RECORDS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

VOL. XV.

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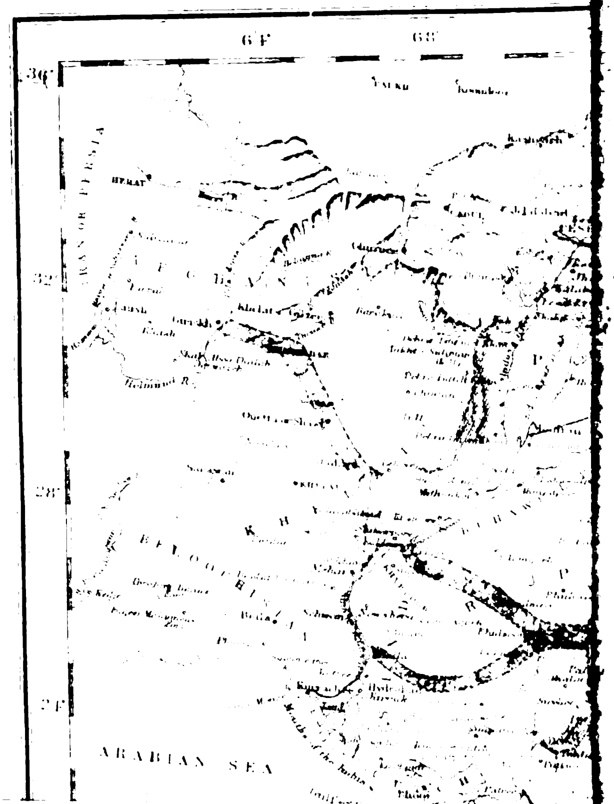


RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 1.] **1882.** **[February.**

Annual Report of the Geological Survey of India and of the Geological Museum, Calcutta, for the year 1881.

The work done or published during the past year involves some considerable changes in the mapping and grouping of Indian rocks as hitherto set forth. These changes are duly noticed in the following report.

Southern India: Travancore. *Mr. King.*

After closing his work in the Godávari region, Mr. King took up as yet unsurveyed country in Travancore. The neighbourhood of Quilon has for many years been known through the observations of General Cullen, published by Dr. Carter in his Summary of the Geology of India (1853), as having yielded a limestone containing eocene fossils, and we have long been anxious to bring this rock into connection with other tertiary beds of uncertain horizon in the coastal region of the peninsula. In this we have been disappointed of any positive result, beyond the fact of super-position, for Mr. King's most diligent search failed to bring to light any trace of General Cullen's limestone. The point had been independently investigated by the Public Works Department in searching for lime, but with the same negative result. General Cullen's statements are, however, too circumstantial to be called in question, and we must only suppose that all the rock available at the outcrop, which was at the very base of the cliff-section, had been removed, thus favouring the concealment of the bed. The overlying deposits of ferruginous sandstone and clays with lignite (or rather fossil wood) Mr. King describes[1] as the Warkilli beds, correlating them with the Cuddalore sandstone of the Coromandel Coast. They only occur for a length of about 20 miles, from a little north of Quilon to Amjengo on the south.

At the particular request of the Travancore Durbar, Mr. King made an examination of a tract of gneissic upland in which auriferous rocks were reported

[1] The paper will be published in the Records for May next.

to occur. The outcrops in question turned out to be bedded quartzite and not true reef rock; there seemed to be no prospect of a fruitful gold-field.

Godavari.

The publication of Mr. King's description of the Pranhita-Godávari area (Memoirs, Vol. XVIII, pt. 3), has brought to a crisis some doubts and discrepancies that have been long impending regarding the older rocks of the peninsula. It was duly pointed out in the Manual (pp. 3 and 55) that the division of the separated rocks of transitional character into an upper and a lower series was a provisional compromise, until connected surveys should declare what the true relations might be, the only immediate test—the relative ages of the gneissic rocks adjoining each area—not being available. In the same connection it was noted (*l. c.*, p. 70) that the categorically marked separation of the lower Vindhyan from the upper transition rocks, as then constituted, was especially arbitrary and precarious. As a matter of course, whatever discrepancies there might be were bound to come into collision in the then little known middle ground in the Máhánadi and Godávari basins, as was pointed out at pages 75 and 76 of the Manual. Mr. King's survey of the latter area seems to have brought observation sufficiently close for a settlement of the main question at issue. In his statement of the case (*l. c.*, p. 73), there is some confusion between a local difficulty and the principal point of classification. In the Máhánadi basin, and again on the Pemganga, which belongs to the Pranhita-Godávari basin, there was a difference of opinion as to the relative ages of the shales and limestones occupying the low ground and certain quartzites resting on the gneiss of adjoining uplands; and this minor question remains still in doubt. When the Manual was published, the data for the general question had not got clear of this minor one; but now Mr. King has extended his observations to the shales of the Pemganga and, for the first time, the major question is clearly at issue. These shales had been classed as lower Vindhyan. Mr. King decides that they are Kadapah, and his statement of the case would be understood to imply that the other position must be wrong. It seems to me that the simpler and truer adjustment is to accept both as right. I do not question Mr. King's identification, which is based on a connected survey from the Kadapah field; but I see no reason to reject the independent determination of the Máhánadi and Pemganga beds as lower Vindhyan: so the obvious reconciliation is to conclude that the Kadapahs also are lower Vindhyan. There are numerous collateral points in support of such a decision, but they cannot be detailed here; and the further questions raised by it are not seriously in the way—such as, whether the rock-groups in Southern India (the Karnul and Bhima series), hitherto ranked as lower Vindhyan, must now be classed as upper Vindhyan. The intelligent student of the Manual will, on the whole, accept this new reading as a relief.

COMORIN: *Mr. Foote.*

On his return from furlough, Mr. Foote took up work again at Mádura, and made a traverse thence to Cape Comorin along the junction of the gneiss and the coastal alluvium. The formations which, to the north, intervene in this position seem to be almost wholly wanting here to near Comorin, where representatives of the Cuddalore sandstone again appear and seem to extend some little way westwards towards the tertiary deposits of Travancore. About Comorin there were also observed at least two banks of marine beds, one of them at about 100 feet over present sea level; they consist of sands with calcareous induration, and are full of marine shells of living species. Mr. Foote remarks that he has not found a single trappean intrusion in the gneiss south of Trichinopoly, a circumstance in strong contrast with the profusion of eruptive dykes in the adjoining gneiss of Salem and Arcot.

RAJPUTANA.
Mr. Hacket.

As mentioned in last Annual Report, the publication of the Rájputána work had to be postponed until some doubts, suggested by the most recent observations, had been cleared up. This was effected during the past season, and the result published in Mr. Hacket's paper in the last number of the Records (Vol. XIV, part 4), with an outline map of an immense stretch of country, from Delhi to Erinpura and Mandsaur. The early work in the northern part of this ground was described in the Records for 1877 (Vol. X, p. 84), and the account there given of the Arvali rocks is that presented in the Manual (Chapter II). Already, in the following Annual Report (February 1879, Records, Vol. XII, p. 5) considerable alterations were necessitated by subsequent field work: the groups of distinguishable deposits, all more or less metamorphic, brought together under the title Arvali series, were reduced in number by a clearer interpretation of the sections, and one of the lower members was identified with some rocks outside this metamorphic area and previously described as the Gwalior series, resting quite undisturbed and unaltered on the gneiss of Bundelkhand. The interesting fact was thus established that the gneissic metamorphism of the Arvali region was of immensely later date than that of other portions of the peninsular area.

A similar change has now to be introduced regarding the upper member of the original Arvali series, the great quartzite deposits of the Biána and Alwar hills, and of Delhi, which Mr. Hacket now proposes to distinguish separately as the Delhi series. In making a preliminary traverse of the country northwards from Bág in the Narbada valley, in 1865-66 (Records, Vol. I, p. 69), I came upon certain quartzite sandstones at Mandsaur with underlying shales, very little altered or disturbed, and both most nearly resembling the familiar upper Vindhyan types; and they have since passed as such in the Manual and its map. The overlying shales and limestone well seen north of Nímach (Neemuch), and the sandstone of Chitor Hill I took to represent the Bánrer (Bundair) stage of the upper Vindhyan series. Had my route continued north-eastward across the Vindhyan plateau, I should have discovered my mistake by finding the higher upper Vindhyan stages still in front of me; but no suspicion of error was suggested. Mr. Hacket's continuous survey from the north has satisfied him that the Chitor rock is the Kaimur sandstone, the lowest member of the upper Vindhyan series; and that the limestone of the low ground to the west is the lower Vindhyan (Rotás) limestone. Although a slight unconformity is found between these beds and the Mandsaur sandstone, it is scarcely greater in appearance than may be found between the upper Vindhyan groups, where they overlap each other on the borders of their typical area; and so the Mandsaur rock might have been provisionally entered as a member of the lower Vindhyan series, but for a further discovery: Mr. Hacket shows good ground for asserting that the Mandsaur sandstone passes northwards into connexion with quartzites of the Arvali area that are more or less continuously traceable through Eastern Rájputána into the hills of Alwar and Delhi. This fact would necessitate a prodigious significance for the unconformity west of Nímach, for the Delhi series has partaken fully in the Arvali disturbance; while the whole Vindhyan system dates from an age when the Arvali mountains had already undergone great denudation. Geologists will appreciate what an interval that implies.

Collateral facts support these observations. The conspicuous erosion-unconformity in the Gwalior area between the Vindhyans and the Gwalior rocks, which represent the lower (Arvali) series, contrasts appropriately with the less apparent unconformity of Vindhyans on the Mandsaur rock, which represents the higher (Delhi) series of the Arvali region. Further, the condition of the Delhi rocks at Mandsaur is accounted for by the fact that to the west of them there occurs a mass of gniess, which is presumably identifiable with that of Bundelkhand, whereby they were protected from the crushing and metamorphism that affected the Arvali region proper.

These modifications of our rock-grouping have a further significance with reference to the changes already noticed in connexion with the Godávari region. Hitherto the Gwalior rocks have been provisionally correlated with the Kadapah series, as upper transition. The Kadapah rocks having now been brought up to the lower Vindhyan horizon, and the Gwalior beds put down immeasurably below that horizon, the separation of the two is very great, and the Gwalior rocks must take approximate rank in the Survey classification with the Bijáwars, their affinities with which have been duly noticed before (Manual, p. 56); while the Delhi quartzites become the highest member of the transition series as now distinguished.

There is one more change in the Arvali region to be mentioned. From a small and very local occurrence of a felsitic-rock in the middle of the range, the trappean rocks described by Mr. Blanford as the Maláni group had been (Records, XIII, p. 4) doubtfully placed by Mr. Hacket in the Arvali series. His extended examination of these rocks south of Jodhpur has shown such a position to be untenable, as the Maláni beds exhibit very little disturbance, and rest upon contorted Arvali strata. According to this relation, their apparent horizon would be lower Vindhyan.

As mentioned in last Annual Report, some simple field work was marked out for Sub Assistant Kishen Singh, in extension of Mr. Hacket's previous work on the Vindhyan rocks in the Gwalior territories. From his maps and report there seems much reason to be satisfied with his work on the score of care and industry, for it is impossible, under existing circumstances, as I have often explained, and without extravagant waste of our very limited power of qualified observers, to arrange for the inspection of detached work. At the same time there is ample evidence of such radical defects as were to be anticipated: in the barren accumulation of simple details of stratification, with ambitious but weak attempts at speculation upon remote theoretical considerations quite beyond the scope of the work in hand, and that can only be profitably undertaken by one who has in some degree mastered the subject; and withal there was a conspicuous failure to understand the obvious condition—that ordinary geological maps are meant to represent the formation next below the soil. Some improvement may be expected with experience.

SOUTH REWAH: GONDWANA. *Mr. Hughes.*

Mr. Hughes' work during the past season was confined to the coal fields on the southern outcrop of the South Rewah basin. A notice of results was published in the Records for November. Although the prospects of coal are not so promising as may have been hoped for, some good seams have been traced, but unfortunately they are the most distant from any existing line of railway. Since taking the field for the present season, Mr. Hughes has marked sites for trial borings he has recommended to the Rewah Durbar, in the small Umria field, the nearest to the Jabalpur railway.

Sub-Assistant Hira Lal worked with Mr. Hughes, and did good service in hunting up coal outcrops and main boundaries.

Dr. Feistmantel.

Dr. Feistmantel was able to devote a few weeks during the field season to visit some of the coal-fields in the Upper Damuda valley. He has made considerable additions to our collection of fossils from that ground, many from new localities. It becomes more and more evident that in the central basins of the Gondwána system, the possibility of discriminating horizons in the masses of homogeneous deposits there prevailing will depend almost entirely upon the scanty fossil evidence; so it is more than ever important to obtain a closer knowledge of the distribution of the flora in ground where the stratigraphical sequence is otherwise discernible.

NARBADA; CRETACEOUS: *Mr. Bose.*

Mr. Bose has submitted a very promising progress report of his season's work on the cretaceous rocks of the Narbada valley, generally known as the Bág beds. They are remarkable as being the only fossiliferous marine deposits beyond (inside) the coastal region of the peninsula. An excellent preliminary sketch of these rocks was given in 1869 (Mem., Vol. VI., pt. 3) by Mr. W. T. Blanford in his general description of the Tápti and Narbada valleys, with a map on a very small scale; wherein the whole are grouped from the small fossil evidence then existing as of middle cretaceous (cenomanian) age, on about the horizon of the Utatúr beds of Southern India, and as probably, in part, representing the freshwater infra-trappean (Lameta) beds of more midland districts. Mr. Bose proposes to give an immensely extended range to the series: besides finding the Lameta beds distinctively in the marine area, he gets fossil evidence to suggest that the three limestones of Mr. Blanford's classification (Manual, p. 294), may represent the divisions of the cretaceous series of Southern India, and that the underlying sandstone may be lower cretaceous (neocomian). If these conjectures should be established, a considerable lift will be given to the presumed age of the Deccan traps. Under these circumstances Mr. Bose has judiciously deferred giving any publication of his work until he can present it with more confidence in his results.

