river, and a little beyond, and forming also a narrow outcrop fringing the general line of the trappean boundary to the east and north of Jabalpúr, a distinct group of rocks was recognised by Mr. J. G. Medlicott in 1856-57. This limited group of beds is partially coal-bearing, and from this fact and from certain other obscure relations, it was at first designated under the inappropriate name of *Upper Damúdá*, with which series it was, pending further inquiry, supposed to be connected, while the fossil plants which it imbedded were closely allied to those occurring in the *Jurassic* beds of Rájmahál and Cutch. Subsequent inquiry showed that there was really no ground for supposing any connection of these beds with the true *Damúdá* as parts of one formation, and the name *Jabalpúr* group was substituted for *Upper Damúdá*.

At about 100 miles to the north-east of the Narbadá coal basin the boundary of the plateau of trap-rocks recedes south-eastwards, and the narrow outcrop of these *Jabalpúr* beds expands here into the open ground of South Rewá; there the *Jabalpúr* shales and silt beds were found passing upwards into massive sandstones (at Bandogarh) so generally identical with the rocks of the great Mahádeo hills, that they were at once accepted as their representatives; while below the *Jabalpúr* shales overlaid strong pebbly sandstones and conglomerates, which again in the southern part of the same area rested upon a coal-bearing group, recognisable at once by its contained fossils and general character as representatives of the *Damúdá* series. The *Jabalpúr* beds have not as yet been traced with any care in other districts, and I am unable to state their true limits. Their contained fossils point distinctly to a *Jurassic* age and to the lower part of that great period. In the Narbadá nothing but plant-remains have been found. We may, however, although the connection has not been traced, point to the remarkable beds near Kota—about five miles from Sironchá—which have yielded several well-marked fish-remains *(Lepidotus Deccanensis, Æchmodus, &c.)* considered as *Liassic* in their relations, as a probable representative to the south of the *Jabalpúr* beds to the north. There are also some detached patches of rock which occur in the intermediate country which may be representatives of the same general age. The coal found in these *Jabalpúr* beds is very irregularly developed (Sher river; Lametá-ghát). It is jetty, and has much of the character of a true lignite; indeed in many specimens the structure of the now-carbonised stems, of which a large portion of it is made, is well preserved. It has been economised recently to a considerable extent by the contractors on the Great Indian Peninsula Railway. But neither in amount nor in quality does it constitute a source of fossil fuel of any importance in a general view. I mentioned above, that immediately resting on the *Jabalpúr* beds, where the succession is best seen *(South Rewá)*, came the massive sandstones of Bandogarh, which were accepted as representatives of the great *Mahádeo* group, so well seen in the upper and magnificent scarps of the Pachmarhí hills (Central Provinces).

Mahádeo beds.

This *Mahádeo* group was first established after a brief examination of these hills in 1856-57, and was shown to contain a vast thickness of massive sandstones, with many ferruginous bands which *appeared* to be entirely unconformable on the *Damúdá* beds forming the lower ground adjoining. Unfortunately the same name was applied to rocks in other places which showed an approximation to the same general character, and which appeared to stand in the same general relation of an entirely unconformable series above the *Damúdá* rocks. It was from the first indicated that these *Mahádeo* rocks would require further examination. The progress of geological investigation in India has since shown the necessity also of greater sub-division than was at first apparent. These *Mahádeo* rocks, with the exception of a few badly-preserved and generally large stems, are, so far as known, unfossiliferous, and have therefore not attracted quite as much attention as some of the other series I have noticed. This absence of fossils also, and the detached, or comparatively detached, positions in which the *Mahádeo* rocks occur, have rendered the question of their geological age more difficult than it would have otherwise been.* Mr. W. Blanford, carrying up his examination of the country from the west, gave some good reasons for supposing that the *Mahádeo* beds were the continuation and expansion of the cretaceous sandstones found near Bágh in the western Narbadá. A similar general conclusion had been suggested by Mr. Hislop previously, but without much proof. On the other hand, it is right to state that Mr. Medlicott, working up from the east, saw reason for supposing that the *Mahádeo* beds in the Narbadá districts, which he presumed to be truly representative of the Bandogarh rocks in South Rewá (and as a subordinate member of which he considered the *Jabalpúr* beds), were at the same time only an upward extension of the same uninterrupted succession of deposits, which elsewhere had been justly believed to belong to the *Panchet* series.

It will be seen from this that the true position of these beds has not as yet been fixed. When first examined it was by me supposed that they, including the *Lametá* group (to which we shall presently refer), represented the lowest portion of the tertiary period. The Rev. Mr. Hislop, whose untiring exertions have done so much to elucidate the palæontological history of the Central Provinces, was disposed to view them as below all the tertiary deposits, and as representing in India the upper portion of the *cretaceous* epoch of Europe—a view strongly confirmed by Mr. Blanford, who was disposed to put them only a little lower in the series, while Mr. Medlicott would now make them much more ancient, and would place them in the same sub-division as the *Jabalpúr* beds, which latter are probably on the horizon of the Kotá beds—that is, he would consider them *Lower Jurassic*.† As stated, the question cannot at present (January 1870) be definitely settled.

Lametá beds.

When first examining the Narbadá valley Mr. J. G. Medlicott distinguished in the country fringing the river to the south, and between the Mahádeo hills and Jabalpúr, a series of well-marked beds, which he was then disposed to consider as the uppermost group of the *Mahádeo* formation, and to which he applied the local name of Lametá. These *Lametá* beds consisted chiefly of whitish earthy and silicious (cherty) limestones or calcareous muds, often a good deal indurated. These sandy calcareous beds formed only a thin band immediately underlying the trappean rocks. Further and subsequent examination, extending more to the east, proved that this band was entirely independent of the rocks below it, with

* The statement originally made that a very perfect specimen of a true *Archegosaurus* found under the Pachmarhí hills had been obtained from these rocks, was at once refuted by the mineral character of the rock in which it was imbedded. It was from the *Damúdá* beds below.

† The Rájmahál group of Bengal would in this view be of course younger than the Máhádévá of the Central Provinces.

which it was associated, inasmuch as, following the trappean boundary to the south-eastwards, the *Lametá* group was found to accompany the trap-rock steadily and to rest indiscriminately upon all rocks, from the gneiss up. It was therefore clear that it must be viewed as entirely separate from the great *Mahádeo* series, and as intimately connected with the overlying trappean rocks. As noticed above, these *Lametá* beds consist chiefly of cherty and gritty limestones, with subordinate beds of a nodular limestone, loose greenish sandstone, and purplish or greenish argillaceous beds either sandy or marly. They have been traced considerably south of Nágpúr, and thence at intervals round by the trappean boundary to Jabalpúr, and down the Narbadá valley to near Hoshangábád. If Mr. Blanford's views be supported by further examination, the limit must be carried very considerably to the west to the Punásá and the Dhár forest. In all cases, too, the trap-rocks, where any section is seen, appear to rest quite conformably or continuously on these *Lametá* beds, and beds which cannot be distinguished from them mineralogically are frequently met with interstratified with the traps (as near Nágpúr and between Nágpúr and Jabalpúr).

Intertrappean series.

These remarkable sedimentary beds intercalated with the traps of the Deccan and Málwá areas have received much attention. They constitute the *Intertrappean series* of Hislop, and are interesting from their fossil contents, as well as their mineral character, and peculiar stratigraphical position. It would be out of place here to enter into any discussion of the various explanations which have been given of these. It must suffice to say that both in their lithological character [calcareous muds]; in their distribution [local and irregular lenticular masses, not extending laterally to any great distance]; in the fossils contained [fresh-water and lacustrine shells, fragments of plants, &c.], and in their occurrence invariably between the successive flows of trappean rock, the upper surface in all cases being the only one really indurated or altered by the contact of the igneous, heated mass, they indubitably point to their origin in the small and irregular deposits in lakes or pools of varying size, tranquilly thrown down during the intervals of the successive flows of the lava, which now forms the great covering of this immense volcanic region. And I believe that the true explanation of the *Lametá* beds of which I have just been speaking, is that they were deposited in a similar way in more widely-extended lacustrine areas, previously to the commencement of the great outbreaks of lava. It need not detain us here to indicate the apparently long interval of time which elapsed during the outflowing of these successive lava streams, nor to point out how entirely different in age the *intertrappean* beds of the upper part of the series (Bombay, &c.,) may be from those which accompany the lower and older flows. None of these very much newer beds occur within the limits of the Central Provinces.

The geological epoch of these intertrappean beds seems to be tolerably well established as belonging to the *Eocene* period of European geologists; it being just possible that the lower beds of the *Lametá* group may represent a part of the upper cretaceous time. The evidence against this supposition of Mr. W. Blanford seems, however, decidedly stronger than that in its favour.

Deccan trap features.

The wondrous features of the great trappean country of the Deccan which extend over so large a portion of the surface of the Central Provinces, have been well described by many observers. The immense area covered continuously by these volcanic rocks; the enormous accumulation of horizontal, or nearly horizontal, layers of basaltic rocks; the distinct separation into beds, or stratification; the peculiar physical features,—massive flat-topped hills with sharp precipitous scarps; the abundance of beautiful zeolites and other minerals, and the occurrence of those curious intercalated beds, containing fresh-water fossils, which I have just

mentioned, could scarcely escape the notice of any observer. I have already briefly alluded to the general distribution of these rocks, so far as the Central Provinces are concerned, and shall not therefore delay further than to refer to the labours of Malcolmson, Newbold, Grant, Carter, Hislop, Medlicott, Blanford, &c., for more detailed discussions of this extraordinary series, which extends, or has extended, certainly over an area of 10 degrees of latitude by 15 to 16 of longitude. "The area covered by them in the Peninsula of India can be little "less than two hundred thousand square miles." Their limited extent within the boundaries of the Central Provinces is therefore but a very small fraction of their entire area.

Post-trappean deposits.

Of deposits later than the trappean rocks there is a great variety and an immense area. These would include all the soils of the present surface with their numerous modifications and varying agricultural value.

Laterite occurs in detached areas in Ságar and adjoining districts; it covers a considerable space in the north-east of Jabalpúr district, and is found at intervals passing to the south in Chándá, where it covers extensive areas in the eastern and north-eastern portions. It presents all the usual characters of this deposit, but nowhere within the Central Provinces attains that great thickness and massiveness which admit of its being freely used for building purposes.

Tertiary conglomerates.

The older gravels and clays of some of the river valleys would appear to be next in succession. These have been the object of more careful study, on account of the numerous remains of large animals, as well as ordinary shells, of which some of the beds contain locally in large number. The largest continuous area of these ossiferous gravels and clays is found in the Narbadá valley, along which they extend in unbroken continuity for more than a hundred miles from the falls of the 'marble rocks' near Jabalpúr to below Hoshangábád. They also occur in the banks of the river both above and below these limits. Very similar deposits are found forming the banks and often the beds of the upper feeders of the Godávarí—the Wardhá, Paingangá, &c.—and in the Godávarí itself; and here also they locally contain a large number of bones, sub-fossilised, the remains of animals which existed at the period of their deposition. The valleys of these streams are, however, by no means so well defined as that of the Narbadá, and the limits of the ossiferous gravels and clays are not easily fixed. The gravels are for the most part cemented into a conglomerate of tolerable hardness by the infiltration of carbonate of lime, and these beds might not unfrequently be mistaken for conglomerates of greatly older date on a cursory examination. There is, however, one fact which enables them to be readily distinguished, and that is the abundant presence in them of rolled pieces of the trappean rocks—of numerous agates, pieces of bloodstone, &c., which at once prove them to have been post-trappean in their origin. The immense variety and abundance of these pebbles also abundantly indicate the vast denudation to which the trappean rocks have been subjected since their outflowing and deposition.

Ossiferous gravels.

In general character these deposits in their lower portions consist of gravels and sands, frequently, as mentioned, cemented together much in the same way as a concrete is, and sometimes so hard as to be quarried for building. Towards the base the clays become sandy and pebbly. Sandy beds occur even in the clays, and irregular deposition and oblique lamination (false-bedding) are frequent—indeed so frequent as to be almost the normal condition. It is not easy to arrive at any just conclusion as to the thickness of these deposits. Actual sections of more than fifty feet in thickness are occasionally met with, but twenty to thirty feet are the more ordinary limits. The greater portion of the deposits is generally clay, the coarser beds being chiefly confined to the portion near the base. Fossil bones are not generally

abundant, but locally considerable numbers have been met with. Shells are not uncommon, and they appear to be all of species now existing in the rivers. These beds are obviously of fresh-water origin, and were in all probability the fluvio-lacustrine deposits of the rivers themselves, at a time when the levels and areas of their valleys were very different from those now existing.