KATTYWAR: *Mr. Fedden.*

Mr. Fedden resumed his survey of Kattywar where he had left off in 1879, and mapped a large additional area. Deccan trap is the greatly prevailing rock. A small area of the newer tertiary beds on the east coast was examined, and some patches of jurassic (Umia) beds on the north; but nothing of importance was noted.

HIMALAYA; KASHMIR: *Mr. Lydekker.*

During the past field season Mr. Lydekker rounded off the western limits of his work in the Kashmir territories, in the lower Kishanganga valley, joining his lines with those of Mr. Wynne in Hazára. These observations have removed whatever nominal doubt remained upon a small point of geographical interest. Certain geographers have insisted upon classing some of the great trans-Indus peaks with the Himalayan range proper. The intrinsic objections to this arrangement have been duly pointed out by the Geological Survey, and they are now fully ratified by Mr. Lydekker's work, showing that the Pir Panjál and Zánskár axes, which are the attenuated extensions of the great snowy range, become wholly extinct on either side of the west end of the Káshmír valley. As part of this feature, a considerable extension of the tertiary rocks of the sub-Himalayan area has been traced out: in our maps hitherto published the deep northern prolongation of this area up the valley of the Jhelam between the two confluent systems of disturbance has been stopped at Musafirabad, near the junction of the Kishanganga with the Jhelum; Mr. Lydekker has now mapped a deep recess of these rocks reaching 20 miles further north. In this connexion Mr. Lydekker makes some inferences regarding an extensive pre-eocene Himalyan elevation: it is a conclusion that has some time since been very explicitly ennunciated upon good evidence (Manual, Part II, pp. 569, 680), yet in very recent sketches of the great east-west Asiatic mountain system, of which the Himalaya is the most conspicuous member, we find it asserted that the upheaval commenced in the oligocene epoch, as has apparently been made out for the European extension of that great system of disturbance.

HIMALAYA; SIMLA REGION: *Mr. Oldham.*

Mr. Oldham spent a profitable season in the Simla region. A good part of the time was of course expended in making acquaintance with the characters and general features of the rocks as hitherto set forth, regarding which he has made some important observations and conjectures. On the Giri he has observed some clear cases of intrusion of the syenitic trap into the middle tertiary sandstones at their junction with the older rocks. To the west of old Sirmur he notices distinct evidence of an actual creep now in progress along this boundary fault, as shown by a continuous line of depression to the south across the spurs and gullies running northwards into the Giri. Well within the Lower Himalayan area Mr. Oldham describes some masses of rock, as the red slates and quartzites of the Chakráta ridge and the purple and red shales, with pebbles derived from a neighbouring limestone, in the Maura forest north of the Karambar peak which he conjectures may be of lower tertiary (Sirmur) age. The verification of this suggestion is a point of great interest in the discussion of Himalayan history; the non-occurrence of the nummulitic (Subáthu) band at the base of these supposed outliers would at least show that there was great overlap towards the mountain axis, as already observed at Subáthu (Manual, pp. 533, 569). Among the Lower Himalayan rocks themselves, Mr. Oldham considers that there is a clear case in Deoban mountain of a great unconformity of the Krol limestone with the subjacent rocks. The obvious doubt in such sections is the risk of the results of extreme contortion with over-folding and sliding being taken for original relations of the masses. An observer unaccustomed to the study of 'true mountains' might well be excused for such mistakes; and the detection of them without fossil evidence would often be impossible. Any one wishing initiation to these mysteries should study Professor Heim's "Untersuchungen über den Mechanismus der Gebirgsbildung," an inspection of Plate VII of which work will suffice to remove any scruples as to the capabilities of the folded flexure in mountain structure.

It has been with much regret that I have interrupted Mr. Oldham's work after so promising a beginning; but an opportunity occurred of sending a geologist with the party proceeding to demarcate the Manipur-Burma frontier, and I could not miss so rare a chance of exploring an unknown region. Mr. Oldham volunteered for the expedition; and there being no other officer available at the time, I was glad to commission so trustworthy an observer.

HIMALAYA; KUMAON: *Mr. Griesbach.*

After his service in South Afghanistan Mr. Griesbach returned in April last to the work he had begun in the summer of 1879 in the high Himalaya of Kumaun, of which a sketch was given in Vol. XIII, pt. 2 of the Records. He has now completed the survey of that ground up to the Nepál frontier. The same great sequence of sedimentary rocks has been traced throughout, only greatly more disturbed than in the Niti section. This may be simply the approach to a middle region of maximum Himalayan disturbance, or it may indicate the proximity of a block of crystalline rock such as to the north-west breaks the continuity between the ellipsoidal basins of the fossiliferous series. Mr. Griesbach was again prevented by the vigilance of the Chinese frontier guards from making any way into Hundes; in this attempt he also experienced much obstruction and even personal violence from the people within the British border, who seem far more under the control of the Tibetan officials than of our own officers at Almora. For both these reasons he could not this year get within reach of any beds higher than the Spiti shales (Oolitic), some remnants of which were found folded in the flexures of the older formations. The natural completion of this piece of work will be its extension up to the gorge of the Sutlej, where the gneissic mass of Purgial cuts off, at least in great part, the continuity of the fossiliferous rocks, dividing the basin of Hundes from that of Spiti and Zánskár. This, it is hoped, can be accomplished next season, meanwhile arrangements are being made to reproduce effectively the admirable profile views which Mr. Griesbach's artistic skill has enabled him to figure of the grand sections displayed in these stupendous mountains.

In the lower hills Mr. Griesbach has confirmed an interesting observation, made more than 30 years ago by General Richard Strachey, of the irruption of the trappean rock of the Lower Himalaya, so extensively exhibited to the east of Naini Tál, into the tertiary sub-Himalayan sandstone on the Gola river, and its conversion thereby into a granite. It was, indeed, only provisionally that any hesitation was admitted regarding an observation by so competent a witness; but the remarkable absence of igneous rocks, whether intrusive or eruptive, in the sub-Himalayan zone throughout an immense sketch of country, even in the immediate vicinity of their extensive exhibition in contiguous rocks, as on the Biás and the Sutlej, could not but suggest doubt regarding an isolated instance, and this although upon general reasoning it was apparent that the trap of the Lower Himalaya was of tertiary age (Manual II, p. 607). Mr. Theobald, moreover, had mapped the tertiary boundary at the Gola river without detecting any eruptive contact. Mr. Griesbach, however, declares that the facts are as described by General Strachey. In this connexion Mr. Griesbach is disposed to maintain that some altered sandstones about Bhím-tál, inside the sub-Himalayan zone, are of the same age as the rocks outside the main boundary on the Gola. This is not quite equivalent to the observation recorded by Mr. Oldham in the Simla region, where the lowest tertiary sandstones are at hand. It is not yet proven that the lower tertiary beds are represented in the sub-Himalayan zone of Kumaun.

HIMALAYA; SIKKIM.

At the request of the Government of Bengal to have an opinion upon a newly opened copper locality in the Darjeeling district, Mr. Mallet was deputed to examine it. He found it to occur in the same beds and in the same manner as the ores previously described in his report on the geology of the district (Mem., Vol. XI, pt. 1). The deposit is no richer than in some of the old mines.

On the report that serviceable blocks of coal had been obtained from a seam near Tindhária station on the Darjeeling tram railway, I visited the place to satisfy myself upon a question of so much importance. I found the seam to be one of those marked on Mr. Mallet's map, and the whole condition of the case to be exactly as described by him in the report just quoted. These were, no doubt, originally strong seams of good coal; but, owing to the compression undergone during the upheaval of the Himalaya, the coal and its measures have been so shattered that the question of profitable extraction is a very precarious one. There is, I consider, very little hope of finding coal in a directly serviceable state anywhere in these measures; so that complete arrangements for the conversion of the dust coal into bricks must be a preliminary condition of the experiment. Then as to the mining: there is, I believe, a sufficient quantity of the coal in the ground, and although no doubt often squeezed out and slipped, it would not be very difficult of extraction but for the shattered condition of the surrounding rocks. These are not, like the older rocks of the higher mountains in which the copper occurs, consolidated by crystalline metamorphism, but are still in the slaty state and shivered to splinters to the very core, so that every foot of drift or gallery would have to be protected in the most solid, and of course costly, manner by posts and boarding. This was the experience gained by the short trial drift made on the outcrop south-west of Tindhária (see Records, Vol. X., pt. 3).

THE BOLOGNA CONGRESS: *Mr. Blanford.*

In December 1880 I applied for official sanction to attend the international congress of geologists to be held at Bologna in September 1880; formal permission was received in May 1881. To my great disappointment, as the time drew near, the unexpected delay of work that could not be left in other hands made it impossible for me to avail myself of this permission, so I requested that Mr. W. T. Blanford, who was then on leave in Europe, might be deputed in my stead, and this was granted. Mr. Blanford's report of what was effected at the congress is published in the current number of the Records; it is a much more complete account than any I have yet seen in print. Where a definite result was possible—in the simpler matter of nomenclature—we may perhaps be satisfied with what was accomplished, though it certainly is not what would have been arrived at by a plebiscite, or a fairly representative assembly, of geologists. At least one stiff-necked nation seems to have declined co-operation, or to have held to its own, for which it will no doubt pay the natural penalty of isolation; but we may hope that the English-speaking peoples will adopt the suggestions agreed to, even though it may involve a temporary wrenching of the vernacular sense of current terms; the advantage of uniformity of speech will well repay the struggle.

It would be hard to complain of failure where success was impossible, as is pretty much the case with a proposal to fix an universal scale of colours as assigned to any existing scale of systems. Stratified rocks will everywhere be naturally divisible into systems, series, stages, and strata; but these *cannot* correspond in different great sections of the earth. It would be as reasonable to attempt to unify the periods of Chinese, Egyptian, and Peruvian history as to unify the geological histories of the three great continents. Some general principles of approximation might indeed be suggested for guidance, and such an attempt was to have been expected from a nominally universal congress. This was verbally implied in the programme laid down for Bologna; and, in view of it, I submitted a test case (Records, XIV, 4) for the consideration of that congress, as being the main difficulty from the Indian point of view. The congress did not, however, get within sight of this question, but lapsed into the discussion of a scale of colours for the scale of European systems. It is no doubt most easy to account for this event, subjectively and objectively: it is a truly vexatious result of nationality that the maps of adjacent patches of the western promontory of Asia should have rocks of the same age represented under contrasting colours. The adjustment of this local barbarism seems to be the necessary preliminary of approach to the wider question, so we must fain be content with this proposal for the present.

Mining Records.—A fair start has been made in the preliminary system of collecting mining records, as announced in the last annual report. Fifty-three plans of coal mines in Bengal have been received from the following owners (in order of date): Messrs. Apcar, 12; Equitable Coal Company, 2; East India Railway Company, 6; Bengal Coal Company, 11; New Beerbhoom Coal Company, 5; Burrakar Coal Company, 1; thirteen different native proprietors, 16.

Publications.—The most generally useful publication during the year was the 3rd volume, or part, of the Manual, relating to economic geology, by Mr. V. Ball. It gives a complete classified summary of all information collected by the Survey, or independently published, regarding the distribution of useful minerals in India. The area is so large that details of any particular locality had to be greatly curtailed, but careful reference is given to the original authorities.

Three parts, forming Volume XVIII, of the Memoirs, were issued during the year. The first is Mr. Griesbach's description with numerous illustrations of the section between India and Girishk, in Southern Afghanistan. Part 2 is a description of a large area in Mánbhum and Singhbhum, by Mr. Ball, from a survey he made several years ago. The third part is Mr. King's Memoir on the Gondwána basin of the lower Godávari. This is an important district, as possibly containing a considerable supply of coal and the only one within comparatively easy reach of Southern India. From this point of view the geological indications are not so detailed as would be desirable: it is a very wild country, and for large parts of it maps on an adequate scale for close work were not available; the rocks are, moreover, very unfavourably disposed for observation, the most important ground, where the coal measures or the strata next them might be exposed, being very extensively covered by superficial deposits.

The Volume (XIV) of Records for the year is the fullest yet published, containing 28 papers of varied interest relating to the Geology of India, with numerous maps and plates.

Of the Palæontologia Indica three parts appeared during the year. Dr. Feistmantel issued two parts (86 pages of text and 35 plates), completing the 'Flora of the Gondwána System,' in three volumes. It is most satisfactory to have this complete foundation laid for the study of this series of fossils, representing the most important rock system of peninsular India. There is now a safe guide at hand for exploring any horizon in these deposits; that we have still much to learn regarding the Gondwána flora will, however, be readily understood when we recollect that the detailed survey of the two principal central basins has only begun. In the concluding remarks of his 3rd volume, Dr. Feistmantel seems to have worked out a satisfactory reconciliation of the diverse opinions regarding the correlation of the plant-bearing series of India and Australia.

The third part of Dr. Waagen's work on the fossils of the Salt-range, containing the *Pelecypoda* of the Productus-limestone series, was issued during the year. This is the first marine fauna of the older formations in this part of the world that has been worked out from anything like adequate materials; and as the work advances it becomes more and more apparent how difficult it will be to place it in any one of the would-be standard periods.

Museum.—In every branch of the museum due progress has been made in arrangement and the addition of new specimens. Dr. Feistmantel issued a 'Popular Guide' to the general palæontological collections, uniform with those already published. The numerous series of useful mineral substances and their products mentioned in last year's report have been laid out by Mr. Mallet, and make a very instructive exhibition.

Library.—One thousand six hundred and seventy-two volumes, or parts of volumes, have been received during the year; 970 by donation or exchange and 702 by purchase. A catalogue is nearly ready for publication.

Personnel.—Mr. Blanford returned to duty in England on the 22nd of August in connection with the Bologna Congress, and arrived in India on the 25th of October. He has taken up work on the north-west frontier in extension of his former work in Sind. Mr. Theobald went on furlough in March, and has since taken his pension after a service of 32 years. In so long a period he has of course done work in many parts of India; the report on Pegu is his principal contribution to the Survey Memoirs. As an enthusiastic naturalist, Mr. Theobald made good use of his opportunities; especially in the branches of land and fresh-water shells, and the *Reptilia*, he has left his mark in the annals of Indian zoology. He takes with him the hearty good wishes of all his colleagues on the Survey. Mr. King went on furlough on the 10th of May. Mr. Wynne has been absent for the whole year, having had to get an extension of his sick-leave. Mr. Mallet was absent on privilege leave from 10th to 28th of October. Mr. Ball left India on the 14th of October, having retired from the service. Although still in sound health, he was reluctantly compelled to take this step on account of a local weakness that disabled him from following any longer the hard pedestrian labours of field geology. He has, however, reaped a fair reward for the good work he has done in India, having had the honour of being elected to the Chair of Geology at Trinity College, Dublin, in succession to so distinguished a Professor as the Revd. Samuel Haughton. Mr. Griesbach went on privilege leave on the 21st December. Mr. Thomas Henry Digues La Touche, B.A. (Cantab), was appointed to the Survey by the Secretary of State in the room of Mr. Theobald, and joined his appointment in India on the 29th of November. I had intended him to have taken up work on the Deccan trap in the Konkan, but an urgent demand having arisen for particular information regarding coal with reference to a proposed railway to Assam through the Gáro Hills, Mr. La Touche has been sent to complete the survey of the cretaceous coal-fields in the valley of the Sumesari.

H. B. MEDLICOTT,
Superintendent, Geological Survey of India.

CALCUTTA,
The 28th of January 1882.

List of Societies and other Institutions from which Publications have been received in donation, or exchange, for the Library of the Geological Survey of India, during the year 1881.

ALBANY.—New York State Museum.
AMSTERDAM.—Netherlands Colonial Department.
BATAVIA.—Batavian Society of Arts and Sciences.
,, Royal Natural History Society, Netherlands.
BELFAST.—Natural History Society.

BERLIN.—German Geological Society.
" Royal Prussian Academy of Sciences.
BOLOGNA.—Academy of Sciences.
" Geological and Palæontological Institute.
" International Geological Congress.
BOMBAY.—Bombay Branch Royal Asiatic Society.
" Meteorological Department, Western India.
BOSTON.—American Academy of Arts and Sciences.
" Society of Natural History.
BRESLAU.—Silesian Society of Natural History.
BRISTOL.—Bristol Museum.
" Naturalists' Society.
BRUSSELS.—Geographical Society of Belgium.
" Geological Survey of Belgium.
" Royal Academy of Sciences.
" Royal Museum of Natural History of Belgium.
BUDAPEST.—Geological Institute, Hungary.
BUFFALO.—Society of Natural Sciences.
CALCUTTA.—Agricultural and Horticultural Society.
" Asiatic Society of Bengal.
" Marine Survey.
" Meteorological Department.
" Survey of India.
CAMBRIDGE, MASS.—Museum of Comparative Zoology.
CHRISTIANA.—Editorial Committee, Norwegian North Atlantic Expedition.
COPENHAGEN.—Royal Danish Academy.
DIJON.—Academy of Sciences.
DRESDEN.—Isis Society.
DUBLIN.—Royal Geological Society of Ireland.
" Royal Irish Academy.
EDINBURGH.—Royal Scottish Society.
GENEVA.—Physical and Natural History Society.
GLASGOW.—Philosophical Society.
GOTTINGEN.—Royal Society of Gottingen.
HALLE.—Imp. Leop. Carol. German Academy.
" Natural History Society.
LAUSAUNE.—Vandois Society of Natural Science.
LIEGE.—Geological Society of Belgium.
LISBON.—Geographical Society.
" Geological Department, Portugal.
LIVERPOOL.—Geological Society.
" Literary and Philosophical Society of Liverpool.
LONDON.—Geological Society.
" Iron and Steel Institute.
" Linnean Society.

LONDON.—Royal Asiatic Society.
„ Royal Geographical Society.
„ Royal Institute of Great Britain.
„ Royal Society.
„ Society of Arts.
„ Zoological Society.
LYONS.—Museum of Natural Sciences.
MADRID.—Geographical Society.
MANCHESTER.—Geological Society.
„ Literary and Philosophical Society.
MANCHESTER.—Scientific Students' Association.
MELBOURNE.—Mining Department, Victoria.
„ Royal Society of Victoria.
MILAN.—Italian Society of Natural Sciences.
MONTREAL.—Geological Survey of Canada.
MOSCOW.—Imperial Society of Naturalists.
MUNICH.—Royal Bavarian Academy of Sciences.
NEUCHATEL.—Society of Natural Sciences.
NEW HAVEN.—Editors of the American Journal of Science.
NEW YORK.—American Meteorological Society.
NEW ZEALAND.—Colonial Museum and Geological Survey.
PARIS.—Geological Society of France.
„ Mining Department.
„ Zoölogical Society of France.
PENZANCE.—Royal Geological Society of Cornwall.
PHILADELPHIA.—Academy of Natural Sciences.
„ American Philosophical Society.
„ Franklin Institute.
„ Zoological Society.
PISA.—Society of Natural Sciences, Tuscany.
RIO DE JANEIRO.—School of Mines.
ROME.—Royal Geological Commission of Italy.
„ Royal Academy.
ROORKEE.—Thomason College of Civil Engineering.
SAINT PETERSBURG.—Imperial Academy of Sciences.
SALEM, MASS.—Essex Institute.
„ Peabody Academy.
SINGAPORE.—Straits Branch Royal Asiatic Society.
STOCKHOLM.—Geological Survey of Sweden.
„ Royal Academy.
SYDNEY.—Department of Mines, New South Wales.
„ Philosophical Society of New South Wales.
„ Royal Society of New South Wales.
TURIN.—Royal Academy of Sciences.
VIENNA.—Agricultural Ministry.
„ Imperial Academy of Sciences.

VIENNA.—Imperial Geological Institute.
WASHINGTON.—Department of Agriculture.
" Smithsonian Institute.
" United States Geographical Survey, west of 100th Meridian.
" United States Geological and Geographical Survey.
WELLINGTON.—Geological Survey of New Zealand.
WELLINGTON.—New Zealand Institute.
YOKOHAMA.—Asiatic Society of Japan.
" German Naturalists' Society.
ZURICH.—Natural History Society.
The Commissioner of Inland Customs.
" Resident, Hyderabad.
" Government of Bengal.
" " of Bombay.
" " of Madras.
" " of N.-W. Provinces and Oude.
" " Punjab.
" Chief Commissioner of Assam.
" " " of British Burmah.
" " " of Central Provinces.
" " " of Mysore.
" Superintendent of Farms, Madras.
Foreign, Forest, Home, and Revenue and Agricultural Departments.

Geology of North-West Káshmír *and* Khágán *(being sixth notice of Geology of* Káshmír *and neighbouring territories) by* R. LYDEKKER, B.A., F.Z.S., *Geological Survey of India.*

(With map and section.)

INTRODUCTORY.

The geological work accomplished by myself during the past summer has completed the preliminary examination of the rocks of the north-western part of Káshmír territory. Some additional observations have also been made on the rocks of the Pír-Panjál range, and on those in the neighbourhood of Sonamarg and the Zoji-lá: the latter observations have led to a complete re-determination of the age of certain rocks. The season's work was concluded by a trip up the valley of the Kúnhár river, through the British district of Khágán, an appendage of Hazára. In spite of it being frequently impossible to leave the road owing to the neighbourhood of unfriendly tribes, results of considerable geological importance have been yielded by the latter trip.

As I hope at no very distant date to publish a general memoir on the geology of Káshmír territory and the neighbouring districts, the observations of the past season will be but briefly noticed here. The rocks of the several districts will be treated of in the order in which they were visited, commencing with—

I.—North-West Káshmír and the middle Kishanganga valley.

Limestones of Trigama.—In the last paper of this series,[1] it was stated that the limestones occurring near the village of Trigama, at the north-western extremity of the valley of Káshmír, were probably in part of triassic age, though they had hitherto been referred exclusively to the carboniferous. A re-examination of these rocks has now shown that they agree exactly in all their characters with the trias, or (?) trias-jura, of other parts of the Káshmír valley, and they have accordingly been referred to that series. These limestones do not cross the watershed of north-western Káshmír. On their northerly and easterly borders they are underlaid by some shaly and slaty beds (often of a greenish hue), mixed with earthy limestones, which are doubtless the representatives of the carboniferous. On the western border of the series the basal beds are in great part concealed by alluvium. No fossils have yet been obtained from these rocks, and accordingly the limits of the carboniferous can only be approximately indicated.

Other outliers of carboniferous and triassic rocks in north-west Káshmír.—In various places in the north-west of the Káshmír valley, and in the district between that and the lower Kishanganga valley, numerous small outliers of limestones and shales are to be met with, whose distribution is sufficiently indicated on the map, and, therefore, does not need further particularising. These rocks overlie, in all cases, the older palæozoics, and contain representatives of both the carboniferous and trias, though the exact discrimination between the two, in the absence of fossils, is a matter of considerable difficulty and uncertainty. The occurrence of these rocks in the tributary valleys of the lower Kishanganga is a matter of some importance, since, from their great resemblance to the limestones of the outer hills with which they are in proximity, and from their identity with the undoubted carboniferous and trias of Káshmír, they afford a strong confirmation of the view already entertained as to the carboniferous and triassic age of the latter limestones, and of the similarly situated band further to the south-east in the outer hills. The absence of fossils from the undoubted carboniferous and trias of north-western Káshmír, and from the corresponding rocks of the lower Kishanganga valley, affords a negative point of connection between these rocks and the unfossiliferous limestones of the outer hills.

Older palæozoics of north-west Káshmír.—The older palæozoics of north-west Káshmír, in their unmetamorphosed state, continue across the Kishanganga in the lower part of that valley; but higher up that valley, between Títwál and Changa, the river crosses their north-western boundary, and above this point their limit, for some miles, lies at some distance to the south of the river, the boundary again crossing the river in the Fúlme (Foolmai) district, and thence sweeping round to the north of the secondary basin of Tilel, described in previous papers. The mineralogical composition of these rocks varies considerably in different districts, trappean rocks occurring more abundantly on the

[1] *Supra*, Vol. XIV, p. 30.

northern flanks of the Káj-nág range, while shales and slates are more abundant in the Kishanganga valley. Here, as has been already noted in previous papers, as in other parts of Káshmír it has not yet been found possible to subdivide these rocks into minor divisions from the evidence of strata of distinct mineralogical composition.

A section in the neighbourhood of the Tútmári pass, of the rocks below the trias, may be instanced as a fair average example of these rocks:—

Blue limestones and shales, the latter frequently carbonaceous . . .	carboniferous.
Dark-coloured shales, slates, sandstones, &c.	silurian?
Quartzites, sometimes with gneissic structure, slates, amygdaloids, and conglomerates.	silurian?
Porphyritic-gneiss-granite	Primitive?

From this section it will be seen that the amygdaloids occur at a horizon far below the carboniferous, thus differing from the Káshmír sections described in previous papers, where the amygdaloids and other traps immediately underlie the carboniferous. Among the traps of this district there occurs a rock, with a peculiar star-shaped arrangement of crystals, named by the late Dr. Verchere soolimanite.[1] The conglomerate mentioned in the foregoing section is seemingly the same as that occurring in the Pír-Panjál: it here apparently occupies a somewhat low horizon in the series, and probably has a constant position. In Pángi, on the Chináb, Colonel McMahon has lately come to the conclusion [2] that the conglomerate occurring in the slates of that district is probably the equivalent of the so-called Blaini conglomerate of the Simla district, which has been referred to the upper silurian period. Before seeing Colonel McMahon's paper I had come to the same conclusion as to the homology of this conglomerate in Káshmír, for it appeared to me highly improbable that such a widely distributed rock should not belong to the same horizon. I am, however, by no means sure whether this horizon can be certainly fixed as upper silurian, seeing that in Káshmír these rocks seem to always occur a long distance below the fossiliferous carboniferous horizon. It may be, however, as I have often suggested, that in Káshmír a considerable portion of the trap and slate series, usually classed as silurian, is carboniferous. The Blaini limestone of the Simla district, according to Colonel McMahon's identification, should correspond with the part of the Káshmír slates immediately overlying the conglomerate.[3]

Metamorphics of the Káj-nág.—In the foregoing section the lowest rock exposed is a porphyritic gneiss-granite, the same as that already described in

[1] 'J. A. S. B.,' Vol. XXXV, pt. II, p. 120. This rock was named from its occurrence in the hill known as the Takht-í-Sulímán (throne of Solomon) at Srínagar in Káshmír. As the rock is generally found detached in worn boulders, and is of intense hardness, I have been unable to hammer off a specimen for examination. It is easily recognised in the field by its fine-grained green base, with many-pointed radiating stars of small white crystals scattered through it, and is valuable in identifying the Káshmír traps when met with out of the valley. Dr. Verchere discribes it as a "passage between a trachyte and a felspathic porphyry."

[2] *Supra*, Vol. XIV, p. 309.

[3] I defer further remarks on this point until I have personally visited the Chamba territories in the neighbourhood of Pángi.

previous papers as occurring on either side of the Jhelam gorge below the Káshmír valley. The mass of this gneiss on the northern side of the Jhelam does not form a continuous core down to the Kishanganga valley, but merely a comparatively small island where the highest peaks of the Káj-nág range are situated. The slates overlie this gneiss, and dip away from it on all sides. Unfortunately no distinct section, exhibiting the junction of the gneiss and slates, was seen; but from its resemblance to the gneiss, classed as primitive in other parts of the Himalaya, I am inclined to think that this Káj-nág gneiss is likewise primitive.