It is not intended to give here a complete list of the organic remains found, which would belong rather to a detailed description. But the very remarkable admixture of existing and extinct forms which these deposits exhibit must be noticed; for along with well-preserved remains of *Hippopotamus*, *Rhinoceros*, *Mastodon*, peculiar forms of *Elephas*, and very remarkable Bovines (which, if not identical with European forms, approximate so closely that nothing but the most minute distinctions can be made, while they are entirely distinct from any present Indian forms), are found equally well preserved remains of animals still existing in the country. The not uncommon tortoise* *(Emys* [*Pangshura*] *tecta)* is found quite as fossilised in these beds as any of the other remains, and yet the species still lives in the valley itself. The imbedded shells, too, are all of species still living, and the evidence is conclusive that the change from the condition under which *Hippopotami* wallowed in the muds, and *Rhinoceros* roamed in the swampy forests of the country, where *Mastodons* abounded, and where the strange forms of the *Sivatherium*, *Dinotherium*, *Camelopardalis* existed, has been one of continuous and gradual alteration, unmarked by any great breaks or vast changes in climate. In the general series of successive epochs into which the geological periods distinguished in Europe have been classified, these ossiferous gravels and clays would seem to mark the upper portion of the *Miocene* and the *Pliocene*; while, with unbroken succession, and with nothing more than local change or break, these *Pliocene* beds pass upwards into the deposits now being formed. We thus find that numerous forms of animals, which are now contemporaries of man, existed at this very early period cotemporary with numerous forms of the larger animals now utterly extinct in this country. Was not man also cotemporary with these now extinct animals? As I have now endeavoured to show briefly, there is no physical break in the long series that would account for the destruction of these species; there is not a shadow of proof that the country was not then, as now, fitted for the abode of man. And although no human remains have yet been found, there is not a single fact which would lead to the conviction that man could not have existed and lived under the conditions which then prevailed. In this point of view, the discovery—although not in the Central Provinces—of a well-formed agate knife,† which had obviously been in use, and which was undoubtedly shaped and made with an intelligent purpose, in gravels of the same age as these ossiferous gravels of which we have been speaking and also containing remains of large animals, becomes one of the highest interest, as giving some amount of positive proof of the existence of man at this early period *(Pliocene)*.

Stone implements.

Of a later date, and scattered through the upper soils of large areas, flint (or rather agate) knives, agate cores, from which these knives have been chipped off, and numerous forms of artificially-shaped agate implements, have been met with in the Narbadá and Nágpúr country. And of a later date still, and invariably in the surface-soils, or taken out of these soils and brought together under trees, or at the rude shrines of the forest races, a large number of well-shaped and *polished* celts, axes, and other shaped stone implements have been found in the Central Provinces. The most remarkable fact perhaps connected with these implements is the identity of form and of design which they exhibit when compared with those found abundantly in Northern Europe—an identity common to both forms of these stone antiquities, the rudely-chipped and almost undressed, or, as they have been called, the Palæolithic, and the more finished and polished, or Neolithic, types.

* See Records Geological Survey of India, 1869, p. 36. † *Ibid*, 1868, p. 65.

The Central Provinces present many localities peculiarly likely to throw light, if carefully studied, on this intensely interesting question—the antiquity of man. But such inquiries can only be satisfactorily carried out by those who are long resident in the immediate vicinity, and can therefore watch the constant changes which occur, and take immediate advantage of any opportunity which may present itself.

Saline sands and clays.

Beneath the recent conglomerates and ossiferous gravels of a large portion of western Chándá is a well-marked deposit of brownish-yellow sand or clayey sandstone. This is seen over many miles of the country wherever the streams cut through the upper beds to any depth. It is not at all improbable that it may prove to be of different geological age, and quite distinct from the beds resting on it. No good sections have yet been seen. It is specially noticed here inasmuch as it contains a certain amount of salt, which is thrown out as an efflorescence where this loose sandstone is exposed to the weather, and produces miry places always wet and soft, and often difficult to cross. In connection with this deposit we may recall the occurrence of beds very low down in the alluvium, or below it, all containing a considerable quantity of common salt, in the Berár alluvial plain not far to the west of Chándá. Into this salt-bearing stratum wells are sunk for the extraction of brine, from which much salt is obtained. I am not aware of any brine-wells in the Chándá district, but this deposit contains a considerable amount of common salt, although much mixed with impurities, chiefly sulphate of magnesia (Epsom salts).* It is not impossible that the presence of common salt in sensible quantities may indicate that the clays containing it have had a marine origin, and are thus quite distinct from the beds which rest upon them.

Surface soils.

To treat of the more recent alluvial deposits of the country would involve rather more of agricultural than geological questions, and I would leave such to others more competent to enter upon them.

Regar.

The black soil or *regar*, or as it is not uncommonly called the 'cotton soil,' forms one of the most marked varieties in these provinces. It is the common soil of the Deccan, Málwá, Narbadá valley, &c. It varies greatly in colour, in consistence, and, with these, in fertility, but throughout is marked by the constant character of being a highly argillaceous, somewhat calcareous clay, being very adhesive when wetted, and from its very absorbent nature expanding and contracting to a very remarkable extent, under the successive influence of moisture and dryness. It therefore becomes fissured in every direction by huge cracks in the hot weather. It also retains a good deal of moisture, and requires therefore less irrigation than more sandy ground. The colour of this soil, often a deep and well-marked black, with every variation from this to a brownish-black, would appear to be solely due to an admixture of vegetable (organic) matter in a soil originally very clayey. Thus deposits of precisely the same character as this *regar* are being formed now at the bottom of every *jhíl* in the country, and throughout the very area where the *regar* is best marked, it is not by any means an uncommon thing to find the slopes of the small hills or undulations formed

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* Two specimens of salt roughly prepared from this sandy clay by lixiviation and evaporation were assayed at the Geological Survey Office, and yielded—

Chloride of sodium	82·89	87·58
Sulphate of magnesia	16·02	11·86
Clay and organic matter	1·60	1·40

The first of these was obtained from what is called the white *chopan* soil; the second was from the dark *chopan* soil.

of more sandy reddish soil, while the hollows below consist solely of the finest *regar*. This appears to be due to the more argillaceous and finer portions of the decomposed rocks below being washed away by ordinary pluvial action from the slopes and accumulated in the hollows, where this finer mud forms a soil much more retentive of moisture, and which therefore rapidly becomes more impregnated with organic matter, and is often marshy. *Regar* can thus be formed wherever a truly argillaceous soil is formed: and its general, but by no means universal, absence over the metamorphic and other rocks is easily accounted for by the fact that these rocks for the most part yield sandy, not clayey soils. It is never of any very great depth, and, excepting when re-arranged by rivers in their recent deposits, it is therefore never met with at any great distance below the surface.

Obviously formed from the re-arranged wash of the older and more widely-extended soils we find large areas of very fertile soil, consisting of clays rather more sandy than the older alluvium, and not therefore so black or adhesive. Though rarely formed altogether of the true *regar* soil, it frequently contains a large proportion of this, mixed with other clays and sands. Every intermediate form of soil occurs, and it would by no means be an easy task to distinguish them all. In an agricultural point of view, it is interesting to see how exactly the limits of certain kinds of cultivation coincide with the limits of these marked varieties of the alluvial deposits of the country—facts which the local officers will doubtless be able to illustrate more fully than I can.

The preceding sketch has necessarily been of the briefest and most general character. Those who desire to study the geology of the Central Provinces in greater detail may refer to the many papers more or less immediately bearing on this country—of Malcolmson, (Transactions, Geol. Soc., Lond.); Hislop (Journal of Asiatic Society, Bengal; Journal of Bombay Branch Royal Asiatic Society; Quarterly Journal Geological Society, London); Medlicott, Oldham, Blanford, Theobald, (Mem. Geological Survey of India; Records Geological Survey of India), in which full details will be found so far as the country has yet been examined carefully.

I shall also leave the discussion of the economic value of the several rocks to the detailed statements of the local officers, who have infinitely better opportunity of knowing how and to what extent such materials are economised within their own districts. I have solely attempted to give as briefly as possible a general connected outline of the successive formations known to occur within the limits of the Central Provinces, trusting that this outline may be filled in with greater detail by future researches.

N. B.—The following papers bearing on the Geology of the Central Provinces have been published since the foregoing was written:—

The coal-field near Chándá, Central Provinces.—Records, Geol. Surv., India, 1869, p. 94.
Lead in Ráípúr district, Central Provinces.—*Ibid*, p. 101.
On the lead vein near Chicholi, Ráípúr district.—*Ibid*, 1870, p. 44.
The Wardha river Coal-fields, Berar and Central Provinces.—*Ibid*, p. 45.
Coal at Korba in Bilaspúr district.—*Ibid*, p. 54.
Mohpani Coal-field.—*Ibid*, p. 63.
Lead ore at Slimanabad, Jabalpúr district.—*Ibid*, p. 70.
Coal east of Chhattisgarh in country between Bilaspúr and Ranchí.—*Ibid*, p. 71.
The plant-bearing sandstones of the Godávarí valley; on the southern extension of rocks belonging to the Kámthí group to the neighbourhood of Ellore and Rájámandrí, and on possible occurrence of coal in same direction.—*Ibid*, 1871, p. 49.

ADDITIONAL NOTE ON THE PLANT-BEARING SANDSTONES OF THE GODÁVARÍ VALLEY, *by* W. T. BLANFORD, F. G. S., *Deputy Superintendent, Geological Survey of India.*

Since writing the paper in this volume of the "Records," p. 49, I have found that the occurrence of sandstone near Ellore was mentioned by Voysey, Jour. As. Soc., Bengal, Vol. II, 1833, p. 400. Both Voysey and Walker refer in several places to the occurrence of sandstone in the valley of the Godávarí below Sironchá, so that Wall was not the first to make it known, although he appears to have been the first who explored its extent on the river banks. In explanation of my mistake, I should mention that my paper was written when I was encamped on the Godávarí without a single book of reference available.

I have also ascertained that the sandstone which extends to the neighbourhood of Ellore is connected with the large tract to the north-west by a narrow strip about six miles broad to the west of Palúncha, thus confirming Voysey's statement on the authority of a Mr. Ralph (Jour. As. Soc., Bengal., Vol. XIX, p. 290). The sandstones, therefore, extend, apparently without a break, from Mangli and Phizdúra, 60 miles south of Nágpúr, to within a few miles of Ellore, or nearly 300 miles in a direct line.

The boundaries of this enormous tract are in many parts most imperfectly known: by far the greater portion of the area consists of rock in which no trace of coal has hitherto been detected, and in which the occurrence of the mineral is highly improbable. It is along the edges that there is the best chance of valuable discoveries being made.

Since writing the paper above alluded to, I have visited Alápali, a village about thirty miles west of Dúmagúdem on the Kinarswámi stream, at which I had been informed by one of the officers of the Nizam's Government, the Naib of Naganienpol, that some coal had been discovered. Mr. Vanstavern, Executive Engineer of Dúmagúdem, had, at my request, sent some specimens of the coal found at Lingálá to the Naib for distribution amongst the minor officials, and for enquiry as to the occurrence of a similar mineral throughout the great sandstone country on the right bank of the Godávarí. This resulted in a report of the occurrence of coal near Alápalí, but on visiting the spot, I found that all which had been found consisted of fragments brought down by the stream. I had not time to trace these to their source, and this was the less necessary, as I found that an officer of the Nizam's Government had been sent from Warangal in order to do so. I have since been informed by the Tehsildár of Kamarmet that the spot has been found. It is some distance to the east of Paikhal on the confines of the Kamarmet and Warangal Sircars. This discovery will not be of much value at present if any permanent supply can be found on the Godávarí below the second barrier, but should no such supply exist, the locality near Paikhal will be well worthy of attention. The fragments of coal found in the Kinarswámi are shaly and of inferior quality, but where this exists better coal may, of course, be found.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1871. [November.

ABSTRACT OF RESULTS OF EXAMINATION OF THE AMMONITE-FAUNA OF KUTCH, WITH REMARKS ON THEIR DISTRIBUTION AMONG THE BEDS, AND PROBABLE AGE, by WILLIAM WAAGEN, PH. D., *Geological Survey of India.*

IN preparing for the "Palæontologia Indica" a monograph of the fossil Cephalopoda and in particular of the AMMONITIDÆ, represented in the Kutch Jura, I have obtained some general results, which may be interesting to notice in connection with the study of the jurassic deposits in that province.

The Cephalopoda seem rather common in all the principal jurassic strata of Kutch, excepting in the lowest beds, which have as yet furnished only some Gastropods, a great number of Pelecypods, besides some undeterminable fragments of Belemnites and a few other fossils.

The number of species of *Ammonites* collected by Messrs. Blanford, Wynne, and Fedden, in the course of a few working seasons, amounts to about 80, of which number, however, all are not in a sufficiently good state of preservation to allow of accurate determination. According to the different genera, which have been lately distinguished in supercession of the old genus "*Ammonites*," the following are represented in the Kutch Jura: 5 species of *Phylloceras*, 2 of *Lytoceras*, 1 *Haploceras*, 6 *Oppelia*, 6 *Harpoceras*, 7 *Peltoceras*, *(n. g.)* 4 *Aspidoceras*, 17 *Stephanoceras*, and about 32 *Perisphinctes*. If we inquire into the geological distribution of those genera in the European jurassic districts, we will find that the *Phylloceras* and *Lytoceras* are not limited to certain strata of the jurassic formation, but begin in the Trias, and extend without any interruption into the middle, and even upper layers of the Cretaceous period. *Haploceras*, on the contrary, occurs within narrower limits, appearing solitary for the first time in the Bathonian, and disappearing again in the lowest beds of the Neocomian, its principal development being in the Tithonian group. Of the genus *Oppelia* the greatest number of species is found in Oxfordian and Kimmeridgian beds, furnishing only a few sporadic species in lower strata, and beginning in the Inferior Oolite. *Harpoceras* is characteristic for the Lias, but extends, however, in well developed forms up into the Oxfordian, and even into the Kimmeridgian group. *Peltoceras* is chiefly an Oxfordian, *Aspidoceras* chiefly a Kimmeridgian and a Tithonian genus. *Stephanoceras* occurs through the whole Jura, whilst *Perisphinctes*, represented by a larger number of species and specimens than any of the other genera, is mostly characteristic for the Upper Jura.

If we now consider the number of species, by which every single genus is represented in the Kutch Jura, the simple comparison of the numbers before given, with the facts known regarding the geological position of the genera in Europe as stated above, will show us

clearly, that at least a part of those jurassic strata must belong to the Upper Jura, unless we presume that the faunæ have followed laws of distribution quite different from those which were prevalent during the time of the jurassic deposits in Europe.

Proceeding to the species, I will give brief distinctive characters of the new forms which I have described. There are of *Phylloceras*, preserved in the Geological Survey Museum,—

Phylloceras disputabile, Zitt. (golden oolite of Keera hill near Charee; brown oolite of the Jooria hills).
„ *Lodaiense*, Waagen, n. sp. (brown oolite of Lodai).
„ *Feddeni*, Waagen, n. sp. (oolite with iron nodules near Dhosa).
„ *ptychoicum* Quenst. (coarse iron sandstone of the Katrol range).
„ *Zignodianum*, Orb. (golden oolite of Keera hill).

Phylloceras Lodaiense, Waagen, n. sp. Very closely allied to *Phyll. disputabile*, Zitt., but the furrows disappearing on the siphonal side and very deep near the umbilical margin; it has also much shorter and broader lobes than *Phyll. disputabile*.

Phylloceras Feddeni, Waagen, n. sp. Closely resembling *Phyll. Homairei*, Orb., but the umbilicus a little smaller and the external saddle finishing in three unequal leaves. It differs from *Phyll. euphyllum*, Neum., by a little larger umbilicus and less developed third leaf on the external saddle.

The genus *Lytoceras* has furnished, as stated before, only two species, one of them being new; they are:

Lytoceras Adeloides, Kudern. (golden oolite of Keera hill).
„ *rex*, Waagen, n. sp. (sandy yellow rock, S. of Charee).

Lytoceras rex, Waagen, n. sp. A specimen of 600 m m. in diameter. Inner whorls finely striated without any prominent ribs; body-chamber with a few prominent ribs, with broad smooth spaces between them; ribs with 7 folds on each side.

The species of *Haploceras* which I have mentioned before is not determinable with sufficient certainty, as the last part of the body-chamber is wanting; but it is very probably

Haploceras tomephorum, Zitt. (coarse sandy iron rock, S. of Boojooree).

The genus *Oppelia* has furnished several well known European species of great interest, only two new forms were among the number. The species are:

Oppelia subcostaria, Opp. (golden oolite, Keera hill).
„ *glabella*, Leckenby (gray marl nodule, Keera hill).
„ *trachynota*, Opp. (coarse sandy iron rock, Katrol range).
„ *Cutchensis*, Waagen, n. sp. (same layer and locality).
„ *plicodiscus*, Waagen, n. sp. (rock indistinct, S. of Madapoor).
„ cf. *serrigera*, Waagen (gray limestone, S. of Nurrha).

Oppelia Cutchensis, Waagen, n. sp. Very much like *Oppelia compsa*, Opp., however much smaller; the siphonal side rounded, granulated; tubercles on the body-chamber scarce, distant, rounded; ribs entirely disappearing.

Oppelia plicodiscus, Waagen, n. sp., belonging to the group of *Oppelia subtililobata*, W. and nearly allied to *Opp. tenuilobata*, Opp. The shell is small and covered with rather broad, strongly falciform ribs, which are a little swollen at the middle of the sides; near the siphonal margin a great number of very fine, short ribs, which are not in connection with the others, are visible.

Among the species of the genus *Harpoceras*, there is a single European form; all the other species are as yet known only from the Indian Jura. The species are:

Harpoceras hecticum, Rein. (golden oolite, Keera hill).
„ *ignobile*, Sow. (yellow limestone, Keera hill).
„ *crassefalcatum*, Waagen, n. sp. (same layer and locality).
„ *Orientale*, Orb. (rock indistinct, Keera hill).
„ *fornix*, Sow.
„ *Nurrhaënse*, Waagen, n. sp. (iron nodule, Nurrha).

Harpoceras crassefalcatum, Waagen, n. sp., resembles very much *Harp. ignobile*, Sow., but the whorls are depressed; the ribs much stronger, less numerous and much more irregular; the species is also of smaller size, when adult.

Harpoceras Nurrhaënse, Waagen, n. sp. Allied to *Harp. lunula*, Rein., but the ribs which cover the sides of the shell are much finer and sharper, and much more curved than in the last mentioned species.

Peltoceras, Waagen, n. gen. This genus is, I consider, very closely allied to *Aspidoceras*, Zitt., and possibly only a sub-genus of it. It is established for the species which Zittel in his last volume on the Tithonian fauna has separated from his genus and united with *Perisphinctes*, but I think the relation between those forms believed to belong to *Perisphinctes* and *Aspidoceras perarmatum*, as he calls this Ammonite, are much closer than the relations between them and the true *Perisphinctes*, though contractions of the whorls also occur in the former species. I am disposed to consider in this case the form of the lobes as the most important distinguishing character. Thus, for instance, in *Amm. Arduennensis* and *Amm. perarmatus*, the lobes are nearly identical in both species, the first lateral lobe being so much enlarged that the second lateral lobe becomes nearly obsolete; and as this form of lobes never occurs in the true *Aspidoceras* (as *Asp. iphicerum* and others) nor in the true *Perisphinctes* (as there the auxiliary lobes have another position), I think it reasonable to separate those species with this particular shape of lobes under a distinct generic designation. The genus *Peltoceras* is, therefore, characterised by the *particularly enlarged lateral lobe, a discoid, largely umbilicated shell; the whorls sometimes with contractions, always covered with strong straight ribs, which are sometimes provided with two or three rows of spines; siphonal side more or less flattened or even excavated, ribs crossing over or disappearing before they reach the siphonal part of the shell. Aperture more or less rectangular.* Thus characterised, I believe, the genus should include the groups of *Pelt. Arduennense, transversarium, perarmatum, hybonotum* and a few other, less known, forms. The species of this genus occurring in the Kutch Jura are:

Peltoceras athleta, Phill. (gray marl nodule, N. of Goodjinseer).
„ *aegoceroides*, Waagen n. sp. (brown oolite of the Jooria hills).
„ *Arduennense*, Orb. (same layer and locality).
„ *semirugosum*, Waagen, n. sp. (brown oolite of Lodai and the Jooria hills).
„ *bidens*, Waagen, n. sp. (same layer and locality).
„ *perarmatum*, Sow. (brown oolite of Lodai and Jooria, and doubtful from the red sandy iron rock of Kuntkote).
„ *monacanthus*, Waagen, n. sp. (coarse yellow sand rock, Katrol range).

Peltoceras aegoceroides, Waagen, n. sp. A very small species, with many thin somewhat rounded whorls and numerous simple ribs which cross the siphonal side undivided; whorls barely touching each other.

Peltoceras semirugosum, Waagen, n. sp. This species becomes extremely large, and in that form closely resembles *Pelt. perarmatum*, Sow. Young specimens, however, have almost

entirely the form of *Pelt. Arduennense*, Orb., with the single difference, that the ribs, which are, as long as they exist on the shell, divided into two branches nearly from the umbilical margin, are stronger and less numerous. Growing larger each rib is produced at the point, where it passes from the lateral to the siphonal side, into a prominent spine, from which the rib proceeds regularly over the siphonal side. In yet larger specimens a second row of spines appears also near the umbilical margin, the ribs become then nearly obsolete, and fragments are only distinguishable from *Pelt. perarmatum* by the peculiar flattening of the ribs which connect the corresponding tubercles of both the umbilical and perispherical rows.

Peltoceras bidens, Waagen, n. sp. Very much resembling the former species, but distinguishable by the ribs being mostly undivided and very coarse; they are provided on the siphonal side with two indistinct tubercles. Large specimens have more distant spines than *Pelt. semirugosum*.

Peltoceras monacanthus, Waagen, n. sp. Allied to *Pelt. hybonotum*, Opp., but with only one row of spines near the umbilical margin, and less distinct granulations on both sides of the median excavation on the siphonal side.

The genus *Aspidoceras*, though represented in our Museum by a good many fragments, has furnished only two determinable species; they are:

Aspidoceras iphicerum, Opp. (red, fine sandy iron rock, N. of Dhosa).
„ *Wynnei*, Waagen, n. sp. (coarse sandy iron rock, at Toodoora, S. of Boojooree, together with *Hapl. tomephorum*) in the highest layer containing *Ammonites*).

The other fragments are from the coarse iron sandstone of the Katrol range, and appear to be referable to *Asp. iphicerum*, Opp., and *binodum*, Quenst.

Aspidoceras Wynnei, Waagen, n. sp. Most nearly allied to *Asp. Apenninicum*, Zitt., but the outer row of tubercles stronger, and more numerous; and in general more irregular than in the species just quoted.

The genus *Stephanoceras* is extremely rich in forms in the Kutch Jura, but notwithstanding this, it only represents there a single group, the Macrocephali. Several sub-divisions among the species belonging to the genus can be distinguished, facilitating the determination of the species themselves. I distinguish (1) a group of species, allied to the true *St. macrocephalum*, (2) a group of species with bent ribs on the siphonal side, which replace in India the group of *St. goverianum*, &c., of Europe, (3) the group of *St. modiolare*, represented in India but by a single species.

To the first group belong the following species:

Stephanoceras macrocephalum, Schloth. (golden oolite of Keera hill, brown oolite of Jooria, grayish yellow marl rock of Jumara).
„ *tumidum*, Rein, (golden oolite, Keera hill).
„ *Polyphemus*, Waagen, n. sp. (common in the brown oolite of Lodai, Jooria and N. of Goodjinseer, very rare in the golden oolite of Keera hill).
„ *lamellosum*, Sow. (golden oolite, Keera hill; ? yellow sand rock, N. of Dhosa).
„ *Chareeënse*, Waagen, n. sp. (golden oolite, Keera hill; yellow marl rock, Jumara).
„ *Grantanum*, Opp. (same rocks and localities as the preceding sp.; also in a sandy iron rock at Kaora, Putchum).
„ *elephantinum*, Sow. (brown oolite, Lodai).
„ *arenosum*, Waagen, n. sp. (same rock and locality).
„ *? Maya*, Sow. (red iron rock, Kuntkote).

Stephanoceras Polyphemus, Waagen, n. sp. This species grows enormously large, 1½ feet in diameter, and seems identical with d'Orbigny's drawing of *St. tumidum* (Orb. non Rein.). It differs from the real *St. tumidum* by very broad rounded ribs and a smooth body-chamber, while Reinecke's species has fine sharp ribs and a plicated body-chamber.

Stephanoceras Chareeënse, Waagen, n. sp. Allied to *St. Morrisi*, Opp., but much broader near the umbilicus and with a very narrow siphonal side, on account of which the transversal section of the whorl is nearly triangular. There are also some differences in the sutures.

Stephanoceras arenosum, Waagen, n. sp. Of a very flat lenticular form, with faint, broad rounded ribs somewhat resembling *St. Lalandeanum*, Orb., but the ribs are not undivided, and only few of them reach to the umbilical margin. The lobes are also quite different.

The second group includes the following species:

Stephanoceras dimerum, Waagen, n. sp. (golden oolite, Keera hill; gray marl rock, Jumara; sandy iron rock, Kaora; doubtful, Jooria).
„ *subtrapezinum*, Waagen, n. sp. (golden oolite, Keera hill).
„ *eucyclum*, Waagen, n. sp. (brown oolite, Keera hill, Jooria hills).
„ *opis*, Sow. (iron nodules, Keera hill; brown oolite, Jooria; oolite, Dhosa).
„ *fissum*, Sow. (red iron rock, Kuntkote; brown oolite, Lodai, Jooria; oolite, Dhosa; iron nodule, Keera hill).
„ *Nepalense*, Gray (red iron rock, Kuntkote; brown sandstone, Trummo river).

Stephanoceras dimerum, Waagen, n. sp. Allied to *St. Herveyi*, Sow., but with smaller umbilicus and with the ribs curved in front on the siphonal side. The ribs are broad and prominent; the general shape of the specimens somewhat globular. Body-chamber with strongly curved, high, lamellose ribs. The species attains scarcely more than a diameter of 50-60 m m.

Stephanoceras subtrapezinum, Waagen, n. sp., very much like the preceding species, but with much finer ribs, and with flattened sides of the whorls; the aperture having a somewhat trapezoidal shape and the form of the whole shell being more lenticular. It attains a little larger size than the preceding species.

Stephanoceras eucyclum, Waagen, n. sp. Full grown specimens with preserved body-chamber have a slight resemblance to similarly preserved specimens of *Cosmoceras ornatum* or *Duncani*, but the examination of the inner whorls shows that the species belongs to *Stephanoceras*. The umbilicus is very wide, the whorls a little compressed, and covered with polytome fine ribs; the lobes are very short and broad.

The last group of *Stephanoceras* is that of *Steph. modiolare*, Luid., only represented in Kutch by a single species.

Stephanoceras diadematum, Waagen n. sp. (golden oolite: Keera hill).

Stephanoceras diadematum, Waagen, n. sp. The species attains nearly one foot in diameter. Full grown specimens are entirely smooth, and closely resemble large individuals of *St. modiolare*, Luid., except that the umbilicus is always wider; small specimens, however, are entirely different, as they never have the "Lamberti-like" shape, which characterises young individuals of the last mentioned species. *St. diadematum* has always very broad, depressed whorls, which are covered in the first youth with dichotome ribs becoming afterwards polytome, and passing with a slight curvature in front over the flat siphonal side; the lateral lobes are situated on this latter portion of the shell.