Gneiss south of the Jhelam.—In previous papers of the present series, it has been shown that a core of gneiss forms the back-bone of the Pír-Panjál range. Immediately south of the Jhelam this gneissic core consists of the above-mentioned gneiss-granite, together with some schistose gneiss. This mass of gneiss is, however, not continuous with that of the Pír-Panjál pass, described in a former paper, since the section across the Nilkanta pass exhibits no gneiss at all. The gneiss of the Pír-Panjál and Banihál passes is entirely of a schistose type between these two points: but the occurrence of gneiss pebbles in the conglomerate of the Pír-Panjál indicates the existence of some gneiss of a primitive type. From the difference in the mineralogical composition of the gneiss in the neighbourhood of the Jhelam, and that of the Pír-Panjál pass, I am now inclined to think that the latter is very probably altered palæozoics, while the former, as already stated, is primitive.

Metamorphics of north-west Káshmír.—To the northward of the great mass of slaty rocks, noticed above, as occurring at the north-western end of the Káshmír valley, we come upon another vast series of metamorphic and sub-metamorphic rocks, belonging to more than one geological period, continuous to the north-east with similar rocks in Dárdistán and Baltistán, described in the preceding paper of this series,[1] and to the north-west continuous with the metamorphic rocks of Khágán, noticed in the sequel.

In the Kishanganga valley these rocks occasionally consist of thin bands of a granitic but more usually of a schistose gneiss, varying in its degree of crystallization till it passes into scarcely altered slates; many of the schists are highly micaceous, and frequently garnetiferous. At the village of Changa, and again higher up the river at Doga, there are found overlying these schists, or sometimes folded in among them, certain more or less altered limestones or dolomites, which from their characters seem undoubtedly to correspond to the trias of the Káshmír valley. The occurrence of these limestones indicates pretty clearly that, at all events, some of these gneissic rocks must be the altered representatives of the palæozoics,—a conclusion which we shall find confirmed when we come to treat of the rocks of Khágán. The higher parts of the lofty range separating the Kishanganga from the Khágán valley consist of a granitic and frequently porphyritic gneiss, almost certainly primitive ('central'). Here a considerable difficulty presents itself in regard to the colouring of the map, since in Khágán the primitive and the palæozoic gneisses can be easily separated

[1] *Loc cit.*

and distinguished on the map, while, as noticed in my last paper, no such separation has been found practicable in Baltistán. Hence, in this intermediate country, it is almost impossible to give a true representation, and it must be observed that while in Khágán and the lower Kishanganga valley the gneiss of the two ages is distinguished by different colours, yet in the upper Kishanganga valley, and to the north and east of the same, the one colour on the map (red) must be considered to embrace gneiss of two ages, the easterly termination of the purple area on the map being merely an arbitrary one, and not in the least representing the real distribution of the newer gneiss.

To the north-east of Shàrdi, on the Kishanganga, the garnetiferous schists are again underlaid by a highly crystalline and sometimes granitic gneiss, pebbles of which are found in the palæozoic conglomerate somewhat higher up the river. Still higher up the river the granitoid gneiss is underlaid by the garnetiferous schists, probably a case of inversion. At the village of Kel,[1] and up the valley leading thence northward, there occurs much of the "augen-gneissth" of Astor, described in my last paper. As at Astor, it is impossible to say whether this gneiss be primitive or altered palæozoic.

Metamorphosed trias.—Up the tributary valley (Brai valley) to the northward of Kel, the "Augen-gneissth" is overlaid by less completely crystalline schists. Near the upper end of the same valley there occur numerous small outliers of the characteristic banded trias limestones and dolomites of the upper Kishanganga valley, more or less altered by metamorphic action. These altered calcareous rocks conformably overlie the gneiss, and are sometimes found capping the highest peaks and ridges, and in other places let down deep into the river gorges, being not unfrequently completely inverted among the gneiss. The distribution of these outliers can only be approximately indicated on the map. No carboniferous horizon can be detected among these triassic outliers, but their presence affords abundant evidence to show that the underlying schists must contain representatives both of the carboniferous and silurian; while, from the presence of pebbles of gneiss in the palæozoic conglomerate, it seems equally clear that a moiety of the metamorphic series must be primitive. The position of these outliers in the Brai stream is such that they lie exactly on the line of strike of the great triassic basin of the upper Kishanganga (Tilel) valley, whence we may conclude that this basin once extended much further to the north-west than at present. In my last paper it was stated that a mass of similar limestones had been noticed by the late Mr. Vigne as occurring in the Indus valley in Chilás, on the strike of the Kishanganga trias: it is probable that this mass of limestone is another triassic outlier among metamorphic rocks. These metamorphic triassic limestones of the Kishanganga basin are precisely similar to those of Baltistán described in my last paper.

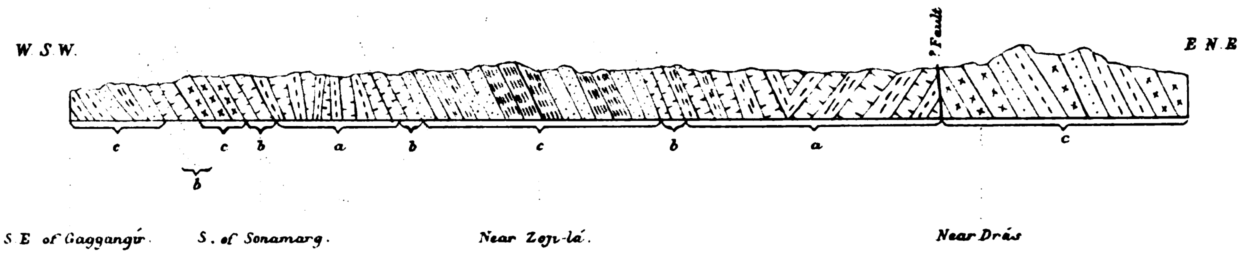
Northerly termination of Kishanganga secondary basin.—The secondary basin of the Kishanganga valley and the Zoji-lá has been already described in previous

[1] There is a considerable error in the map (copied from the Indian atlas) at this point, the mouths of the Brai stream, and the stream from Machel, on the opposite side of the Kishanganga, being represented as opposite one another, whereas they are really about 4 miles apart.

Ideal Section from S.E. of Gaggangír in Sind Valley to the neighbourhood of Drás

Scale 8 Miles = 1 Inch

a - *Trias*. *b* - *Carboniferous*. *c* - *Silurian*



On Stone by S. Khadem Hosain.

papers, though its northerly termination was not fixed. It has now been found that it extends only a short distance to the north-west of Gurez, the carboniferous rocks sweeping round the trias to become continuous with those of the Kamri pass and Burzil river. The carbonifereous is underlaid by the older palæozoic slates, which a short distance to the north-west pass gradually into the great mass of metamorphics of Dárdistán and Baltistán.

Rocks of Sonamarg and the Zoji-lá.—A re-examination of the rocks in the neighbourhood of Sonamarg and the Zoji-lá, at a time when the country was free from snow, has resulted in an entirely different determination of the age and relations of several of these rocks from that previously entertained by myself.[1] It has hitherto been considered that on the southward border of the Sonamarg trias no carboniferous strata existed, the palæozoic amygdaloids adjoining the trias, and a fault existing at the line of junction. The closer examination of the carboniferous of the Káshmír valley undertaken last year has, however, shown that certain carbonaceous and pyritiferous shales, and blue, frequently quartz-veined, limestones, occurring immediately above the amygdaloidal rocks of Sonamarg, must be the representatives of the carboniferous, from their identity in mineralogical structure with the fossiliferous carboniferous of Wardwan and Káshmír. These rocks, which form a very thin band, are succeeded by the trias, as is shown in the accompanying section. The triassic rocks have at first a northerly dip, subsequently becoming southerly, after which, owing to inversion, it again attains its northerly direction; approaching the Zoji-lá, this trias is overlaid by the same carboniferous rocks as occur at Sonamarg. On the same side of the pass the carboniferous rocks are in turn overlaid by slates and greenish trap-like rocks, which must now be considered as the representatives of the older palæozoics. These rocks were originally so classed by Dr. Stoliczka; but observations made by myself in the upper Lidar valley (Panjtárni) led me to the conclusion that they were newer than the trias. In that district the section showed that the slates rested on a synclinal of the trias, whence it was inferred that they were the newer of the two. The conclusion now arrived at as to the relations of the same rocks on the Zoji-lá leads to the inference that in the Panjtárni section the slate rocks must really form an inverted anticlinal below the trias, spreading out above in a fan-shaped manner so as apparently to overlie the latter. To the south-east of the road leading up to the Zoji-lá the strata appear to be in normal sequence, the palæozoic slates dipping to the south-west and south-east and underlying the limestone series. The anticlinal, formerly stated to occur in the trias near Báltal, seems to be merely an inversion.

II.—The Lower Kishanganga valley and Khágán.

Tertiary rocks.—In the lower Kishanganga valley the palæozoic slates of Káshmír extend to within a couple of miles of the village of Pala, sweeping round in a horse-shoe form on either side to Nága station on the south, and Makra station on the north. Within this horse-shoe or bay of older rocks there occurs a large

[1] The Sonamarg district is shown in the map accompanying my last paper.

extent of the red tertiary rocks of the Murree group.[1] These and other tertiary rocks occupy the rest of the Kishanganga valley, and are continuous with those of the Jhelam valley, while to the north they extend into Khágán. The junction between the tertiaries and the palæozoics seems to be an original one, the rocks of both series presenting a parallelism of stratification, with a general highly inclined outward dip, though there is very frequently slight inversion: further to the west this inversion becomes the rule. The red Murree rocks continue to within a short distance of Musafirabad (Mozafirabad), where they are underlaid by limestones, crowded with nummulites.[2] These nummulitic limestones form a tongue, stretching in from the north-west and cutting off almost entirely the Kishanganga and Khágán Murree rocks from those of the Jhelam valley, though there is a narrow communication near Chenasi station. The 'tongue' of nummulitics probably forms an anticlinal axis, inverted towards the south. It would seem from the relations of the Murree rocks to the palæozoics that the nummulitics were 'overlapped' by the former rocks, and that they never underlay the whole tertiary area. The Musafirabad nummulitics unite with the band bordering the right bank of the Jhelam below the Musafirabad bend: to the north these limestones continue to a point a little beyond Bála-kot, being overlaid to the north and east by Murree beds. In the Khágán valley the tertiaries form another bay, rather smaller than the one in the Kishanganga valley. The lower part of this bay is formed by Murree beds, and the higher by nummulitic limestones; the bordering rocks are in all cases palæozoics.

Relations of tertiaries to older rocks.—At the junction of the nummulitics with the palæozoics, on the Kúnhár river below Khágán, the strata are nearly vertical, with a slight south-westerly dip, the nummulitics overlying the palæozoics. There appears to be strict parallelism between the strata of the two rock series, as far as can be observed in the limited portion visible in the section. A similar relation of the palæozoics to the tertiaries has been previously noticed in Ladák.[3]

General conclusions on the tertiaries.—The occurrence of the bay of tertiaries

[1] It may not be out of place to mention that, from the middle rocks of the Murree group, near Chakoti, in the Upper Jhelam valley, I obtained last autumn a fragment of the frond of a palm, belonging to a species which Dr. Feistmantel has described below as being very closely allied to, if not identical with, *Sabal major*, of the middle and lower miocene of Europe. The occurrence of this miocene palm in a horizon far below that of the mammaliferous siwaliks is of some importance, as it goes some way in confirming the conclusions previously arrived at by Mr. W. T. Blanford and others, as to the pliocene age of the latter. The presence of nummulites marks the eocene age of the Subáthu group. The present fossil indicates the miocene age of the Murree group (the fossil was found about the middle of this series); and hence, on this evidence alone, the Siwaliks should be pliocene.

[2] These Musafirabad limestones have been the source of considerable discussion and difficulty. In the first paper of this series (*Supra* Vol. IX, p. 155, *et seq.*) they were classed as nummulitics (Subáthu), but were confounded with the palæozoics to the northward. In a subsequent paper (Vol. XII, p. 16), owing to this mistake and the non-discovery of nummulites in the limestone at Musafirabad, I came to the conclusion that these rocks must be the equivalent of the Uri limestones higher up the Jhelam valley, and hence of early mesozoic or late palæozoic age. The observations of the past season have finally set the question at rest.

[3] *Supra*, Vol. XIII, p. 39.

running up the valley of the Kúnhár and Kishanganga rivers is a fact of much geological interest. The presence of this bay, taken together with the circumstance that the inner tertiary boundary is immediately outside a snowy range, the nature of that boundary, and the non-occurrence of any tertiary rocks beyond it, seem to point to the conclusion that that boundary is approximately an original one, though, of course, the limits of the strata have been somewhat curtailed by denudation.[1] Hence we may probably infer that the Káj-nág and Pír-Panjál range marks an old shore line, while the Jhelam flowed into the sea or estuary at Uri,[2] and the Kúnhár and Kishanganga rivers, by distinct mouths into a gulf northward of Musafirabad. From these obervations it will follow that the present drainage lines of the country must have existed in early tertiary times.

The lower Murree beds are certainly of marine origin, as they locally contain nummulites; while, from the occasional occurrence of fresh-water shells in the higher beds of the series, we may infer that the latter are of fresh-water or brackish origin. Hence it seems probable that the nummulitic sea gradually receded, and was replaced by estuaries and lagoons. We may further infer that Himalayan land existed in eocene times, forming a shore of the eocene sea, and affording material for the immense series of tertiary deposits. Considering that we have fair evidence that the Pír-Panjál and Káj-nág range-formed an old shore line, it seems remarkable that no pebble beds are found in the lower tertiaries. This may, perhaps, be explained as follows:—Seeing that in most places where the junction between the palæozoics and tertiaries has been observed, (as in Khágán and on the Jhelam at Uri,) there is a strict parallelism between the two series of strata, frequently (as at Uri) with inversion, we must suppose that the palæozoics forming the old shore line had originally a low and gradual dip towards the sea; the tertiaries would then be thrown down upon these rocks with the same general inclination which, in a limited area, would appear parallel. Further, since the older rocks dipped towards the sea, they would be but slightly affected by denudation, and since the sea may have been a currentless gulf, it is not so difficult to imagine the absence of a pebble beach. Finally, a steady upraising of the whole area by a lateral thrust would very easily crush the tertiaries against the palæozoics and invert the latter upon them. It may be concluded from this, that here, as suggested by Mr. Medlicott ("Manual," pp. 569,980), a great upheaval and denudation of the older rocks took place in pre-tertiary times, while the great epoch of contortion and crushing took place subsequently.

Extinction of gneissic axis of the Pír-Panjál at the Kishanganga valley.—In the "Manual of the Geology of India," it has been concluded[3] that the valley of the Kishanganga at Muzafirabad, and of the Jhelam below its great bend at that place, formed the boundary of the Himalayan area proper. This conclusion is strikingly confirmed by the bay of tertiary rocks occurring in the lower Kishanganga valley, and by the gradual but complete extinction, some distance to the south-

[1] The opinion at first expressed by myself (*Supra*, Vol. IX, p. 155), that this boundary was a faulted one, will not hold.

[2] See map accompanying paper last quoted.

[3] pp. 478, 518.

east of this valley, of the gneissic axis of the Pír-Panjál range,—an axis which can be traced up to this point continuously from the Dhauladhár range, with but slight interruption, and, as we approach the valley of the Kishanganga, becomes gradually less and less marked until its final disappearance beneath a mass of silurian and carboniferous rocks in that valley. The gneiss to the westward of the Kishanganga belongs to an entirely different mountain system, namely that of the Mustág and Chilás ranges of Baltistán and Ladák, described in previous papers of this series.

Older rocks of Khágán.—Reverting to the rocks of Khágán, we may continue our survey by commencing at the upper end of the valley, where we find the rocks of the valleys and bordering ranges to consist mainly of a compact gneiss-granite, frequently porphyritic, with large twin crystals of orthoclase, but more generally fine-grained. This gneiss-granite is undoubtedly identical with the similar rocks described in my last paper as occurring so frequently in Baltistán, and apparently the representative of the central gneiss of Dr. Stoliczka. It is, however, quite probable that among this gneiss there are beds of the newer gneiss.

In several places on the south side of the upper Khágán valley, this primitive gneiss, frequently lacking all signs of stratification, is distinctly seen to be overlaid by a newer and schistose gneiss, with considerable indications of unconformity. This newer schistose gneiss, and other schists, are frequently highly garnetiferous and micaceous. As we descend the valley, the newer schists gradually become less and less crystalline, till near the village of Khágán itself they become almost unaltered slates and shales; while below that place they pass into greenish sandy and slaty rocks, undoubtedly the same as many of the older palæozoics of Káshmír. In various parts of upper Khágán these semi-metamorphic rocks are overlaid by carbonaceous and pyritous shales, which have undergone a partial metamorphism, and these again by a hard white or buff metamorphic limestone or marble. The close resemblance of these rocks, whose distribution is approximately indicated on the map, to the metamorphosed trias of the Kishanganga valley, and also to the unaltered carboniferous and trias of the Káshmír valley, indicates a strong presumption that they are the same; it is further probable that the representatives of the Hazára 'Tanol' group of Mr. Wynne are represented among these rocks.

Frequently, owing to the extent to which the metamorphic action has been carried, the presumed carboniferous zone cannot be detected. The presence of these rocks, if rightly assigned, confirms the conclusion that the newer Khágán gneiss, which is the same as that of the lower Kishanganga, is the altered representative of the palæozoics.

Unknown rocks.—In upper Khágán, at the village of Soch, there occur certain greenish sandstones, mingled with some slightly altered blue limestones, and some shales, resting on the gneiss. These rocks are left uncoloured on the map, as I cannot determine their age: they are not unlike some of the nummulitics, but I could find no trace of nummulites in the limestones.

Rocks of Northern Hazára.—In conclusion, a few remarks may be added, as to the correlation of the rocks of northern Hazára, comprehending the lower portion of the course of the Kúnhár river, and the adjacent country to the west and south with those of Khágán. The latest report on the geology of Hazára is by Mr. Wynne, and will be found in the 12th volume of the "Records,"[1] accompanied by a map, which includes part of the area exhibited in the map accompanying the present notice. In the two maps some slight differences will be noticed, occasioned by the different estimates taken by Mr. Wynne and myself of the distinctions between slates and schists. A short notice of the section between Murree and Abbottabad, in Hazára, is given by Mr. Wynne in the same volume;[2] and the geology of the Sirban mountain in lower Hazára is treated of by the same gentleman in the 9th volume of the "Memoirs."

In northern Hazára Mr. Wynne distinguishes the following divisions of the infra-jurassic rocks, *viz.*:—

4. Trias { upper, lower.
3. { Infra-trias and Tanol series, passing to the north into gneissic rocks.
2. Attock slates.
1. Hazára gneiss.

The trias Mr. Wynne identifies with that of Káshmír, and there can be no doubt that this is correct.

The age of the Tanol rocks is not determined, but it is evident that this must lie between some part of the palæozoic and the trias.

The Attock slates are concluded to be palæozoic, with a possibility of being silurian. Mr. Wynne doubts whether these rocks are the same as the silurian of Káshmír, mainly on account of their non-association with gneiss.

The Hazára gneiss is identified with that of the Káj-nág (Pír-Panjál) range, but is said to be differently placed.

In Mr. Wynne's map[3] there appears a large series of schistose rocks, lying to the north of Abbotabad. These rocks do not appear in the table given on page 128 of Mr. Wynne's notice, unless they be included in the Tanol series. They are undoubtedly the same as the newer gneiss of Khágán, which has been shown to contain representatives of the palæozoics.

My own observations tend to point to the intimate relationship of these schists with the Attock slates; the rocks on the lower Kúnhár river, mapped as such by Mr. Wynne,[4] appearing to pass imperceptibly into the newer gneiss and other schists, of Khágán to the north, and of Hazára to the south-west. I am thus led to conclude that the newer gneiss series (or schists of Mr. Wynne), is, at all events in great part, the metamorphosed representative of the Attock slates. Both these rock series would, therefore, seem to correspond to the slate series of Káshmír, which has been mainly classed as silurian, though there is a possibility of its upper part being carboniferous.

Since the publication of Mr. Wynne's notice of northern Hazara, Dr. Waagen has suggested[5] that the Attock slates may be of carboniferous age, his suggestion

[1] p. 114, *et seq.*
[2] p. 208, *et seq.*
[3] *Supra*, Vol. XII, p. 132.
[4] *Ibid*, p. 120 (Mr. Wynne terms the Kúnhár the Nainsúk river).
[5] *Supra*, Vol. XII, p. 184.

being based on the evidence of a carboniferous brachiopod, embedded in dark shale, said to have been obtained from the Punjab. The evidence connecting. this fossil with the Attock slates is, however, only circumstantial.

Seeing that, according to Mr. Wynne, the Tanol group overlies the Attock slates with marked unconformity, it seems difficult to accept the view of the carboniferous age of the former, since there would thus seem to be no place for the Tanols. Perhaps a way out of the dilemma might be found by considering that merely the topmost Attock slates are of carboniferous age. Even then however, we have the Tanols vastly thicker than the undoubted carboniferous of Káshmír, to say nothing of the unconformity between the Tanols and the trias.

The Hazára gneiss of Mr. Wynne is undoubtedly the same as that of upper Khágán, where we have seen it underlying the newer schists, and doubtless corresponds to the 'central gneiss' of Dr. Stoliczka. Its apparent super-position on the newer schists in Hazára must be due either to inversion on a very large scale, or to a fault.

In confirmation of the view of the correspondence of the Attock slates with the slate series of Káshmír, I may add that I have this season identified, as far as this can be done from exact structural similarity, the slates occurring on the upper road from Abbottabad to Murree at Kálabágh, described by Mr. Wynne as Attock slates,[1] and those occurring in the gorge leading from Láma-Yuru to Kalsi on the Indus in Ladák,[2] considered both by Dr. Stoliczka and myself as being probably of silurian age. Similar rocks occur at Drás, on the Káshmír and Ladák road, and have been identified with the great mass of the slate series of Káshmír. The proximity of the same Káshmír slates in the Kishanganga valley to the Attock slates of the lower Kúnhár valley seems of itself sufficient proof of the identity of these rocks.

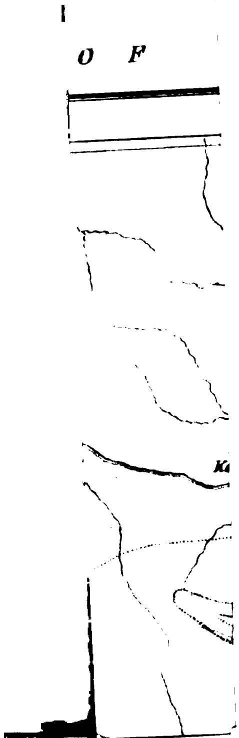
On some Gondwána Labyrinthodonts, *by* R. LYDEKKER, B.A., F.Z.S., *Geological Survey of India.*

(With a Plate).

Introductory.—Since my last notice of Gondwána vertebrates,[3] Professor Huxley has returned to the Indian Museum certain remains of labyrinthodonts from the Panchet and Maleri groups of the Gondwána rock series, some of which are of sufficient interest to merit a short notice here, as they illustrate more fully than previous specimens the structure and distribution of certain forms of these interesting salamandroid animals. In the plate accompanying this notice some of the best preserved of these remains have been figured, together with (fig. 1) the small lower jaw of a Panchet labyrinthodont collected by myself last year, and referred to in the above-quoted notice. I now proceed to notice the various specimens *seriatim.*

Mandible of PACHYGONIA INCURVATA *from the Panchet group.*—In his description of the "Vertebrate Fossils from the Panchet Rocks,[4]" Professor Huxley

[1] *Supra*, Vol. XII, p. 208.
[2] *Ibid*, p. 46.
[3] *Supra*, Vol. XIV, p. 176.
[4] "Pal. Ind." Ser. IV., Vol. I, pt. 1, p. 6.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described and figured the hinder moiety of the left ramus of a labyrinthodont mandible under the new name of *Pachygonia incurvata.* This lower jaw is characterised by its roughly sculptured outer surface, and by its carrying a row of minute teeth, transversely elongated at their bases, but becoming sub-cylindrical higher up. The part of the dentary element remaining in the specimen is nearly straight, with a slight indication of the symphysial incurving.

At a subsequent date I described[1] the symphysial portion of another labyrinthodont mandible from the same formation, which was referred to the same species. This specimen showed a series of small teeth, placed along the free edge of the ramus, like those in Professor Huxley's specimen, and also a single and larger isolated tooth placed internally to the marginal series in juxtaposition to the symphysis.

In figure 2 of the plate accompanying this notice is represented the dentary portion of the right ramus of a labyrinthodont mandible from the Panchet group of rocks, being one of the specimens returned by Professor Huxley. The anterior portion of this specimen is precisely the same as the fragment of the symphysis described by myself. The hinder part of this specimen, as far forward as the point where the teeth become separated by a distinct interval, corresponds with the anterior part of Professor Huxley's specimen; the new jaw is, however, rather deeper than the latter, and must have belonged to a somewhat larger individual. The new specimen makes us, therefore, acquainted with the whole of the mandible of *Pachygonia.* It will be noticed that the hinder teeth are closely approximated, transversely elongated at their bases, sub-cylindrical higher up, and bending in at their extremities. In advance of these approximated teeth are four rather larger teeth, separated by intervals about equalling their own shorter diameters. In advance of these, we again find another series of smaller and closely approximated teeth, continuing up to the symphysis, as in many other labyrinthodonts. There is one large isolated tooth placed close to the symphysis, and internally to the marginal series.

In describing his specimen, Professor Huxley remarked that "inside the dentary piece there seems to be a distinct splenial element......It exhibits minute, round, crater-like elevations, as if (as is the case in some Amphibia and Ganoid fishes) it had given attachment to teeth." The absolute correctness of this suggestion is illustrated by the new specimen, for this shows on its inner surface a small remnant of a splenial element, bearing two minute teeth; this probably continued along a considerable portion of the hinder part of the dentary piece. The outer wall of the mandible is nearly vertical, and of great relative depth at the symphysis. The general form of the complete mandible was probably very similar to that of the European *Labyrinthodon pachygnathus.*

PACHYGONIA *from the Kota-Maleri group.*—In figures 3 and 4 of the accompanying plate are represented two fragments of labyrinthodont jaws from the Maleri section of the Kota-Maleri group. They were collected by the late Mr. Hislop in Chutia Nagpúr, and were sent to Professor Huxley, who never described them: they are coated with the red clay characteristic of the Maleri

[1] "Pal. Ind." Ser. IV., Vol. I, pt. 3, p. 18, pl. III, figs. 12, 13.

fossils. The fragment represented in figure 3 is a portion of the dentary element of a mandibular ramus, posterior to the symphysis; while that represented in figure 4 is a portion of a left ramus, immediately contiguous to the symphysis. These fragments so closely resemble the above-described jaws of *Pachygonia incurvata*, that it appears to me that they may be safely referred to the same genus, and not improbably to the same species.

The identification of a Panchet fossil in the much lower Maleri horizon is a matter of some interest, as hitherto the fossils from these two horizons have been entirely distinct. The present determination makes a closer link between these two series of the great Gondwána system.

GONIOGLYPTUS HUXLEYI (*nobis*) *from the Panchet group.*—Another specimen from the Panchet rocks, represented in figures 5 and 8 of the accompanying plate, consists of the hinder portion of the left ramus of the mandible of a comparatively large-sized labyrinthodont. Figure 5 gives a view of the articular cavity, and figure 8 of the outer surface of this specimen. It will be remembered that in the above-quoted memoir[1] Professor Huxley described and figured a slender labyrinthodont mandible, which he provisionally referred to *Gonioglyptus longirostris*, a species named from the evidence of a fragementary skull from the Panchet rocks. The relatively common occurrence of fragments of both these skulls and mandibles in those rocks renders it almost certain that this provisional determination is correct, and it will henceforth be assumed to be so.