The genus *Perisphinctes* has furnished, of all the Ammonites, the greatest number of species, and I regret that the European species of this genus are as yet so little known, that in many cases a comparison of our fauna with the forms found in European strata becomes utterly impossible. The forms of *Perisphinctes* found in Kutch may be conveniently divided into a few larger sections, which I may call after the oldest and best known species, without, however, assigning these sections the value of developmental series (Formenreihen, Entwickelungsreihen). I distinguish (1). *A section of forms, related to Per. Königi*, Sow.; the species to which I refer represent a connecting link between the last mentioned species and *Per. Rolandi*, *Frischlini*, and other Ammonites of the European Upper Jura. The whole section ranges between the true *Perisphinctes* and *Stephanoceras*, and, following the external form, it could almost with equal right be referred to the one or the other of the two genera. (2). *Section of forms allied to Per. Martiusi*, Orb. The species of this section chiefly occur in middle Jurassic and Callovian beds, and their number was recently considerably increased by the description of new forms in Europe. The latest representatives of it in Europe are known from Oxford strata. (3). The species of this section are *allied to Per. plicatilis*, Sow., and are chiefly from Oxfordian and Kimmeridgian beds. (4). *Section of forms allied to Per. Rehmanni*, Opp. A small series of species with a very peculiar shape, in many points entirely separated from all the other *Perisphinctes*, and chiefly characteristic for the Callovian. Besides these there occur in the Kutch-Jura also some other species which cannot be referred to any of those sections, and which must for the present be looked upon as sporadic, or isolated species.

The first section, characterised by the great scarcity of contractions on the whorls, mostly without any umbilical edge, and by thick scarce ribs, includes the following species from Kutch:

Perisphinctes obtusicosta, Waagen, n. sp. (oolite of Dhosa; iron nodules of Keera hill; gray marl nodules, N. of Goodjinseer).
„ *angygaster*, Waagen, n. sp. (same rocks and localities as preceding species).
„ *Dhosaënsis*, Waagen, n. sp. (oolite of Dhosa; brown oolite of the Jooria hills; iron nodule, Keera hill).
„ *mutans*, Waagen, n. sp. (dark red iron rock, N. of Goodjinseer).

Perisphinctes obtusicosta, Waagen, n. sp. Slightly resembling *Per. Rolandi*, Opp., but with less numerous and rounder ribs, which are not divided so far down as in the last mentioned species; in large specimens the ribs become flatter and more numerous. The lobes are much finer and more ramified than in *Per. Rolandi*.

Perisphinctes angygaster, Waagen, n. sp. In its general form resembling *Per. involutus*, Quenst., but with only dichotome ribs, which are few in number and obtusely rounded; in some places there is a broad, flat, contraction of the whorl visible. The lobes are very much like those of the preceding species.

Perisphinctes Dhosaënsis, Waagen, n. sp. A small species of about 40 m m. in diameter, with wide umbilicus, rounded whorls and very strong dichotome ribs, which often become a little broader in passing over the siphonal side, resembling the ribs in some *Aegoceras* or in *Amm. fissicostatus*, to which latter species our specimens have a certain resemblance as regards their general form. The lateral margins of the aperture have two not very long lancet-shaped ears. The species seems to be common.

Perisphinctes mutans, Waagen, n. sp. Young specimens of this species have a certain resemblance to *Per. Dhosaënsis*, but the form changes even at an early stage: the whorls

become compressed, the ribs flattened, and the body-chamber of a specimen of 60 m m. in diameter (about the largest size the species appears to attain) is nearly quite smooth.

The section of *Per. Martiusi* is represented in the Kutch Jura by nine determinable and at least four, as yet undeterminable, species, the latter being in our Museum only indicated by fragments, not sufficient for a reliable definition of the species. The better known species belonging to this section are:

Perisphinctes spirorbis, Neum. (golden oolite, Keera hill).
„ *bracteatus*, Neum. (same beds and locality).
„ *funatus*, Opp. (same beds and locality).
„ *paramorphus*, Waagen, n. sp. (same beds and locality).[1]
„ *arcicosta*, Waagen, n. sp. (same beds and locality).
„ *curvicosta*, Opp. (oolite of Dhosa; marl nodules, Goodjinseer; yellow marl rock, Jumara).
„ *euryptychus*, Neum. (hard yellow limestone, Keera hill).
„ *Pagri*, Waagen, n. sp. (red iron rock, Kuntkote).
„ *Gudjinsirensis*, Waagen, n. sp. (marl nodules, Goodjinseer).

Perisphinctes paramorphus, Waagen, n. sp. A remarkable species, which undergoes great changes according to age. When quite young, the whorls are rounded and slightly involute, covered with strong, few, and dichotomous ribs; middle sized specimens have a slightly squarish section of the whorls, these being more involute and covered with moderately numerous, strong bipartite ribs. Growing only a little larger than 100 m m. in diameter the whorls become rather high oval with a narrowly rounded siphonal side, and the ribs disappear entirely; in this stage the species resembles large specimens of *Per. spirorbis*.

Perisphinctes arcicosta, Waagen, n. sp. An intermediate species between *Per. aurigerus*, Opp., and *curvicosta*, Opp. The whorls are compressed like those in the former species, whilst the kind of ribbing agrees more with that of the latter. The largest size to which the species attains is about 60—70 m m. in diameter. In such specimens the body-chamber is but slightly ribbed and the lateral ribs are disconnected from those situated on the siphonal side.

Perisphinctes Pagri, Waagen, n. sp. In its general form very nearly allied to *Per. Orion*, Opp., but with less strongly prominent and more numerous lateral ribs; the ribs on the siphonal side are slightly turned backwards.

Perisphinctes Gudjinsirensis, Waagen, n. sp. A species also belonging to the group of the Convoluti, but certainly one of the most extraordinary forms of the whole group. The whorls are very depressed and the umbilicus large. Young specimens are of the usual habit, but fuller grown ones become provided with high, distant lateral ribs, which are divided into three flat branches on the depressed siphonal side. Full-grown specimens do not exceed a diameter of 100 m m.

In connection with the few last mentioned forms I shall describe three species, which are as yet unknown from European jurassic formations, and which are, strictly speaking, more geologically than zoologically related to the former. They are:

Perisphinctes frequens, Opp. (oolite of a valley, west of Soorka hill, together with *Rhynch. myriacantha*).
„ *denseplicatus*, Waagen, n. sp. (same layer and locality).
„ *aberrans*, Waagen, n. sp. (white marl rock, Keera hill).

Perisphinctes denseplicatus, Waagen, n. sp. Very nearly allied to *Per. frequens*, Opp., but with a somewhat smaller umbilicus, higher whorls, and much finer lateral ribs, which

are never tripartite on the outer margin, but sometimes bipartite and sometimes cross undivided over the siphonal side.

Perisphinctes aberrans, Waagen, n. sp. The only species with which I can compare this form is *Per. Albertinus*, Cat., but the difference lies in Catullo's species possessing a furrow on the siphonal side when young, while there is no trace of it in the present species. The dissimilarity, however, between young and old specimens of *aberrans* is by no means less marked than in *Per. Albertinus*. The young form resembles a little *Per. convolutus*; it has many separate rounded whorls, with fine ribs and tolerably numerous very oblique contractions of the whorls. When growing larger the ribs of the individual become in an equal degree more distant, stronger and higher on the sides of the whorls, whilst, on the contrary, they gradually disappear on the siphonal side.

The third section (of *Per. plicatilis*, Sow.) is the richest in forms in the whole Jura. In Europe it is represented by at least 100 species, all occurring in strata of Oxfordian, Kimmeridgian or Tithonian age, but for the greater part the species are as yet undescribed. The difficulty, therefore, not only in determining, but in comparing the Indian species with European forms, is much greater in this section than in any other, and the conclusions, which in other groups and genera are so naturally associated merely with their names, can in this instance not be drawn from the identity of the species, but only from the general habitus of the forms; however, some of the Indian species can nevertheless be identified with European Ammonites. The species belonging to this section are:

Perisphinctes Indogermanus, Waagen, n. sp. (brown oolite, Jooria hills; yellow marl rock, Joorun).
„ *plicatilis*, Sow. (red iron rock of Kuntkote; same rock at Joorun).
„ *torquatus*, Sow. (coarse iron sandstone of the Katrol range).
„ *bathyplocus*, Waagen, n. sp. (same layer and locality).
„ *Pottingeri*, Sow. (same layer and locality).
„ *euplocus*, Waagen, n. sp. (same layer and locality).
„ *Katrolensis*, Waagen, n. sp. (same layer and locality).
„ *virguloides*, Waagen, n. sp. (red iron rock of Kuntkote).

Perisphinctes Indogermanus, Waagen, n. sp. Very nearly allied to *Per. plicatilis*, Sow., and often mistaken for this species, but distinct from it by rounded whorls and flattened ribs on the siphonal side. There are specimens in our museum from Kutch as well as from Trouville in Normandy (Zone of *Am. cordatus*).

Perisphinctes bathyplocus, Waagen, n. sp. Allied to *Per. torquatus*, Sow., so much so that young specimens are almost undistinguishable. *Per. bathyplocus* has, however, always finer ribs and thicker whorls. When large, the lateral parts of the ribs are much swollen and distant from each other, and to each of them correspond five or six fine ribs on the siphonal side; only in very large specimens the latter become obsolete, or very nearly so.

Perisphinctes euplocus, Waagen, n. sp. Allied to *Per. Pottingeri*, Sow., but with much thinner whorls, and S-shaped, irregular, fine ribs. On the body-chamber the ribs become scarcer, more prominent and straight.

Perisphinctes Katrolensis, Waagen, n. sp. Equally allied to *Per. Pottingeri* as the last, but attaining a much larger size, and with the body-chamber much less strongly ribbed.

Perisphinctes virguloides, Waagen, n. sp. Closely resembles *Per. virgulatus*, Quenst; the ribs are, however, not so fine and the contractions of the shell indistinct.

The next species belongs to a group which is of great importance for the geology of the European Jura: it is—

Perisphinctes leiocymon, Waagen, n. sp. (red iron rock of Kuntkote).

The group is typified by *Per. polyplocus*, Rein. This latter species is known in Europe to be very characteristic for the Kimmeridgian, and not alone that, but the whole group is restricted to a similar horizon. It is doubtful whether in India the geological position is exactly the same, but nevertheless *Per. leiocymon* deserves particular notice.

Perisphinctes leiocymon, Waagen, n. sp. Closely allied to *Per. polyplocus*, Rein., but with much fainter ribs and of by far larger dimensions; only the ribs are near the umbilical margin somewhat more strongly marked. The species shows also by its rounded ribs some slight resemblance to *Per. albienus*, Opp., and thus the Indian species may be said to represent a connecting link between the section of *Per. Martiusi* and the *Polyploci* group.

The last section of *Perisphinctes* is that of *Per. Rehmanni*, Opp. The species belonging to it usually possess spiny whorls and a flat band along the middle of the siphonal side. Though I think the section originates with *Per. sulcatus*, Hehl., I quote as the first species *Per. Rehmanni*, because the geological relations between those two species have not as yet been established. The Indian species belonging to the section are:

Perisphinctes Rehmanni, Opp. (golden oolite, Keera hill).
„ *anceps*, Rein. (iron nodules, Keera hill; oolite, Dhosa).
„ *arthriticus*, Sow. (iron nodules, Keera hill).
„ *Jooriensis*, Waagen, n. sp. (brown oolite, Jooria hills).

Perisphinctes Jooriensis, Waagen, n. sp. Allied to *Per. Balderus*, Opp., but more evolute, with less numerous contractions on the whorls and sharper and more regular ribs.

The 73 species above enumerated have been determined and described from the materials in our Museum with sufficient certainty. Several forms I was obliged to put aside, partly because the materials were in bad preservation, and partly because there was not a sufficient number of specimens existing, in order to point out the exact relations or distinctions of the species; this is particularly the case among the *Perisphinctes*.

The oldest known locality where Ammonites occur, and at the same time the richest in forms, is the Keera hill near Charee, and the mineralogical differences of the rocks in which different species are preserved clearly indicate that there must be several distinct groups of middle and upper jurassic strata exposed. This variety of the rocks cannot be accidental, as is, for instance, shown by *St. tumidum* or *Per. funatus*, which never occur in an iron nodule, while *Per. arthriticus* has never been found in the golden oolite. Of the different beds in this locality, containing different Ammonite-faunas, I can at present point out two, each with a sufficiently large number of species, the golden oolite and the bed with iron nodules; all the other strata are represented only by a few species:—

(1.) Ammonites of the *Golden Oolite* of *Keera hill* near Charee:

Phylloceras disputabile, Zitt.
„ *Zignodianum*, Orb.
Lytoceras Adeloides, Kud.
Oppelia subcostaria, Opp.
Harpoceras hecticum, Rein.
Stephanoceras macrocephalum, Schloth.
„ *tumidum*, Rein.
„ *Polyphemus*, Waagen.
„ *lamellosum*, Sow.
„ *Chareëense*, Waagen.
Stephanoceras Grantanum, Opp.
„ *dimerum*, Waagen.
„ *subtrapezinum*, Waagen.
„ *diadematum*, Waagen.
Perisphinctes spirorbis, Neum.
„ *bracteatus*, Neum.
„ *funatus*, Opp.
„ *paramorphus*, Waagen.
„ *arcicosta*, Waagen.
„ *Rehmanni*, Opp.

Of these species *Ph. disputabile*, Zitt., *Zignodianum*, Orb., and *Lyt. Adeloides*, Kud., are known to be characteristic in the mediterranean province of the jurassic formation of Europe for a group of strata beginning with Bathonian and most probably terminating with lower Oxfordian rocks. The following species indicate a much more narrowly limited horizon: *Steph. macrocephalum*, Schloth., *tumidum*, Rein., *Grantanum*, Opp., *Perisph. spirorbis*, Neum., *bracteatus*, Neum., *funatus*, Opp., and *Rehmanni*, Opp., all without exception in the central European province are highly characteristic for the lower Kellovian beds, or the "zone of *St. macrocephalum*" of Oppel. The Ammonite-fauna of the 'Golden Oolite' shows very little resemblance to the faunas of other localities, and in fact there are only three species which are common to this layer and the brown oolite of Lodai and the Jooria hills; those are *Phyll. disputabile*, *St. macrocephalum* (very rare at Lodai), and *Polyphemus* (very rare at Keera hill). It seems to me that the characteristic species of the Ammonite-fauna of this Golden Oolite appear again only at Kaora in Putchum, and at Jumara, though similar rocks may be often represented in different horizons throughout the Kutch jurassic territory.

2). Ammonites of the *Iron nodules* of *Keera hill* near Charee—

Stephanoceras opis, Sow.
„ *fissum*, Sow.
Perisphinctes obtusicosta, Waagen.
„ *angygaster*, Waagen.
„ *Dhosaënsis*, Waagen.
„ *anceps*, Rein.
„ *arthriticus*, Sow.

The greater part of these species also occurs at the two next localities, and I shall, therefore, quote those occurring in the two latter immediately following.

(3). Ammonites of the *Oolite* of *Dhosa*—

Stephanoceras opis, Sow.
„ *fissum*, Sow.
Perisphinctes obtusicosta, Waagen.
„ *angygaster*, Waagen.
„ *Dhosaënsis*, Waagen.
„ *curvicosta*, Opp.
„ *anceps*, Rein.

(4). Ammonites of the dark-gray *marl nodules*, *Goodjinseer*—

Peltoceras athleta, Phill.
Perisphinctes obtusicosta, Waagen.
„ *angygaster*, Waagen.
„ *curvicosta*, Opp.
„ *Gudjinsirensis*, Waagen.

There is, I think, but little doubt that the Ammonite-fauna of these three localities indicates very closely the same geological horizon, particularly when we consider the small number of specimens (there are in our Museum not more than about 60 specimens preserved from all the three localities) which were examined, and that these have furnished so many identical species.

Of the species noticed, the following are found in the European Jura: *Pelt. athleta*, *Perisph. anceps* and *curvicosta*; all three are most characteristic forms of the upper Kelloway strata.

The next localities which have furnished a greater number of species are Lodai and the Jooria hills. The rock containing the fossils is a very fine, often sandy dark-brown

oolite with much iron, and the Ammonite-fauna of both places is so very closely allied that it will not be necessary to quote the species separately.

(5). Ammonites of the "*Brown oolite*" of *Lodai* and the *Jooria hills*—

Phylloceras disputabile, Zitt.
„ *Lodaiense*, Waagen.
Peltoceras aegoceroides, Waagen.
„ *Arduennense*, Orb.
„ *semirugosum*, Waagen.
„ *bidens*, Waagen.
„ *perarmatum*, Sow.
Stephanoceras macrocephalum, Schloth.
Stephanoceras Polyphemus, Waagen.
„ *elephantinum*, Sow.
„ *arenosum*, Waagen.
„ *eucyclum*, Waagen.
„ *fissum*, Sow.
Perisphinctes Dhosaënsis, Waagen.
„ *Indogermanus*, Waagen.
„ *Jooriensis*, Waagen.

Of *Phyll. disputabile* I have already mentioned the geological position; among the other species in the list it may seem a little strange to find together, apparently in the same layer, *St. macrocephalum* and *Pelt. perarmatum*. The discrepancy may be explained in two ways. Either there exist in Lodai and Jooria two layers of very similar lithological aspect, but of different age, or *St. macrocephalum* had in India a greater vertical distribution than in Europe, that is, the species passes in India from lower into higher strata, during the deposition of the latter of which it was already extinct in Europe. The latter explanation seems to me the more plausible one, because there occurs also in another locality, at Kuntkote, a species of the *Macrocephali*, (*St. Maya*, Sow.,) which is so closely allied to *St. macrocephalum*, that it is hardly possible to distinguish them specifically, and also because in Kutch the *Macrocephali* group in general seems to continue, in a great variety of forms, into higher beds than is the case in Europe. Under these circumstances, we may, therefore, consider as the most valuable species for determining the age of the strata above noticed the species of the *Peltoceras*, which in Europe are highly characteristic for lower and middle Oxfordian. The most important species are *Peltoc. Arduennense* and *perarmatum*, and next to these *Per. Indogermanus*, which is very common in the "zone of *Am. cordatus*" of the "Vaches noires."

The brown oolite has, in common with the oolite of Dhosa, *Steph. opis* and *fissum*, whilst on the Keera hill we again find *St. eucyclum* in an indurated yellow limestone, together with *Per. euryptychus*, Neum., which possibly could represent the brown oolite in that place.

The locality west of Soorka hill has furnished only two species of Ammonites—
Perisphinctes frequens, Opp., and
„ *denseplicatus*, Waagen,
associated with *Rhynch. (Hemithyris) myriacantha*, Desl., in a brown oolite, very much like that of Lodai.

The next locality of considerable geological interest is that of Kuntkote, because Sowerby has described from there several species, and among them *Per. calvus*, which was most probably wrongly identified with one occurring in Europe; but unfortunately no specimen of true *A. calvus*, Sow., is found among our materials. The rock of Kuntkote is dark-red, fine sandy, ferruginous, much impregnated with salt and gypsum. The species are—

(6). Ammonites of the *red ferruginous rock* of *Kuntkote*:
Peltoceras cf. *perarmatum*, Sow. (possibly *Pelt. Oegir*, Opp.)
Stephanoceras Maya, Sow.
„ *fissum*, Sow.
„ *Nepalense*, Grav.

Perisphinctes Pagri, Waagen.
„ *plicatilis*, Sow.
„ *virguloides*, Waagen.
„ *leiocymon*, Waagen.

These few species can serve merely by their general character as a guide towards the determination of the age of the Kuntkote beds, because the only species of which the geological position is well known in Europe, *Per. plicatilis*, indicates only generally strata of lower or middle Oxfordian age. The other forms of *Perisphinctes* occurring at Kuntkote resemble in general character such species as, if found in Europe, would be referred to the middle or upper Oxfordian. This and the appearance of the rock leads me to believe that the Kuntkote beds are a little younger than the brown oolite, with which they have only a single species, *St. fissum*, in common. A similar rock to that of Kuntkote occurs only at a certain distance north from Dhosa, where *Aspidoceras iphicerum*, Opp., has been found in a dark-red and a slightly sandy ferruginous rock.

The last locality of importance which has furnished nearly the greatest number of specimens of Ammonites, though the number of species is not very large, is the Katrol range, the rocks there being represented chiefly by coarse ferruginous sandstones and sandy ferruginous concretions, with frequent occurrence of fossil wood. The species found there are—

(7). Ammonites of the coarse *ferruginous sandstone, Katrol range:*
Phylloceras ptychoicum, Quenst.
Haploceras cf. *tomephorum*, Zitt.
Oppelia trachynota, Opp.
„ *Cutchensis*, Waagen.
Peltoceras monacanthus, Waagen.
Aspidoceras Wynnei, Waagen.
„ 2 sp. indet.
Perisphinctes torquatus, Sow.
„ *bathyplocus*, Waagen.
„ *Pottingeri*, Sow.
„ *euplocus*, Waagen.
„ *Katrolensis*, Waagen.

The first three species are European forms, and two of them, *Phyll. ptychoicum* and *Hapl. tomephorum*, are very characteristic for the Tithonian formation of the Mediterranean Jurassic province, whilst *Opp. trachynota* occurs in the middle and upper Kimmeridge and Tithonian layers of the Mediterranean and Central European provinces. Of the other species, only *Pelt. monacanthus* and *Asp. Wynnei* have a decidedly Tithonian character, whilst among the *Perisphinctes*, the absence of the group of *Per. polyplocus* also indicates very high jurassic beds. It should also be mentioned that Mr. Fedden notes on the label accompanying the specimens of *Asp. Wynnei* and *Hapl.* cf. *tomephorum*—"From the highest beds containing *Ammonites*."

Recapitulating briefly what I have said regarding a few of the principal localities containing *Ammonites*, it seems clear (1) that at different places there are strata of a different mineralogical character represented; (2) that these strata contain species of *Ammonites* mostly peculiar to themselves; and (3) that these species indicate distinct geological horizons.

If we take only those species into consideration which occur in the Kutch, as well as in the European Jura, we find that in the golden oolite of Keera hill there are nine species of the "zone of *St. macrocephalum*;" in the oolite of Dhosa and the equivalent beds there are three

species of the "zones of *Perisph. anceps* and *Pelt. athleta*;" in the brown oolite are three species of the "zone of *Am. cordatus*" and one of the "zone of *St. macrocephalum*." In the ferruginous rock of Kuntkote there is one species common to the "zones of *Am. cordatus* and *Pelt. transversarium*;" and, lastly, in the coarse sandstone of the Katrol range are two species of the Tithon-formation and one common to middle and upper Kimmeridgian and Tithonian.

If, therefore, the faunas have not in their development in India followed other laws than they did in Europe, we might arrange the deposits of the whole of the Kutch Jura in the following manner:

Rocks.	Localities.	Probable equivalents in Europe.
Ferruginous sandstone { coarse ...	Katrol range	Tithonian and Upper Kimmeridgian.*
Ferruginous sandstone { fine ...	Kuntkote	Upper Oxfordian.
Oolite	Lodai and Joeria	Lower Oxfordian.
Oolite	Dhosa	Upper Kelloway.
Oolite	Golden oolite Keera hill	Lower Kelloway.
Flaggy, sandy limestone and yellow sandstone	Guddera (Ammonites wanting) ...	Bathonian.

The most general division we could at present introduce into the Kutch Jurassic deposits is to separate them into two complex groups of sandstones, divided from each other by a zone of oolites of comparatively small thickness.

But there remains yet the great question, what is Mr. Wynne's "Upper Jura of Kutch" which contains the plants, of which several are considered as identical with those of the Rajmahal hills, for all the beds which I have previously noticed, and which appear to represent the jurassic deposits of Europe from the Bathonian upwards to the Tithonian, compose only the "Lower Jura" of Mr. Wynne's divisions, based on the physical relations of the beds. To answer this question satisfactorily in the present stage of our knowledge is impossible; we must be content to wait the result of further research into the fossils to be found in this interesting province.

THE RAIGUR AND HENGIR (GANGPÚR) COAL-FIELD, by V. BALL, *Geological Survey of India.*

The coal-field thus denominated has hitherto been generally spoken of as the 'Gangpúr field.' The result of my examination having been to show that the greater portion of the area is contained in the district of Raigur and the remainder in the sub-zemindari of Gangpúr known as Hengir (or Hingir)—no portion of the coal-bearing rocks or their associates extending into Gangpúr proper—it seems undesirable to perpetuate a misnomer which is only calculated to mislead.

Whether this area is entirely detached from the Udípúr field or not I am at present unable definitely to affirm. My impression is, that a connection does exist towards the north-

* The Lower Kimmeridgian is only represented by a single species, *Asp. iphicerum*, from N. of Dhosa out of a dark-red fine sandy ferruginous rock.

west, but where I crossed from one to the other there was an interruption of continuity caused by a strip of about four miles of metamorphic rocks. These may possibly only exist as a spur from the southern boundary, which, while they penetrate the area of sedimentaries, do not extend sufficiently far north to cause an absolute separation of the two fields.

Approaching this field from the west, I first struck it about a mile, or rather less, east of the village of Bagchapa on the Kurket in Raigur, and thence traced it to its extreme eastern extension at Kosira on the Baisandar in Hengir. The distance between these points is 34 miles in a direct line. So far as my time admitted, I examined the country to north and south, and at many points ascertained the definite boundaries. At others I was obliged to content myself with conjecture, but from such data as I possess I feel confident that the area occupied by the three groups of sedimentary rocks which occur in this field will be found to extend over at least 400 square miles.

With this introduction I shall, before proceeding to the actual details resulting from my preliminary examination, briefly allude to such previous notices as exist regarding the occurrence of coal and coal-bearing or associated sedimentaries in this area.

Colonel Haughton, 1854.*

Colonel Haughton alludes to the Gangpúr coal formation as possibly connected with that of Sirguja and Palamow, but adds, "on this point I have no reliable data."

Captain Saxton, 1855.†

Captain Saxton communicated to the Asiatic Society in 1855 some particulars regarding coal in the Gangpúr Raja's territory, some 50-60 miles north-west from Sumbulpúr and 25-30 miles from Puddumpúr on the Mahanudi. He writes, "should Calcutta and Bombay be hereafter connected by railway this coal would lie on the way. The bed appears very extensive. A nalá running into the Ebe river which joins the Mahanudi about ten miles above Sumbulpúr passes over, and through, it, and masses of the upper coal which is very light are floated down in the nalá in the rains."

No further precise information regarding the locality is given, though little doubt can exist that the Baisandar is the 'nalá' alluded to.

Dr. Oldham.