The fragmentary ramus figured here comprehends only a portion of the articular and angular elements, the supra-angular having been nearly all worn away, the cavity for articulation with the quadrate and the superior part of the articular and angular elements being the only perfect portions. This jaw belonged to an animal nearly three times the dimensions of the one to which belonged the jaw figured by Professor Huxley: it would, however, be doubtful whether size alone would afford grounds of specific distinction, were it not supplemented by certain differences in form. The general form of the larger mandible agrees so nearly with that of *Gonioglyptus longirostris*, that there is every probability of the two having belonged to the same genus. The following points of difference may, however, be indicated:—In *G. longirostris* the sculpturing on the internal surface extends down to the sharp interior border of the jaw, throughout its length. In the larger jaw, on the other hand, the sculpture occupies only the upper two-thirds of the hinder portion of the outer surface, there being a wide and deep groove on the portion unoccupied by the sculpture. The two diverging grooves, so conspicuous on the outer side of the mandible of *G. longirostris*, immediately below the articular cavity, are only very faintly indicated in the larger jaw. There is, further, a considerable difference in the sculpture of the two specimens, which, though easy to recognise, is difficult to describe.

The foregoing differences appear to me to forbid our referring the two mandibles to the same species, and I therefore propose to form a new species for the larger jaw, which may be named *Gonioglyptus huxleyi*. Judging from the

[1] p. 5, pl. VI, fig. 2.

size of the fragment of the mandible, this animal must have attained a length of at least 5 or 6 feet.

Labyrinthodont Symphysis from the Panchet group.—In figure 6 of the accompanying plate, there is represented the inferior view of the right half of the symphysis of the mandible of a labyrinthodont from the Panchet rocks. The figured under-surface shows a portion of the bone marked with sculpture like that of *Gonioglyptus*, and internally to this an exposed surface which would seem to have articulated with a produced splenial element. The superior surface (not figured) has been somewhat rolled, and only shows sections of the teeth. These comprised a marginal series, and one larger solitary tooth, placed more internally, near the symphysis. The superior surface is nearly flat, while the inferior gradually slopes upwards from the hinder border of the symphysis to the anterior border, which consequently forms a sharp edge.

The form of the symphysis shows that this jaw cannot belong to *Pachygonia* in which the anterior border of the symphysis forms a vertical wall in place of a sharp edge. It may belong to one of the species of *Gonioglyptus*, but this cannot be certainly determined.

Mandible of GLYPTOGNATHUS FRAGILIS (*nobis*) *from the Panchet group*—In my note on Gondwána vertebrates in the last volume of this publication, already quoted, a mandible of a labyrinthodont from the Panchet rocks was described though not named, and shown to be different from the mandible either of *Gonioglyptus* or *Pachygonia.* This specimen has now been figured in the accompanying plate (fig. 1), and it may be well to recapitulate the main points of the description already given. The fragment comprises the greater portion of the right ramus of the mandible, showing the articular cavity, and the greater part of the dentary element. The bases of six anchylosed teeth are shown, decreasing in size from before backwards. The teeth are sub-elliptical in cross-section, the transverse diameter being the longer. The portion of the jaw remaining is quite straight, very slender, rounded interiorly, and sculptured externally.

The jaw of *Gonioglyptus longirostris*, besides being larger than the present specimen, is distinguished by presenting a trenchant edge, free from teeth, for some distance in advance of the articular cavity; while the jaw of *G. huxleyi* is at once distinguished by its enormously larger dimensions. The jaw of *Pachygonia incurvata* makes no approach to the present specimen.

There is, therefore, no doubt but that this jaw does not belong to any of the named Panchet labyrinthodonts; and as I am unable to identify it with any form from other parts of the globe, and as it is highly inconvenient to have to refer to species without any generic or specific name, I propose to provisionally designate the species to which the jaw belonged as *Glyptognathus* (γλύφω, γνάθος) *fragilis.* Though the specimen is not quite perfect posteriorly, it seems probable that it had no 'supra (post) articular' process, whence it would belong to Professor Miall's group of Brachyopinæ, *Gonioglyptus*, and *Pachygonia*, belonging to the group Euglypta, in which that process is present.[1]

[1] See Miall. "Report on the structure and classification of the Labyrinthodonts." Brit. Assoc, Rep., 1874.

Labyrinthodont vertebræ from Maleri.—Among the specimens collected by the late Mr. Hislop in the rocks of the Maleri group, and sent to Professor Huxley, are certain amphicœlous vertebræ of considerable size, which almost certainly belonged to some form of labyrinthodont. One of the more perfect of these bones is represented in figure 7 of the accompanying plate. It is impossible to determine the genus of animal to which these bones belonged, and they are mentioned here merely to indicate the existence of a large labyrinthodont among the Maleri fauna.

It has been suggested to me whether the large dermal scutes found at Maleri and elsewhere might not have belonged to the batrachian rather than to the crocodilian (*Parasuchus*) to which they have hitherto been referred. In regard to this question, it may be observed that dermal scutes and crocodilian vertebræ have been found in association at a place (Rewah) where no batrachian remains have been discovered; also that at Maleri scutes and crocodilian vertebræ are very common, while only five batrachian vertebræ are known; and, finally, that the generally quadrangular form and bevelled edges of the scutes indicate crocodilian rather than batrachian owners. It is, however, quite possible that some of these scutes may have belonged to the latter.

DESCRIPTION OF PLATE.

Fig. 1. GLYPTOGNATHUS FRAGILIS, (Lyd.). Hinder portion of right ramus of the mandible. Panchet group.

Fig. 2. PACHYGONIA INCURVATA (Hux.). Anterior portion of right ramus of the mandible; left ramus restored. Panchet group.

Figs. 3 & 4. PACHYGONIA (?) INCURVATA (Hux.). Portions of the mandible. Maleri beds.

Fig. 5. GONIOGLYPTUS HUXLEYI (Lyd.). Upper view of articular cavity of left ramus of the mandible. Panchet group.

Fig. 6. GONIOGLYPTUS ? sp. Superior view of right half of the symphysis of the mandible. Panchet group.

Fig. 7. Labyrinthodont vertebra. Maleri group.

Fig. 8. GONIOGLYPTUS HUXLEYI, (Lyd.). Lateral view of hinder portion of left ramus of the mandible. From the same specimen as that represented in figure 5.

Note on some Siwalik *and* Jamna Mammals *by* R. LYDEKKER, B.A, F.Z.S., *Geological Survey of India.*

HYÆNA SIVALENSIS *(Falc. and Caut.)*

In a recent number of the 'Records'[1] Mr. Bose has re-opened the question as to the existence of one or two species of Siwalik hyænas. In this notice the correctness of my own measurements of the specimens in the Indian Museum having been called in question, I am compelled, much as controversies are to be deprecated, to vindicate my own statements.

[1] *Supra.* Vol. XIV, p. 266.

Gondwána Labyrinthodonts.

Records, Vol. XV. Pt. I.

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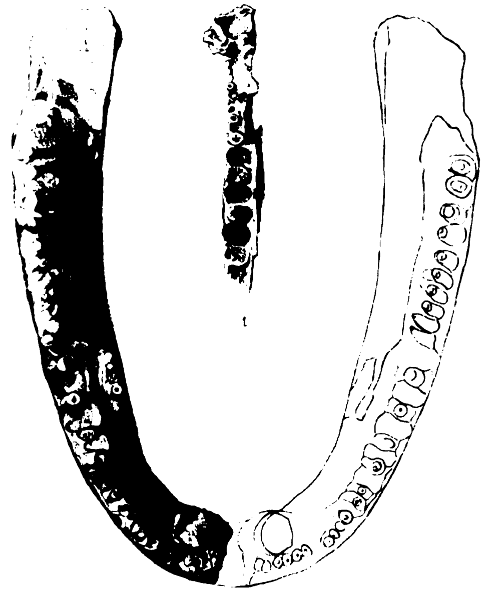

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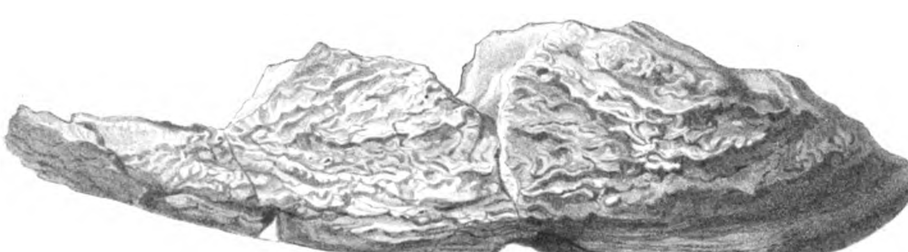

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J. Schaumburg, Lith.

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It would appear that from an unfortunate grammatical inaccuracy of mine, Mr. Bose took another skull for the one in which the small upper molar was stated to exist, and hence concluded my measurements were wrong.[1] In order that the question may be settled, as far as this point goes, and also to remove any personal element from the matter, Mr. J. Wood-Mason, Deputy Superintendent of the Indian Museum, has been kind enough to measure the transverse diameter of the tubercular molar in all the three skulls of Siwalik hyænas, in the Indian Museum.[2] In the following table these measurements are given, together with Mr. Bose's measurements of the corresponding teeth in the two British Museum specimens. In the second column of the table the presence or absence of the first upper premolar is indicated, respectively, by a cross or a cypher:—

	Transverse diameter of tubercular.	Presence or absence of 1 p.m.
a. Indian Museum skull D. 44	0·68	+
b. „ „ „ D. 47	0·59[3]	0
c. British „ type of *H. sivalensis*	0·55	+
d. Indian „ skull D. 45	0·45	0
e. British „ type of *H. felina*	0·22	0

A fragment of the maxilla of another Siwalik hyæna in the Indian Museum (D. 101) has the tubercular molar of the same transverse diameter as in the skull *d*; its shorter diameter is, however, 0·19, in place of 0·23.

In spite of my grammatical blunder, it is rather difficult to understand how Mr. Bose, with the three skulls before him, could have overlooked the above-mentioned differences in the dimensions of the tubercular molars, and committed himself to the statement that "all the three skulls in the collection of the Indian Museum agree in respect of the size of the upper tubercular."

Taking into consideration the graduated scale of the variations in the size of that tooth as indicated in the table, it appears to me that, from this point of view, there are not, as I stated before, sufficient grounds for making more than one species. It will be noted that the difference in size of the tooth in question in the skulls *a* and *d* on the one hand, and *d* and *e* on the other, is the same.

If any division were made of the skulls, including the maxilla, it appears to me that it would be necessary to make six species.

The table further illustrates the extreme irregularity in the development of the first premolar, which, in his original paper, Mr. Bose considered to be an important character of his *H. felina*.[4] The development or non-development of this tooth is seen to bear no relation to the size of the tubercular.

Although Mr. Bose in his last notice seems to rely on the small size of the tubercular as the distinctive character of his species, still he mentions that his

[1] The skull mentioned by Mr. Bose is No. D. 47, while the one I referred to is D. 45.

[2] Mr. Wood-Mason's measurement of the tubercular in D. 45 is somewhat larger than mine.

[3] Mr. Bose's measurement is 0·6.

[4] Mr. Bose ('Quar. Jour. Geol. Society,' Vol. XXXVI, p. 131) remarks on the constancy of this tooth in all known species of *Hyæna*, both living and fossil, except his *H. felina*. A cast of a skull of *H. eximia* from Pikermi, exhibited in the British Museum, shows the absence of this tooth.

type skull of *H. felina* is distinguished by its greater shortness and breadth from his *H. sivalensis*. It is, indeed, perfectly true that there is a very considerable difference between the form of the skulls *a* and *e*, the former being elongated and the latter wide. But then the skull *b* is intermediate in these respects, approaching, however, in its wide palate, nearer to *e* than to *a*.

It is not easy to see the force of the support Mr. Bose seems to derive from the confusion made by the Editor of the "Palæontological Memoirs" over the application of the name *Felis cristata*, as was pointed out by Mr. Bose himself in his original paper.[1]

Finally, as was mentioned in my previous notice, I think from the materials available to him, Mr. Bose, following the lead of Dr. Falconer,[2] was probably right in making two species of Siwalik hyænas. The fuller materials available in India, however, seem to me to point to the conclusion that not more than one species can at present be determined.

TRAGULUS SIVALENSIS, nobis., n. sp.

An upper molar tooth of a small ruminant, from Mr. Theobald's collection from the Siwaliks of the Punjab, is indistinguishable from the corresponding tooth of the living *Tragulus indicus*, and doubtless belonged to an animal of the same genus. Since it is impossible to distinguish the different living species from the characters of the teeth alone, it seems best to indicate the fossil by a distinct provisional name, which I propose should be *sivalensis*.

EVOLUTION OF THE GIRAFFES.

A study of the limb-bones and cervical vertebræ of fossil Siwalik giraffe-like and sivatheroid animals in the collection of the Indian Museum, has shown that the Siwalik giraffe was very like the existing species in the proportions of its limb-bones. Nearly allied to this giraffe was another long-limbed ruminant, the leg-bones of which were, however, considerably shorter than those of the giraffe: this ruminant is possibly the same as *Vishnutherium*. Next in the series we have *Hydaspitherium*, whose limb-bones were considerably shorter and stouter than those of the last form, but longer and slighter than those of *Sivatherium*. Finally, those of the latter genus have the proportions ordinarily prevailing among the ruminants.

It is not pretended that the above is the direct line of the evolution of the giraffes, but it may be taken as a true indication whence these remarkable ruminants were evolved. The specimens examined indicate that the families Camelopardalidæ and Sivatheridæ should be amalgamated.

The details on which these conclusions are founded, will be published hereafter in the "Palæontologia Indica."

[1] pp. 128, 130.

[2] Dr. Falconer, in a letter to the late M. de Blainville, dated 4th October 1847, referred to the probability of there being two species, both of Siwalik hyænas and tigers. (See "Pal. Mem.," Vol. I, "Corrigenda and Addenda.")

HELLADOTHERIUM.