In a preliminary notice on the coal and iron of Cuttack by Dr. Oldham, reference is made to this discovery by Captain Saxton. Time did not admit of the Officers of the Geological Survey—at that season engaged in Cuttack—visiting the locality.

Topographical Survey Map.

On the Topographical Survey Map, recently published, the occurrence of coal is indicated in several localities, especially in the Baisandar river.

The formations occurring in this area are Tálchírs, Barákars, and Upper sandstones, *&c.*, (? Mahadevas).

TÁLCHÍRS.

The only place at which I met with rocks belonging to the Tálchír series in this field was near the village of Kosira at the north-east corner of the area; they are very indistinctly seen, and much mixed up with a kind of *arkose* bed, which is precisely similar to one occurring on an undoubted Barákar horizon, and which will be found described further on. In the Baisandar below Kosira they consist of greenish and yellow sandstones with a boulder bed.

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* J. A. S., B., 1854.

† Proc. A. S., B., March, 1855.

Mr. Medlicott found Tálchírs all along the southern boundary of this area striking north-west from Sumbulpúr, but I had no time to connect these with my work.

Barákars.

The Damúda rocks occurring in this area probably belong to the Barákar group. For the most part they rest immediately on the gneiss, and are covered and overlapped by the upper sandstones and grits so completely that but for the denuding action of rivers they would now be altogether concealed. This is more particularly the case in the eastern portion of the area where the best coal seams occur. Thus, in the Baisandar and Jhajia rivers the Barákars are merely exposed in the beds, while the upper rocks compose the opposing banks.

It will be more convenient to describe the sections from east to west; I therefore commence with that of the Baisandar river.

In the bed of the Baisandar, the most eastern outcrops of Barákars occur south of Kosira. From this point the northern boundary of the field can be most distinctly traced through the southern *tolah* of Tikripara; the south-eastern boundary is less distinct, but I am inclined to believe that a strip of Barákars, bounded by the gneiss on the east and by the upper sandstones on the west, occurs at least as far south as the village of Balingá.

The section of the Baisandar for about a mile west of Kosira discloses ordinary Barákar sandstones and the arkose bed above alluded to; this consists of granitic and schistose materials not showing any sign of having been subject to weathering. Beyond these rocks there is a succession of rolling seams of carbonaceous shale with occasional bands of coal; these strike with the boundary, but as they are all nearly horizontal, constant repetitions occur in succeeding streams, and I had not time to trace out the section in sufficient detail to enable me to affirm positively how many distinct seams exist. The first promising seam which I measured occurs 250 yards south of the Jhapurnga and Tikripara road crossing. The following is the section:—

Descending: dip 15° to 30° south of east.

		Ft.	In.
	Sandstones.		
1.	Blue shales	3	4
2.	*Coal*	4	7
3.	Irregular mass of blue shale	2	6
4.	*Coal*, upper portion shaly	3	10
5.	Parting	0	2
7.	*Coal*, about	5	0
	Several feet below not well seen.		

The coal in this seam at first sight looked very promising, but on analysis it has proved to be of inferior quality, the proportion of ash being 30·6. I very much fear that there is at present no promise of coal of better quality and of workable thickness being found in this neighbourhood. Below is a seam of 80 feet of carbonaceous shale with portions coaly. This could not be measured without excavations being made, for which there was no time. But it gives no promise of containing a workable thickness of coal.

The reaches above this expose the top of a fine seam of carbonaceous shales with coaly bands. The strike being with the stream, a very peculiar terraced appearance is produced. Above its junction with the Jhajia the course of the Baisandar is from north to south, and thus a very distinct section is obtained of one of the largest seams which has been recorded as occurring anywhere.

It is most unfortunately deficient in workable thicknesses of good coal. The following is the section:—

Ascending.

		Ft.	In.
1.	Coarse grit sandstones with interpolated carb. shales ...	0	0
2.	Blue and sandy shale	2	0
3.	Inferior coal with partings of carb. shales, central portion all coal	6	10
	Carried forward ...	8	10

		Ft.	In.
	Brought forward ...	8	10
4.	Sandstone (thinning out to O)	1	8
5.	Blue and black shales with occasional coaly layers of 1 inch and less	5	5
6.	Ditto, more coaly, but useless	2	0
7.	Blue shales	0	7
8.	Papery *coal* and coaly shale	4	1
9.	Blue shale concretionary	1	10
10.	Carb. shale passing into coaly shale	5	6
11.	Blue concretionary shale	5	8
12.	Carb. shale with flaky *coal*	4	10
13.	Blue concretionary shale	1	8
14.	Carb. shales	0	8
15.	Flaky *coal*	2	0
16.	Blue concretionary shales	0	8
17.	Carb. shales, portions coaly	2	9
	Same decomposed	3	6
18.	Blue concretionary shales—Dip south south-east 4° ...	6	0
19.	Carb. shale and flaky *coal*	1	10
20.	Blue concretionary shales	1	9
21.	Flaky carb. and coaly shale with charcoal markings, coaly portion containing much red oxide of iron...	1	6
22.	Blue concretionary shale	2	10
23.	Stony *coal* very impure	1	2
24.	Ditto, portions flaky...	1	3
25.	Flaky carb. shale	2	0
26.	Blue concretionary shale	4	7
27.	*Coal* with red oxide of iron	1	10
28.	Carb. shale	0	3
29.	Flaky coaly shale	1	0
30.	Blue shales	1	2
31.	Flaky carb. shales—portions coaly—Dip 4° south south-east ...	7	0
32.	Carb. shales	1	3
33.	Same as 31	2	6
34.	Blue concretionary shale. Dip south 6° (corner of bend) ...	1	11
35.	Impure *coal* much mixed with red oxide of iron and passing into flaky coal and carb. shales	3	10
36.	Concretionary shale	2	7
37.	Flaky *coal* with iron	0	10
38.	Carbonaceous shale	1	2
39.	Concretionary blue shale	1	3
40.	Carb. shale and coaly shale	1	9
41.	Blue shale	1	4
42.	Carbonaceous shale and stony *coal*	1	10
43.	Flaky *coal* with carb. shale	3	6
44.	Concretionary blue shale passing into pinkish carb. shale ...	3	8
45.	Flaky *coal* with carb. shale	1	3
46.	Blue concretionary shale	3	8
47.	*Coal* permeated with iron	1	2
48.	Flaky *coal*, about	2	0
49.	Concretionary blue shale	3	0
50.	Carbonaceous shale and flaky *coal* ... ... 1′ 4″ to	2	0
51.	Massive sandstones irregularly interpolated and thinning out to south	10	10
52.	Carbonaceous shales	0	8
53.	Coaly shale containing much iron and alternating with carb. shales	2	0
54.	Blue and black concretionary shale	9	0
55.	Same as 5	0	9
56.	Concretionary blue shale	7	0
57.	Concretionary blue and black shales with concretionary layers. Dip 4° south	12	0
	This is on southern bank of Baisandar.		
	TOTAL ...	168	7

This seam is also seen in the streams west of the village of Sardega, but not so clearly as in the Baisandar.

Below No. 1 of the above seam there are some Barákar grits, and underneath them some arkose beds, which plaster over granitic gneiss, showing a most distinctly natural boundary.

There are no traces of coal or other sedimentary rocks brought down from further north by the Baisandar. This, though not a *proof* that none such exist, may be taken as collateral evidence in favor of the view —also supported by the physical characters as represented on the map—that uncovered gneiss continues up to the plateau and is connected with the main gneiss of Eastern Udípúr, &c.

In the bed of the Jhajia river westwards, the large seam becomes much broken up by interpolations of sandstones and shales, and with the dying out of the more coaly bands the change is so complete that it is impossible to recognise it or trace any portion of it through successive reaches. Between Ratansarai and Ghogarpali there are several seams or repetitions of a seam, but none contain coal of useful quality and thickness. As above mentioned, the upper sandstones appear on either bank, and in one place occupy the bed of the stream itself. South of Ghogarpali there is a seam containing about 30 feet of shale to one of coal. Above the village it is seen again, a portion having been burnt: in the unburnt part there is a band of 8 inches of very good coal and several thinner layers. About 25 feet in all of this seam is exposed at this second locality.

Between this and Bograkachar there are frequent outcrops of carbonaceous shale with coaly layers belonging to several distinct seams. Close to Bograkachar there is a seam of similar character with a slight indication of a dip to east south-east. The contained coal is in very thin layers. How far these rocks may extend northwards up the bed of the river I had not time to ascertain, but from the pebbles I think it probable that the gneiss cannot be very far distant.

This little area of carbonaceous rocks which occupies the beds of the Baisandar and Jhajia rivers may be best understood by regarding it as a vast seam of some 500 feet of coaly and carbonaceous shale with irregular partings and interpolations of sandstones. Occasional thin bands of good coal occur, but they are rare, and the prevailing components of the seam are blue and black carbonaceous shales.

The prominence and abundance of the outcrops are such that no one could possibly avoid noticing the coaly looking beds which are particularly well exposed in the vicinity of the road crossing at Tikripara.

As to the extension of these seams southwards underneath the upper sandstones nothing certain is at present known, and should it be found that the latter rest immediately on the Tálchírs of the south boundary, then it will be impossible to solve this question without having recourse to borings.

The centre part of this field is traversed by two principal streams, the Koldiga and the Kelo, with a number of smaller tributaries. The high ground between these is probably for the most part occupied by outlying patches of the upper sandstones, while in the river beds Barákar rocks are exposed.

Kelo Section.—In the river section between Jhargaon and Hokra there are several outcrops of seams consisting of carbonaceous shale. Only one, that near Tiptipa, contains coal, but even there it is in too small quantity to be of any use. At Hokra there is a 10 foot seam of concretionary shale, no coal—dip 4° to 35° east of south.

Beyond the Gari Ghât there is a 2 foot seam of concretionary shale and coal—dip 7° south.

In the Bendia (near the mouth), which joins the Kelo at Gari, there is a considerable seam.

Ascending—Dip irregular, south-west 5°.

	Ft.	In.
1. Carb. shales, bedding irregular, with some slight coaly layers towards base	4—5	0
2. *Coal*, portions flaky, but for the most part burnable, much weathered	4	10
3. Parting, ferruginous sandstones	0	6
4. Flaky *coal* with carb. shale excessively weathered and decomposed	6	0
	15 4—16	4

I think it possible that some good coal might be extracted from this seam. In its present decomposed condition even, it is easy to see from the manner of weathering that good or fair coal exists. The thicknesses given above do not hold for all parts of the seam. In this same stream (Bendia) higher up a rolling seam of carbonaceous shale with a few inches of coal continues on both sides for about half a mile.

Between this and the village of Kornkel there are three seams consisting of blue shales, the most southern of which contains some layers of good coal 6 inches thick.

Returning to the Kelo section. At the top of the next reach beyond the mouth of the Bendia there is a seam containing 12—15 feet of blue and black shales with coaly layers—dip 4° to 30°, south of west.

In the next mile and a half four or five seams are met with; they are apparently repetitions of those above alluded to in the Bendia; none of them contain any useful quantity of coal.

At Milupara there is a change in the dip to more or less north of west, and two or three seams are exposed with intervals covered. Sandstones are the only rocks seen up to Khara, but near the village there are some greenish fine sandstones which I at first thought might be Tálchírs, but they appear to overlie the carbonaceous shale. Near Khara there were still fragments of coal in the stream, which showed that the northern limit of the Barákars had not been reached. There were also, however, a quantity of gneiss fragments which had not the appearance of having travelled any great distance. The hills formed of the upper sandstones impinge close on the banks of the river in this neighbourhood.

Koldiga Section.—In the Koldiga below Mahulai there are rolling carbonaceous shales with ironstones and flaggy beds, but I did not see any coal. The whole aspect of these rocks reminded me more of the "*carbonaceous shale and ironstone group*" than of any other rocks of the Damúda series which I have elsewhere met with. I am not, however, prepared to say at present whether they are susceptible of separation from the Barákar group.

Between the Samkera and Parega and Samkera and Gasbahari road ghâts the flags accompanying the carbonaceous shales present a very peculiar appearance, being of green buff and grey colors, sometimes resembling Tálchírs, but always closely connected with the carbonaceous shales.

East of this the section consists principally of carbonaceous shales up to Dumartoli, where the stream falls from the higher ground occupied by the upper sandstones.

Much remains in this area to be done in the detailed separation of the Barákars from these upper rocks. Except where there are marked physical features, owing to the slightness of the contrast in lithological characters, it is extremely difficult to draw a satisfactory boundary.

West from the Kelo the coal-bearing rocks are found for a distance of 13 miles.

In the Pájú river there are some fragments of coal brought from some seam or seams north of the high road, but none are exposed in its immediate vicinity.

In the Dighi stream at Deogurh there is a seam of blue and black carbonaceous shales with 5 inches of coal at the top. No better seam is exposed in the river for a mile to the south.

In the Hurinara stream there are sandstones and some traces of coaly and carbonaceous shales. Between the valleys of Simra and Charatanga there are some ferruginous sandstones, possibly Barákars. Between Charatanga and the Kurket river there are Barákar sandstones, and the same are better seen in the bed of the river itself. The section examined in both directions north and south for about half a mile showed no signs of coal *in situ*, but fragments occur in the bed of the stream.

The boundary of these rocks must cross the Kurket about midway between the villages of Rábo and Bágchapa.*

Bágchapa itself is on gneiss, and about a mile to the south the boundary of the Vindhyans is marked by a low range of hills.

Upper Sandstones.