In figure 1 of plate A of the unpublished plates of the "Fauna Antiqua Sivalensis,"[1] the skull of a large hornless ruminant from the Siwaliks is represented under the name of the female of *Sivatherium giganteum.*

In describing the skull of *Helladotherium duvernoyi* from Attica, M. Gaudry writes in reference to a cast of the above skull,[2] "le crâne a la même taille que celui de l'*Helladotherium*, et la ressemblance générale est frappante; a la vérité, ses prémolaires sont un peu plus grandes comparativement aux arrière-molaires, sa face palatine s'avance moins, ses condyles occipitaux ne sont pas aussi forts, la face postérieure n'a pas de chaque côte de la crête occipitale un enfoncement profond. Mais, si on tient compte des variations qu'un animal a pu subir en passant de l'Europe dans l'Inde, on sera sans doute disposé à rapporter le crâne dont je parle à l'espèce de Grèce. M. Falconer, qui a examiné nos fossiles, penche vers cette opinion."

I have not hitherto admitted *Helladotherium* into the Siwalik fauna, but a careful comparison of the cast of the above-mentioned skull with M. Gaudry's figure of the skull of *Helladotherium* leaves no doubt in my mind that the two skulls belong, at all events, to the same genus. The question, of course, suggests itself as to whether *Helladotherium* can be the female of *Sivatherium*, but this is negatived by the greater length of limb of the former animal.

The original assignation of the skull in question to the female of *Sivatherium* seems only to have been a guess, founded upon the similarity of the teeth, as the skull really presents no marked resemblance to that of the latter genus. Judging from the analogy of the giraffe,—the nearest living ally of these fossil animals,—it would be more probable that when horns were developed at all, they were present in both sexes.

It is somewhat remarkable that the late Dr. Murie, in his memoir of *Sivatherium,*[3] makes no mention of M. Gaudry's reference of the so-called female of that genus to *Helladotherium.*

I think the Indian species must be provisionally known as *H. duvernoyi*, as its skull seems to present no sufficient points of distinction from the Attic form.

HIPPOPOTAMUS IRAVATICUS (Falc. and Caut.)

In the "Fauna Antiqua Sivalensis," according to the lettering of the plates, and their posthumous description, all the remains of hippopotamus from the sub-Himalayan Siwaliks are referred to *H. sivalensis*. Two fragments of the symphysis of a six-toothed mandible are, however, represented in figures 10 and 11 of plate LVII of that work under the name of *H. iravaticus*, and came from Ava. No other specimens are figured under the same name;[4] and as no description is given, the grounds on which Dr. Falconer specifically distinguished these speci-

[1] Autotype copies of these plates can be obtained at the British Museum.

[2] "Animaux Fossiles et Géologie de l'Attique," p. 260.

[3] "Geological Magazine", Vol. viii, p. 438. M. Gaudry's work was published in 1862, and Dr. Murie's memoir in 1871.

[4] Except a radius in plate lxxxiii, fig. 12.

mens are unknown. The Ava specimens seem, however, to be of smaller size than the others.

In the Indian Museum there is the lower end of the left radius of a very small hippopotamus from Ava, described by Dr. Falconer in his catalogue of the Siwalik collection of the Asiatic Society of Bengal (No. A. 303)[1] as belonging to his *H. iravaticus*, stated to correspond very closely with the specimen represent ed in plate LXV, figure 18, of the "Fauna Antiqua Sivalensis" (as *H. sivalensis*). In the same catalogue another bone (No. A. 307) is described as belonging to *H. iravaticus* in the following words: "Lower end of left femur, showing the articulating condyles and a part of the shaft, both much weathered and the surface abraded, so as to render the character[s] indistinct. The bone is proportionately of much smaller size than *Hippopotamus sivalensis*, and would thus agree with the dimensions of the radius, No. 303, and with specimens assigned to *Hippopotamus iravaticus* in the "Fauna Antiq. Sival."[2]

This is all that is known regarding the species, from which we gather that its remains were obtained from Ava, that it was 'hexaprotodont,' and that it was of much smaller dimensions than *H. sivalensis*, which equalled in this respect the large African species.

During a recent visit to England, Mr. W. Davies, of the British Museum, showed me several limb-bones of a very small but adult hippopotamus from the Siwaliks, which we considered must probably belong to *H. iravaticus*.

In recently cataloguing the remains of Siwalik hippopotamus in the Indian Museum, a left ramus of the mandible (No. B. 395) has from its small dimensions appeared to me very probably to belong to Falconer's *H. iravaticus*. The following are the dimensions of this specimen compared with those of the jaw of *H. sivalensis*.

	H. iravaticus.	H. sivalensis.
Depth of jaw at 2nd true molar	4·2	4·4
Length " five last teeth	7·7	8·5
" " first true molar	1·21	1·5
Width " " " "	0·95	1·3
Length " 2nd " "	1·68	1·9
Width " " " "	1·22	1·55
Length " 3rd " "	2·2	2·82
Width " " " "	1·3	1·6

These dimensions show that while the depths of the two jaws are practically the same, there is a great difference in the size of the teeth : the hinder border of the symphysis is also placed farther forward in the smaller jaw. The pattern of the grinding surfaces of the molars in all species of hippopotamus is so similar that no grounds of distinction can be drawn from their teeth.

Although distinctions merely on the ground of differences of size require to be received with extreme caution, yet the proportions observed in the jaw before

[1] See "Pal. Mem.," Vol. I, p. 142.

[2] The instance of the small radius figured in plate LXV, fig. 18, leaves it doubtful whether this statement applies to the mandibles figured as *H. iravaticus*, or to limb-bones figured as *H. sivalensis*.

us, as compared with those of the jaw of *H. sivalensis*, seem to point to the correctness of Dr. Falconer's conclusions as to the existence of a second smaller species of Siwalik hippopotamus.

MAMMALIAN FOSSILS FROM THE JAMNA ALLUVIUM.

Mr. J Cockburn, of the Opium department, has recently presented to the Indian Museum a small series of mammalian bones, collected by him in the older pleistocene alluvium of the Jamna and its tributaries, in the Bánda district. These remains are in most cases thoroughly mineralised, like the Narbada fossils. They are, however, with a few exceptions, in a very fragmentary condition, so that their specific determination is impossible. They may be referred to the following seven genera, *viz.*, *Elephas*, *Bos or Bubalus*, *Portax*, *Antilope*, *Rhinoceros*, *Equus and Felis.*

The antelope seems to be identical with the black-buck, *A. cervicapra.* The rhinoceros cannot be specifically determined, but as it was furnished with lower incisors, it cannot have been *R. deccanensis* of the Krishna valley pleistocene: it may have been *R. indicus.* The species of *Felis*, a genus, like the last, hitherto unknown from these deposits, is represented by a nearly perfect specimen of the right scapho-lunar bone, which is of slightly larger size than the corresponding bone of a full-sized Bengal tiger. Beyond this slight difference in size, the two bones do not present any appreciable points of distinction, and may have very probably belonged to the same species. It would, however, be rash on this scanty evidence to say that the pleistocene tiger was certainly the same as the living species.

With the remains of a small, specifically indeterminable, horse was associated a small chipped agate flake, and other similar flakes were obtained in the same deposits.

It is unfortunate that none of the mammalian bones can be more accurately determined, so that they might be identified with Narbada species found elsewhere in these deposits; but it is almost certain that they belong to the same epoch, and thus afford another instance of the association of the works of men with pleistocene mammals.

The list of mammals recorded from the older Jamna alluvium is now as follows:—

Semnopithocus, sp.
Euelephas namadicus (F. and C.)
Felis, sp.
Mus., sp.
Rhinoceros, sp.
Equus, sp.
Hippopotamus palæindicus (F. and C.)
Sus, sp.
Bubalus palæindicus, (F. and C.)
? Bos, sp.
Portax, sp.
Antilope cervicapra (Pal.)

The Geology of Dalhousie, *North-West-Himalaya,—By Colonel* C. A. McMahon, F. G. S. (*with a map*).

In beauty of scenery, Dalhousie will bear favourable comparison with any other hill station in the Himalayas north of Darjiling. Richly wooded with oak, rhododendron, and the spruce and silver firs (*Abies smithiana* and *Picea webbiana*), an occasional deodar cedar, horse chestnut, or other deciduous tree, give variety to the foliage; whilst boldly jutting crags of gneiss and granite impart an element of wildness to the scene.

The view on all sides is almost equally good. Towards the plains, the clays and conglomerates of the Siwalik series, bright red in the glancing sun, may be seen rising in fantastic pinnacles next the Náhan sandstones; and then fading away in soft undulations, the warm green of the *Pinus longifolia*, with which they are clad, blending into the deep blue of the distant horizon, where the rivers Rávi, Chaki, and Biás, glow like streaks of molten silver in the glory of the setting sun. On a clear day, after heavy rain, the Chináb may also be seen in the far distance.

Towards the north one looks down upon a perfect labyrinth of mountains, whilst snowy peaks, 21,000 feet high, shut in the view.

The Dhulár Dhár (Dhauladhár) range ends somewhat abruptly at Dalhousie, where it attains an elevation of 9,103 feet above the sea. On the east, north, and west of Dainkund, the river Rávi flows, in its course to the plains, at an elevation of 3,033 feet at Chamba, and of about 2,260 feet near Kairi. As the elevation of the district embraced in this paper ranges from 9,200 to 2,200 feet above the sea, it will be readily understood that the ground is difficult to traverse; and that it would have been impossible for me, with the limited time at my disposal, to have followed throughout its entire length the line of out-crop of each of the rock series described. I have done so, however, to some extent, and have made, map in hand, so many traverses at right angles to the strike, that the accompanying map may be relied on. Until we have a more accurate map to work with, it would be mere waste of time to attempt to mark the boundaries of the different series in closer detail than I have done.

As it forms no part of the object of this paper to describe the tertiary series, I have only roughly sketched in the boundary line between the Siwaliks and the Náhans. I note, however, in passing that the Siwalik conglomerates contain numerous pebbles and boulders of the granitoid gneiss of the Dhulárdhár and of the trap, about to be described, from which it is clear that both these series were exposed when the Siwaliks were laid down.

The Volcanic Series.

A considerable thickness of trap is found in abrupt contact with the rocks of tertiary age all along the line. The trap is of compact texture and of greenish-gray colour on its fractured surface, with occasional purplish patches in it. It usually weathers from a light brown to a rusty brown colour; but sometimes it varies from sage green to a purplish neutral tint. The sage green variety scarcely weathers at all.

Amygdules abound near the upper and lower boundaries of the rock, and are occasionally to be seen in the more central portions. There are four varieties of these amygdules,—white and red, and white centres with red borders, and green centres with red borders. The two first mentioned are the most common. The amygdules are of moderate size. The rock gives no surface indication of bedding.

At page 607 of the Manual of the Geology of India, it was suggested that the trappean rocks of the Lower Himalayas[1] are of post-nummulitic age; the fact that the trap rarely penetrates the tertiary rocks is noted, and the question is asked, "Can the explanation of this apparent anomaly be that the origin of this intrusive rock is rather innate than hypogene?" The rocks to which these remarks would be applicable must, I consider, be different from those now under consideration.

Very similar rocks occur in Kashmir, and from Mr. Lydekker's description of them,[2]—from the few specimens sent me for microscopic examination,[3] and from their mode of occurrence,—I think they represent the traps under consideration. At first Mr. Lydekker seemed disposed to consider the Kashmir traps to be of metamorphic origin,[4] but he gradually came to the conclusion that they are "truly eruptive rocks.[5]"

A microscopical examination of thin slices of the traps described in this paper has quite satisfied me that they are more or less altered lavas. I reserve the further discussion of this branch of the subject for a subsequent paper which I propose to devote to microscopic petrology.

In the Dalhousie area these ancient lavas attain their greatest thickness between Nagali and Kande (Kandao), and the ridge running thence in a northward direction down to the Rávi is composed of them. Beyond the river the band narrows, and beyond Kairi bends sharply round to the west. The last I saw of them in that direction was in the bed of the river which flows into the Rávi at Kairi, and forms the boundary between the Kashmir and Chamba states. I have not had an opportunity of exploring the country over the Kashmir border. The climbing along the bed of this river at the point indicated is very difficult, and I do not recommend it to any one who is not a good cragsman. In its southerly extension, the trap widens somewhat at the elbow-like bend between Lahled (Lalaid) and Chambi, and from thence it gradually narrows until it becomes very thin at the toll-bar gate below the Mámul travellers' bungalow. It is here much crushed and rotten, and is partly buried under talus. It is seen in good condition further down, between Butoli (Patoli) and Auhar (Aur), and the stream running down from Mámul to the Chaki, follows its course for a considerable distance.

The boundary between the trap and the Náhan beds is probably a faulted one. The strata of the Náhan sandstones are often obscured by vegetation, but whenever I have had an opportunity of observing the dip *near* the point of contact, it has been perpendicular or nearly so.

[1] *i.e.*, the lower mountains including and east of the Simla region.
[2] Records, Vols. IX, XI, and XIV. [3] Records, XI, 36. [4] Records, IX, 160.
[5] Records, XIV, 23.

In the Chuári (Chaohari) section, the trap is in contact with the conglomerates of the Siwalik series, the Náhans having probably been cut off by the fault.

The age of the trap will best be considered in connection with the next series.

The Carboniferous Limestone Series.

The rock immediately in contact with the trap along its eastern boundary is a quartzite, for the most part of white colour, as trans-Rávi near Kairi. There follows a thick series of shales and limestones, until the gneiss, which bounds this series on the east, is reached. Next the gneiss the rocks consist of a dark micaceous slate something between a shale and a schist, which disintegrates into a black "crush rock," exactly similar to the "crush rock" of the Simla area. A good and an extensive example of this rock may be seen on the descent from Dalhousie to Sherpur (Sairpur). It is here, especially when wet, almost coal black. This dark slaty rock is not confined to the eastern boundary of the series. I have also seen it at or near the western boundary, as in the river bed trans-Rávi, north of Kairi.

Occasionally limestone is seen within a few yards of the gneiss, and apparently in actual contact with it. An instance of this may be seen in the Chuári section, where the limestone, which is as usual of dark blue colour, is subcrystalline and contains cubes of iron pyrites.