The manner in which, especially in the eastern portion of this field, the coal-bearing rocks have been covered by the upper sandstones has been already alluded to. The principal area of these rocks exists south of the strip of Barákars which are exposed at the drainage level by the rivers and streams. How far it extends southwards is not known, and the important economic question as to the extension of the coal measures underneath has still to be determined. If it be found that the Barákars crop out from beneath them and rest on the Sumbulpúr Tálchírs described by Mr. Medlicott, then the question will be solved, but if, as is possible, and in some degree probable, the upper sandstones lap over on to the Tálchírs without any appearance of Barákars intervening, then the extension of the latter can only be ascertained by borings.

North of the Barákar sections the upper sandstones form large hills, sometimes resting on the former and sometimes resting immediately on the gneiss, as is particularly well seen in the valley north of Jhanjgir. The lithological characters of these rocks are very much the same as they were in the northern fields—highly ferruginous sandstones and grits, and red brown and ochreous clays sometimes with fragments of plants. The bedding is for the most part horizontal, and apparently does not partake of the rolling which characterises the underlying Barákars.

Description of the sandstones in the neighbourhood of the first barrier on the Godávarí, and in the country between the Godávarí and Ellore, by William T. Blanford, F. G. S., *Deputy Superintendent, Geological Survey.*

A brief notice of the great sandstone tract in the valley of the Godávarí and its tributaries has already been given in the Records of the Geological Survey of India for 1871, pages 49—52. The following pages furnish a somewhat more detailed account of the south-eastern portion of this area, extending from the junction of the Tál with the Godávarí to the alluvium of Yelaur (Ellore) and Rájámahendrí.

The only portion of the country which has been closely examined is the area occupied by the Damúda rocks, which are seen in the Godávarí just below the junction of the Tál, and again about 30 miles lower down the river near the village of Deorpalí and Ganara on the left bank, and of Amraváram, Damarcherla, and Mádaváram on the right. The remainder

* As I had no map whatever of this country, I did not attempt any detailed examination.

of the sandstone tract, consisting principally of Kámthí beds, has been more cursorily surveyed. Tálchírs occur in several small patches, mostly isolated, in the immediate neighbourhood of the river.

The description commences at the northern extremity of the area, at the confluence of the Tál and Godávarí. The various rocks seen on the banks of the latter river between the Tál and Bhadráchalam are noticed in succession, then the sandstones around Ganara and Deorpalí north of the Godávarí; and the remainder of the paper is composed of notes on the sandstone tract extending from Mádaváram and Palúnchá on the north to the coast alluvium on the south, commencing at the north-east corner near Mádaváram.

The country has hitherto attracted but little attention from Indian Geologists: a portion of it is briefly described in Dr. Voysey's Second Report on the geology of Hydrabad* and in the extracts from his private journals ;† and the sandstones on the river banks are noticed by Mr. Wall in his "Report on a reputed coal formation at Kota."‡ But none of these papers do much more than to mention the existence of sandstone or other rocks in particular spots.

It may be as well briefly to mention the features of the Godávarí valley above the mouth of the Tál. From Sironchá the river runs through sandstones as far as the commencement of the second barrier just above the confluence of the Indraotí river with the Godávarí. Here it enters metamorphics, the sandstones (Kámthí, &c.,) occupying the country to the south-west. At the bottom of the barrier, after traversing a band of Vindhyan quartzites, the river enters the plant-bearing sandstones, and they are the only rocks seen upon its banks from this point to the mouth of the Tál, but at a short distance inland from the left bank a high range of Vindhyan quartzite runs parallel with the river, and terminates, a few miles before reaching the Tál, not far from the large village of Charla, whilst the quartzites and their associates extend as far as the Tál, and re-appear south of it. On the right bank of the river the sandstones stretch for a considerable distance, much farther than on the left.

All the country between Charla and the Godávarí appears to be alluvial; no rock is seen in the river bank for a long distance above the mouth of the Tál.

Rocks near Charla.

On the road from Charla to Tiagra (Tengra) Tálchírs are seen about a mile from the Tál. Some more are met with in the jungle to the eastward; but between the road and the Godávarí none were detected. At Charla itself, nothing could be seen on the surface, and the hills to the eastward are of Vindhyan sandstone, but blocks of unmistakeable Kámthís have been dug out from the north side of the village to repair the tank. There can, I think, be but little doubt that these are in place, and, if so, both Damúdas and Tálchírs, which appear to the southward, must here be overlapped.

Rocks near mouth of Tál just above Lingálá.

In the branch of the Godávarí east of the island (char or lanka) above the mouth of the Tál one solitary block of coarse conglomerate is seen. Precisely similar rocks come in, dipping at about 17° to the west at the spot where the Tál joins the Godávarí. At this place fragments of coal have been picked up, but despite much search, borings through the sand, &c., their source had not been discovered until after I had left the country.§ Three hundred or 400 yards above its mouth, Tálchírs appear in the Tál, dipping

* J. A. S., B., 1833, Vol. II, p. 392.

† Id. 1850, Vol. XIX, pp. 287-288 and 296-302.

‡ Mad. Jour. Lit. and Sci., 1857, Vol. XVIII, p. 256.

§ Since I left the Godávarí, Mr. Vanstavern has cut into a small seam of coal under the rocks on the north side of the Tál at its mouth. It is about a foot thick and very shaly. This is doubtless the source of the coal found at this spot.

at a high angle to the westward, and the same rocks recur at intervals for about three miles; then limestone belonging to the Vindhyans makes its appearance. This limestone has been employed in the anicut and locks at the first barrier.

Above Tiagra the Tálchírs seem not to extend far east of the bed of the Tál, metamorphics appearing near the stream on the right bank. On the left bank a hill of Vindhyan sandstone appears just above Keshúpúr. The range of hills east of Tiagra, extending to Halverú, are of Vindhyan quartzite, east of which metamorphics occur. To the west of them Tálchírs are seen near Tiagra, but to the southward all is alluvium between the road to Dúmagúdem and the river.

Rocks on banks of Godávarí near Lingálá.

Along the (left) banks of the Godávarí below the mouth of the Tál, reefs of typical Damúda sandstone, more or less conglomeratic, run parallel with the bank to some distance south of Lingálá. The dip is west, and west by south,—at Lingálá W. 30°—40° S.,—with an inclination of 17° to 20°. These beds abound in Vindhyan pebbles and detritus, by which they are coloured quite red in some places. Small seams of coal have been found amongst them by Mr. Vanstavern in two or three places, but none exceeded 2 feet in thickness, and they can be traced a short distance only. Reefs of similar rocks occur in the river at a distance from shore, and beneath one of them a seam 5 feet thick was found by Mr. Vanstavern.

At Omadhárám, below Lingálá, the river bank falls back to the eastward, and the strike of the rocks turns to the south, and then south-west, crossing the river. Beneath the lowest reef of Damúda conglomerate seen is some fine sandstone, probably belonging to the Tálchírs. Below this no rocks are seen on the left bank of the river for more than three miles. About two and a half miles above Parnasálá metamorphics appear, and continue as far as Dúmagúdem.

Rocks south-west of the Godávarí near Managúr.

Above the spot, at a village called Tarkala Singaram (Ryechelgoodium on one map) where the Damúdas appear on the right bank opposite Lingálá, striking across the river, no rocks are seen in the river bank as far as Biaram, a distance of eight or nine miles, and the country near the river bank consists of alluvium. Further inland rock crops out here and there, but much of the surface is covered with sand or sandy clay. On the road from Managúr to Mangampet coarse felspathic sandstone is seen in two or three places. There is a hill of conglomerate dipping westward, south-west of the village of Románjá, and coarse sandstone and conglomerate is seen near Pyáran Tank. The hills west of Managúr consist of similar beds, white and brown in colour. The sandstone has the same loose pseudo-vesicular texture which is seen in some of the Kámthí beds, and in one spot hardened clay is intermixed with the rock as at Sironchá. The dip is low to the west or west by north.

Rock is exposed here and there throughout the thick jungle with which all the country is covered, except in the immediate neighbourhood of the river bank. Some small pits were made and borings put down near Singaram, and sandy shale and clays, white, pale buff, pink and brown, were met with, some of those cut into in the pits containing *Glossopteris*. The beds seen at Singaram must be a continuation of the Damúdas seen at Lingálá, but it is impossible to say how much, if any, of the coarse sandstones and conglomerates seen west of Managúr should be ascribed to this group. Judging from the other rocks found to the south-east, a large proportion of these beds are probably Kámthí, and there is every appearance of the Damúdas being overlapped by the Kámthís near Managúr, as they are in all probability at Charla.

Rocks near Singaram.

Rocks on right bank of Godávarí below Singaram.

The beds seen in the river bank at Singaram are brown and white sandstones, evidently Damúdas, and the prolongation of the rocks seen at Lingálá. Their dip varies, being usually W. 10° to 20° N., and about 20°, but it ranges from 10° to 30°, and is difficult to make out exactly. Down the river, Tálchírs come in about half a mile or rather less below Singaram and 200 yards west of the village of Yegúradigúdem, and dip north-west about 12°. They are thence seen in the river bank at intervals for about three and a half miles, as far as a little village called Raigúdem. Here the last outcrop of Tálchírs occurs at a small jutting point; metamorphics appear about 200 yards further down the river, near the houses of the village. A hill not more than 100 yards from the river bank is of Vindhyan quartzite, but in the river itself only metamorphics are met with. The dip of the Tálchírs is somewhat irregular, but chiefly to the north-west, and a considerable area must be exposed.

Country west of Godávarí near Dúmagúdem.

The country west of the river from this to Bhadráchalam was only very cursorily examined. The great ridge of Ratangota running north-east to south-west is of Vindhyan quartzite; it is isolated, being bordered by metamorphics on the south-east, and partly on the north also; while to the west and south-west Tálchírs occur, and a belt of them extend from its southern extremity to the Godávarí at Dúmagúdem, the village of Mitagúdem resting upon these beds. Vindhyans re-appear in the hills south and south-east of Mitagúdem; they form the hill about a mile west of the Godávarí opposite Dúmagúdem, and extend south as far as Gondigúdem, and thence for an unknown distance to the westward. They are much hardened, and the softer beds are rather schistose. The southern boundary of the plant-bearing series runs from Ratangota hill westwards through Búga, where there is a hot-spring; all Damúdas and Tálchírs disappearing and massive Kámthís abutting against the Vindhyans. From near Búga the boundary runs south-west through a very wild jungle, metamorphics replace the Vindhyans, the latter not being found to the southward so far as the rocks were examined, whilst the area of the plant-bearing sandstones extends for an unknown distance to the west towards Paikhal.

Rocks in Godávarí near Dúmagúdem.

The anicut of the first barrier opposite Dúmagúdem is on metamorphics, but just below Tálchírs come in, apparently continuous with the larger area to the westward. They occupy the river bed for rather more than a mile, and are seen on both banks, but do not appear to extend to the eastward. They are quite characteristic, mudstones and fine sandstones; the dip is variable. Just below Amágarpali some coarse gritty hard sandstone is exposed, dipping north-west; it is unusually coarse for Tálchírs, being even conglomeratic.

Inaccuracy of map.

The map west of the river is very inaccurate, and the two banks by no means coincide. Just below the anicut, the right bank is marked too far south or down the river by 200 yards, whilst a mile farther down points on the right bank are a quarter of a mile farther north than those which are really opposite to them on the left bank.

Tálchírs south of Dúmagúdem.

A small exposure of Tálchírs is seen on the right bank of the river at Sinterál, two miles or rather more below Dúmagúdem; another on the opposite bank (perhaps part of the same) just below. The latter extends for about a mile east of the river. Tálchírs again occur on the left bank just above Dáutheram point, which is of granitoid metamorphics, and a mile and a half below they are seen for a mile along the left bank, not extending across to the right. They, however, stretch inland, to the eastward for about six miles.

The lowest beds seen on the river bank west of Narsápúr are compact fine grained sandstone dipping north-east and resting with pseudo conformity, as not unfrequently happens, on the metamorphics. South of Narsápúr, and a little east of the river bank, close to a small nalá, this fine sandstone has been quarried to some extent for the navigation works at Dúmagúdem. It cuts well, but has been found to have a great tendency to split and crumble after exposure.

East of Narsápúr the ordinary shales or mudstones prevail. Boulders, some of them of great size, abound on the road from Narsápúr to Bandalgúdem. One must have been nearly 10 feet in diameter. The larger blocks are metamorphic, but smaller pieces are of Vindhyan sandstone and limestone.

Metamorphics near Bhadráchalam.

From Tárbáká near Narsápúr to Raigúdem, on the right bank of the Godávarí, close to the mouth of the Pámálerú, four miles below Bhadráchalam, only metamorphic rocks are seen in the Godávarí. In Malcolmson's Map* Deccan overlying trap is represented as occupying a considerable area on both sides of the river close to Bhadráchalam. I have not been able to trace the source of Malcolmson's information, but it must have been founded on the large quantity of hornblendic gneiss occurring at Bhadráchalam and in the neighbourhood. Some of this is so compact as to become mineralogically a greenstone.

Trap on Malcolmson's Map.

Banks of Godávarí below Bhadráchalam.

The north or left bank of the Godávarí is composed of metamorphic rocks until close to the village of Deorpalí, whilst the south or right bank consists of sandstone from Raigúdem, the boundary between the two, which appears to be a fault, running along the channel of the river. The hot spring at Gundala, temperature 140°, is concealed beneath the sand of the river, and a small well is annually made in the sand in order to reach it. This is done at a feast in the month of April. The position of the spring is apparently a little north of the boundary between the metamorphics and the sandstone, but as very few rocks are seen, the exact position of this boundary is uncertain.

Hot spring of Gundala.

Sandstones below Deorpalí.

From Deorpalí sandstones occur, wherever any rocks are exposed, on both banks of the river, with one exception, as far as Nándigúr on the left bank, and a little below Mádaváram on the right. The exception is on the latter for about a mile and a half above the village of Poláram, where metamorphics appear. Below Mádaváram no sandstones are known to occur.

The sandstones around Raigúdem, Deorpalí, Mádaváram, &c., are part of the great area extending southwards to the neighbourhood of Ellore and Rájámahendrí, which has been briefly described in the Records of the Geological Survey for 1871, p. 49. A full detail of the boring operations is given in the same volume of the Records, p p. 59-66.

Arrangement of notes on the sandstone area.

In proceeding to describe the geological features of the sandstone area extending from Raigúdem, Deorpalí, and Mádaváram on the north to the alluvium of Ellore, it will be most convenient first to give such notes as have been made on the small tract north of the river near Deorpalí, next those on the isolated area to the south around Mádaváram, and finally a brief account of the large extent of sandstone extending to the southward from Raigúdem and Palúncha.

* Geol. Trans., Ser. 2, Vol. V, pl. XLVII.

Sandstones north of Godávarí near Deorpalí.

In the small sandstone area extending along the north or left bank of Godávarí from Deorpalí to Nándigúr but little rock is exposed, except in the hills near the first named village, the greater part of the ground being thickly covered with river alluvium. The sandstones extend inland from one to two miles from the river bank, and consist principally of Damúdas, Tálchírs being seen at or outside of the northern boundary in two places, whilst the rocks forming the Deorpalí hills are probably of Kámthí age. It is possible that this tract and the corresponding one south of the river around Mádaváram are faulted in places, as some of the few dips seen are confusing and anomalous.

Sandstone tract near Deorpalí.

The exact position of the eastern boundary is, in great measure, undetermined. The first rocks exposed are in the Nandi Vágú* near Nándigúr. In this, for about half a mile from the Godávarí, fine yellow felspathic sandstone is seen in places, dipping at a considerable angle to north-west by west, that is, in the direction of the boundary. Metamorphics occur to the eastward, but not in the immediate neighbourhood of the stream. The last sandstone seen to the northward in the stream bed has low but irregular dip. Above this no rock is seen for more than a mile, but sandstones probably occur, because rolled pebbles of quartz, &c., are abundant west of the stream and south of the village of Nálagúnta. Metamorphics make their appearance in the Nandi stream nearly due east of this village.

No sandstone whatever is seen in place between the Nandi stream and the Ganár, but metamorphic rocks crop out to the north. Two boreholes put down north of the village of Ganara entered quicksands at depths of 34 and 22 feet respectively, and it was found impracticable, after sinking in the first instance through 18 feet, and in the second through 24 feet of loose sand and water, to penetrate to the rock. In the Ganár Vágú Damúdas are seen in two or three places about half to three quarters of a mile from the mouth, and in a boring at one of these coal was discovered (see Records, 1871, pp. 61-62). Above this metamorphics appear, but still further north Tálchírs are met with, and extend north for about a mile towards the villages of Malipúr and Kishtáram. They are almost, if not entirely, separated from the Damúdas, metamorphics intervening not only in the stream, but to the east of it, while to the west the surface is much covered by alluvium.

West of the Ganár stream sandstone is exposed in several places near the village of Tátpali and south of Egerpeta, but the dip is obscure. Apparently it is to the south, and the borings put down south of Tátpali appear to indicate that it is very slight. But at one spot, at a tank almost due south of Egerpeta and north-west of Golagúdem, sandstone is seen dipping to the north-east at 60,° proving the existence either of faulting or of great local disturbance. From this place little, if anything, is seen to the westward as far as Gogúleáká. In a field close to Egerpeta some Tálchír shales were found, but none could be detected thence to the westward till about half a mile east of Ghútipár, where they are exposed along the boundary for a short distance, and are well seen in a small nalá, all in thick jungle.

The hills near Deorpalí consist entirely of grit or conglomerate, and no shale is seen in the section exposed in the river. It appears most probable that the rocks belong to the Kámthí group. Whether a fault, in continuation of the boundary south of Mádaváram, runs up the river, separating these rocks from those of Amraváram, is doubtful. Even if such be the case, it may be of older date than the Kámthís, which here, as near Lingálá, appear to be proved by their distribution to be quite unconformable to the Damúdas.

* Vágú, Telinga for stream, equivalent to Nadi in Hindustani.

Sandstone tract near Mádaváram.

The tract of sandstone on the right bank of the river opposite to that just described extends from near Mádaváram to Poláram, or rather more than four miles from east to west. Where broadest it is between two and three miles from north to south. The southern boundary is nearly straight, and although there is not, except in the south-east corner, much appearance of disturbance along it, it is difficult to believe that it is natural. The dip throughout is to the westward, and usually rather high, being seldom less than 10°, frequently 15°, 20°, or even 30°. Tálchírs occur in the extreme south-east corner; all the remaining area appears to be occupied by Damúdas.

The Tálchírs are only seen in a stream which runs into the Godávarí near Ráigomá; they are the usual fine silty shales and sandstones, and are vertical, or dip at high angles to the west and north-west. They were not seen between the two hills just north of this spot, the one of metamorphics, the other of Damúda grit and conglomerate.

The whole eastern boundary of the rocks north of these two hills is concealed by alluvium in the river, which here runs north and south; metamorphics are seen along the left bank. To the east of the alluvium is a low rise formed of conglomerate, extending north to the river east of Mádaváram and terminating on the south in the high hill just referred to, which lies west of the village of Kondapali. This hill has precipitous sides to the east and south, exposing a section of the conglomerates composing it.

In the small stream which runs into the Godávarí near Injáram, north of Kondapali, much conglomerate is seen, but no continuous section is exposed for any distance. Rocks are traced at intervals along the southern boundary of the field, and are usually conglomeratic. The hills near Poláram and a smaller rise south-east of it are of the same kind of rock. This of course is in favour of the southern boundary being natural, but it should be remembered that the conglomerates being harder, are more likely to be exposed than the softer rocks which may intervene between them. There is much lime along the southern boundary near the villages of Palchalkar and Gangáram, some compact limestone occurring north of the last named village, but it is apparently a superficial accumulation.

Throughout this sandstone tract, as a general rule, very little rock is seen; usually when any appears above the surface, as west of the tank south of Shirúveli, it is grit or conglomerate. But a tolerable, though by no means continuous, section is exposed in the bank of the Godávarí. Here also the eastern boundary is not seen, metamorphics are met with about half way across the river bed (here about a mile broad) opposite the village of Murmur, and at the salient angle of the river bank below Mádaváram there is horizontal conglomerate and grit, being the same beds as those forming the rise which bounds the sandstone tract on the east. The conglomeratic character appears to diminish rapidly to the westward, in which direction the beds for a short distance dip east, exposing about 100 feet of rocks, sandstone grit, and some argillaceous beds. The dip then changes to the westward just at the mouth of a small nalá, and grey or pale brown sandstone with occasional bands of grit or shale, all of typical Damúda characters, dip at a high and rapidly increasing angle to the westward. At the anticlinal opposite the mouth of the little nalá, a borehole was made to a depth of 193 feet 6 inches in order to prove rocks lower than any exposed on the section. It went through alternations of brown and white sandstones, with thick beds of dark shale containing two or three small and useless seams of coal, none of them exceeding 8 inches in thickness (see Records, 1871, p. 61).

At Mádaváram there is some crushing and, possibly, faulting, the sandstone being cut up by calcareous veins. A high dip, varying from 20° to 40°, continues along the river bank as far as Shirúveli, the beds being coarse or fine sandstones of varying hardness with occasional

shales. Near Shirúveli the dip becomes lower. In some clays just east of the village *Glossopteris*, *Pecopteris*, *Vertebraria*, and *Calamites* occur.

Thence to Damarcherla the dip is moderate, about 5° to 10°, and the rocks fairly seen on the whole. They are much the same as to the eastward, fine felspathic sandstone and fine clays predominating, with occasional hard massive bands of fine brown sandstone. At Damarcherla there is a little conglomerate and some hard ferruginous bands like those in the Kámthís.

About half a mile, or rather less, west of Damarcherla, the beds roll up sharply, and there may be a fault here. They soon roll over again and consist of coarse felspathic sandstones, generally pink coloured or ferruginous, and conglomerates, but associated with hard compact grey felspathic sandstones. These rocks continue to beyond Poláram, metamorphics appearing at the mouth of the stream west of the village.

Magnetic iron ore near Poláram.

Iron manufacture.

A small rising ground in the metamorphics south of Poláram contains large quantities of magnetic iron ore in laminæ with quartz. The ore has evidently been largely dug from this spot for small diggings are scattered over the ground. The iron ore shows very distinct polarity in its action on the needle. In a small village near this I found women making iron in a little furnace barely 2 feet high—a miniature of the Tálchír furnace—worked by small foot bellows about 1 foot in diameter. The furnace inside is only 6 inches in diameter at the base, 3 inches at the top. It is said by the people that two pieces of iron, each weighing 1½ seer and valued at 4 annas, are made in a day.*

Sandstones near Púndigúl and Amravá-ram.

Sandstone again comes in on the right bank of the river close to the abandoned village site of Púndigúl. The actual junction of the two series is again concealed, but there can be little doubt of the boundary being natural. It runs to the southward into dense jungle, where its position is difficult to ascertain correctly on so imperfect a map; the rocks being very poorly seen.

Sandstones near Amraváram.

In the right bank of the Godávarí, from just above the base at Púndigúl to the village of Amraváram, a good section is exposed in which very few breaks occur. The general dip is west, varying in amount from about 7° to 12°. Towards the base yellowish-brown sandstone prevails, coarse and felspathic. Above this, to the north of the hill, there is much conglomerate, and thence to Amraváram sandstone again. No clay or shale is seen, much less coal, but some coarse impure ironstone occurs.

About the middle of the village† the section ends, and only scattered outcrops, concealed beneath the river except in the driest season, occur in the bank of the river above. Just above the mouth of the stream, which enters the river above the village, fragments of coal occur on the river's bank just below a conspicuous clump of green bushes; some sandstone occurs in the bushes, and a boring might be put down through it. Above this, again, but one small outcrop of rock is seen, nearly in front of Thondipálí, as far as Gúmpanápali just below Rágúdem. Even near Mondipák (nearly opposite Gagúbáká) only a few blocks of coarse sandstone are exposed. Near the river bank the country is an alluvial flat, and farther inland a sandy rise covered with thick jungle, amongst which a few scattered blocks of coarse sandstone and conglomerate may occasionally be seen.

* The people were of Lohar caste, *i. e.*, low caste Hindus. The Kois, who are Kolarians (though called Gonds by the Mussulmans of the country), are said to make iron with foot bellows in a hole in the ground without any furnace at all.

† This is placed too far east on the map, which is very inaccurate about here.

The nalá which runs into the Godávarí, east of Amraváram, exposes no rock for some distance from its mouth, and no good section is anywhere seen in it. Soft felspathic sandstones and, towards the base, conglomerates are met with in it here and there. Even less rock is seen in the large Machimangú nalá which runs past Kometlagúdem. Sandstone only appears in this in the form of a few blocks, exposed just below the junction of the two principal streams which unite to form it. The more westwardly of the two joining streams, however, only traverses metamorphics for a very short distance: above this Tálchírs are exposed, although there are none in the main stream a few hundred yards distant, where the metamorphics and Damúdas are seen within a few yards of each other. After about one quarter of a mile of Tálchírs, Damúdas or Kámthís (they are undistinguishable here) again come in dipping west south-west. There is a considerable quantity of coarse felspathic sandstone of various colours, mostly brown, or irregularly streaked, and hard ferruginous bands occur at intervals; occasionally clay is found in the sandstone. Conglomerate is not prevalent, but it is met here and there.

There is absolutely nothing about these beds by which they can be distinguished from Damúdas, but there can be but little doubt that the greater portion, if not all, belong to the Kámthís. From the general dip they must have overlapped the Amraváram beds. They appear softer than the rocks seen in the river's bank near Amraváram and Mádaváram, but this is not an important distinction.

The hills near Kometlagúdem are of open textured felspathic sandstone, usually white or pale brown in colour, with hard ferruginous bands. The sandstones on the hills in this neighbourhood have generally this somewhat open texture, which is not usually seen in ravine sections, and may be due to the washing out of the decomposed felspar from between the grains of quartz. The character of the sandstone is that of the Kámthí beds, but no typical Kámthí rocks occur, neither vitreous sandstone, nor the red and yellow compact shale, nor the fine micaceous variegated sandstone.

From these hills, others formed of similar sandstone stretch away to the southward, bordered to the east in the valley of the Machimangú stream by metamorphics, no Tálchírs intervening.

(To be continued).

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BARRANDE, JOACHIM.—On the Primordial Fauna and the Taconic System, with additional notes by J. Marcou, (1860,) 8vo., Boston.
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„ „ Observations sur les Oursins Perforants de Bretagne, with supplement, (1856-1857,) 8vo., Paris.

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DANISH ACADEMY.

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„ „ „ Geologische Bilder, 5th edition, (1871,) 8vo., Leipzig.

COX, E. T.—First Annual Report of the Geological Survey of Indiana made during 1869, with three maps and colored section in case, (1869,) 8vo., Indianapolis.

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