One of the best sections of the limestone series is, I think, to be obtained on the descent from Dalhousie to Sandára. The gneiss is left a little to the east of Dhalóg; then succeed the dark carbonaceous slates, which exhibit a hypometamorphism in the shape of micaceous glazing. Between this and the quartzite in contact with the trap, I counted four strong outcrops of dark-blue limestone, intercalated with blue slates. The limestone is in bands of from 200 to 250 feet broad, and in beds that rarely exceed 2 inches in thickness.

Along this section the dip of the gneiss varied from about E 11° S to SE, and the micaceous dark rocks from SSE to SE 11° E. The blue slates dipped first high W, then perpendicular, and finally returned to an E or E 11° S dip.

The limestone series, as a whole, dips into the gneiss all along the line.

I think the carbonaceous slaty rocks above described, which disintegrate under the action of water into black "cush rock," are identical with the "*infra*-Krol" slates of the Simla region, which, even in that area, contain "lenticular layers of limestone.[1]"

The series under consideration corresponds, I think, completely with the description of the Kiol group given by Mr. Lydekker.[2] At the bottom of that group there is a purple or white quartzite, and then follow black shales containing thin "bands of brittle coal," followed by dark-blue earthy limestone.

Mr. Lydekker at one time thought the Kiol, which he correlated with the Krol group, to be of carboniferous age,[3] but subsequently he concluded that both the Krol and the Kiol are "representatives of carboniferous and trias.[4] He noted that "some of the shales of the Kiol are much like those of the *infra*-Krol,[5]" and considered that the latter are probably of carboniferous age.[6]

[1] Memoirs, III, 29.
[2] Records, IX, 160.
[3] Records, XI, 43, 62; XIII, 56.
[4] Records, XIII, 56; XIV, 40.
[5] Records, XIII, 56.
[6] Records, XIII, 56.

In Kashmir, rocks of carboniferous age appear to pass by imperceptible degrees into those of the Trias;[1] but in the absence of fossils, from the fact that the black carbonaceous slates similar to those of the "*infra*-Krol" occur at both margins of the series, I see no reason to suppose that we have at Dalhousie representatives of more than the carboniferous series.

As the quartzite only occurs at one margin, namely, next the trap, and is never associated, in this area, with the black slates next the gneiss, there seems to be no room for the supposition that we have here a crushed anticlinal flexure and that the black slates are repeated.

I observe that in the description of the Kiol series, given at page 160, Vol. IX, Records, a black shale is said to occur next the quartzite at the bottom of the series (*b*), and a black slate (*d*), without an accompanying quartzite, at the top. In this respect, also, there seems to be a complete correspondence between the Dalhousie and the Kiol series.

In some minor points the limestone series of Dalhousie corresponds with the *infra*-Krol and Krol groups. Sometimes pale-blue to bluish-white wafery shales occur in the series, the iron in which oxydizes on exposure to various shades of red, yellow, and brown, which colours, combined with the natural blue and white of the shales, perhaps represent Mr. Lydekker's "polychroic slates" of Kashmir.[2] Some of these biscuity shales remind me of the "*infra*-Krol" shales to be seen at Solan[3] and between the Chor mountain and the Giri.

In the Chuári section purple-red shales occur, which closely resemble those of the Chor mountain. They probably have their origin in volcanic dust deposited in water.

In many localities the limestones present a banded appearance, owing to slaty layers of varying thickness being intercalated with the thin beds of limestone; and as the latter usually yields to weathering more readily than the slaty layers, a ribbed appearance is produced. In the river bed, trans-Rávi, these slaty layers are lenticular and fragmentary, and produce a curious graphic appearance. I think it is to small fragments of this mud enclosed in the limestone that the pseudo-fossiliferous appearance, sometimes observed, is produced. I have observed enclosures in some of the Dalhousie limestones, which reminded me of the Kakarhatti rock.

I now pass on to consider the age of the trap and its relations to the limestone series, which I have given reasons for believing to be of carboniferous age.

At page 160, Vol. IX, Records, Mr. Lydekker describes the amygdaloids as overlying the Kiol series, which, we have seen, he considers to be of carbo-triassic age; but the series is represented as inverted. In Vol. XI, page 35, the amygdaloids of the Sind valley and Pir Punjál range are described as being of *infra*-carboniferous age; and at pages 40 and 49, they are classed as the "highest silurians." In Mr. Lydekker's last published paper[4] he gives many instances of the occurrence of the traps at the base of the carboniferous series (as, for instance, at pages 22, 24, 25, 26, and 28), but the following conclusion is arrived at:— "Assuming an eruptive origin for the traps of Kashmir, it would appear that

[1] Records, XIV, 34. [2] Records, XIII, 62. [3] Memoirs, III, 28. [4] Records, XIV, 1.

during the silurian period very considerable outflows of sub-marine trap were emitted, which were naturally of limited extent; that these outflows probably took place in several localities and at several distinct intervals of time. During the whole period of these eruptions continuous deposition of stratified material was taking place, the strata resulting from which became intimately mixed up and amalgamated with the trap, so that it is now extremely difficult, or impossible, to distinguish the different factors of the strata. In certain localities, as at Manisbal, the outflows of trap must have continued to take place during a part, or the whole, of the carboniferous period, and have rendered the rocks of that period also difficult of recognition."

The lava flow of Dalhousie must, from its position, either be of upper silurian or of upper or post-carboniferous age, and it is important to decide to which it belongs.

I think there are more grounds for believing that the traps of the Dalhousie area are of pre-carboniferous than of post-carboniferous age. There are difficulties in the way of believing that an overflow of lava in the Kashmir, Dalhousie, and Mandi areas lasted from middle or upper silurian times to the end of the carboniferous period. It would be remarkable if these ancient volcanoes continued to pour out, through so extended a period, one kind of lava only; and all that I yet know about these amygdaloidal traps leads me to believe them to be very homogeneous in their character. Moreover, if the lava flow lasted from the silurian to the close of the carboniferous period, one would expect to find substantial bands of trap included in that very thick series of limestones that pass by insensible degrees from the carboniferous into the trias, and the more so if the traps were, as suggested by Mr. Lydekker, of sub-marine origin, seeing that the limestones, in some instances at any rate, must have been laid down at no great distance from these ancient volcanoes. I am not aware, however, of any considerable lava flows having been interposed between the carboniferous and the triassic series in the lower Himalayan region.

The altered condition of the Dalhousie traps to a certain extent favours the theory of their being of great age; whilst the fact that the boulders of the trap buried in the Siwalik conglomerates exhibit the same phase of alteration as their parent rock negatives the idea of the alteration being the result of tangential pressure in tertiary times. A more important fact is that they occur below the quartzite band, which is the bottom rock of the Kiol group in Káshmír and of the Krol series in the Simla area.

An apparent difficulty occurs in the correlation of the Kiol to the Krol, from the fact that, in the Simla area, the black *infra*-Krol shales occur below the horizon of the Krol quartzite, whilst at Dalhousie and at Kiol the black slates occur above a quartzite. But I think this difficulty is apparent rather than real. The quartzites may not have been perfectly synchronous in both areas, for one thing; and for another, it is clear from the examination of the Dalhousie series and the recorded description of the Kiol rocks, that the period during which the carbonaceous element was deposited was a very extended one, for black slates are found at the top and bottom of the series; and therefore it seems not improbable that the formation of the carbonaceous material in the Simla region, set in and died out earlier in the carboniferous age than in the Dalhousie and Kiol regions.

If the above conclusions are sound, it follows that from the trap to the top of the limestone series we have a normal sequence of rocks, the carboniferous series resting conformably on the upper silurian or pre-carboniferous trap—both being faulted against the gneiss.

I can see nothing to countenance the idea that the metamorphism of the gneiss, about to be described, is due to the development of heat caused by the compression of strata in which the carboniferous limestone series was involved. Had heat sufficient for the transformation of sedimentary strata into a uniform bed of gneiss, 500 feet in thickness, been developed, I think the dark blue limestone within a few yards of the gneiss would have been much more changed than we find it is.

The junction of the limestone series with the gneiss must, it seems to me, be due either to faulting or to inversion. Something might be said in favour of the inversion hypothesis—it is the theory that naturally suggests itself at first, and when I began to explore the Dalhousie region I adopted it for a time. On the new cart road, a couple of miles on the Dalhousie side of the Duniára road-bungalow, the dark slates may be seen dipping under the gneiss, apparently conformably; and you may stand on the edge of the gneiss, on the ridge about 3 miles north of the Duniára bungalow, and note the black slates far below, at the opposite side of the khad or valley, cropping out about half a mile east of a line drawn north and south through the spot on which you are standing.

A section like this naturally suggests the idea of inversion, but I found this theory would not harmonize with the rest of my facts. If the inversion hypothesis were adopted, it would make the trap to be of post-carboniferous age, and it would put the white quartzite at the top, instead of in its proper place, at the bottom, of the limestone series.

In other ways I found it impossible to work the inversion hypothesis. For instance, one would have to account for the disappearance of all the rocks between the carboniferous series and the gneiss; and one could hardly suppose that extensive and deep erosion sufficient to have caused this would have stopped precisely at the gneiss all along the line—invariably removing everything above the gneiss, yet never cutting into or through it. For these and other reasons, I had to drop the inversion theory and adopt the hypothesis of faulting, against which I know of no serious objection.

If we suppose (and it seems a reasonable supposition) that the disturbances which caused the faults were prior to those which threw the strata into the synclinal and anticlinal flexures we now see, or that the compression of the rocks continued after the rupture of the faults, I can comprehend how a reverse fault with so great a throw was formed. This supposition may account for the curves observable in the trend of the fault; but if, as is suggested further on, a highly compressed anticlinal fold is situated in the gneiss of Dainkund, there will be less difficulty in understanding how the torsion observed in the strike of the gneiss was produced. The sharp minor curves in the boundary-line marked on the map are due to the fact that where the north-easterly dip of the carboniferous series and the gneiss are moderate, the line of outcrop in the deep, narrow valleys occurs further to the east than on the crests of the high steep ridges that run down from Dainkund.

The Silurian and Cambrian (?) Series.

The rock in contact with the carboniferous series, along its eastern boundary throughout the Dalhousie region, is gneiss. It is foliated and never granitoid. The gneiss is composed of quartz, orthoclase and biotite. I have noticed no muscovite or schorl in it, and at times its crystallization is imperfect. The gneiss forms a continuous band, and does not vary much in thickness, which is usually from 400 to 500 feet. From the ridge above Banatu (trans-Rávi), where it is seen stretching away in the direction of Mandoh (Maroh), its thickness remains steady, and it is well seen on the new cart-road south of Duniára, and on the ridge between Buliára and Kailu. It then thins considerably, and the outcrop on the bridle road north-east of Tula might easily be overlooked. On the eastern side of this ridge, however, it crops out in a prominent way on the old and now abandoned road running up to Naina Khad (Nina Kad). It is seen well at Hubár (Ubaur) and at Chuári, where it has regained its normal thickness.

Next the gneiss, comes a rather thick band of decided mica schists. It is thickest on the south bank of the Rávi, extending from the gneiss to near the stream east of Seru (Sairu). This mica schist shades rather rapidly into a series of slates and very fine-grained earthy sandstones, terminating next the granitoid gneiss in slates, which I believe represent the "Simla slates."

An instructive and convenient section is that from the Therah Mall at Dalhousie along the cart-road to Banikhet (Banketra), and thence along the road to Dhalóg. I collected a series of hand specimens along this road for macroscopical and microscopical examination, and the series consist of the following, beginning with the rocks next the granitoid gneiss:—

1. A fine-grained quartz schist, with very minute prisms of hornblende disseminated through it.
2. A fine-grained quartz schist, containing minute prisms of hornblende and microscopic flakes of mica.
3. A very fine-grained earthy sandstone, somewhat schistose in aspect; a few grains of mica are to be seen in it here and there.
4. A very fine-grained earthy sandstone—very earthy looking.
5. A very fine-grained earthy sandstone—extremely earthy looking. A few minute prisms of hornblende are to be seen in it under the microscope.
6. A similar rock, but less earthy looking.
7. A fine-grained micaceous schist. Microscopic grains of a greenish-white mica, and few minute crystals of hornblende disseminated through it.
8. A fine-grained slaty rock.
9. A fine-grained earthy sandstone.
10. A fine-grained slaty rock.

11. A slate with a slight micaceous glaze.
12. A soft flaky shale, with a slight micaceous glaze.
13. An ordinary slate of pale-blue colour.
14. An ordinary slate of darker colour.
15. An ordinary slate of pale-bluish grey.
16. Soft splintery shales of pale-bluish colour.
17. A similar rock, but more indurated.
18. A white wafery shale.
19. A whitish-grey slaty rock, with flakes of white mica here and there.
20. A grey silicious schist.
21. A mica schist– lenticular granules of quartz being coated with silky white micaceous material.
22. The decided mica schists of Banikhet. There are some hundreds of feet of this rock and then follows—
23. Four hundred or five hundred feet of gneiss.

In other sections (as, for instance, at Chuári) clay slates take the place of the fine-grained earthy sandstones. Within a few miles of Dalhousie itself, on the road to Bakloh, good slates are quarried quite close to the granitoid gneiss.

Everywhere the beds immediately in contact with the "granitoid gneiss," for a distance that varies in different sections, exhibit more or less hypometamorphism.

Along a section taken in a westerly direction from Dalhousie the average dip of the silurian beds is NE; but it varies locally from NE 11° N to NE 11° E. As a whole, the series dips into the granitoid gneiss all along the line, and, judging superficially from appearances, one would say that it dipped under the gneiss.

Mr. Medlicott, in vol. III, p. 65, Memoirs, describes the rocks next the granitoid gneiss at Dalhousie as follows:—"For about 50 feet from the granite, the schists exhibit a very marked increase in induration, acquiring a close-grained crystalloid texture. Near the contact, irregular small veins of the granitoid rock are included in this hard contact rock; yet the junction with the main mass is perfectly sharp, indicating no approach to an amalgamation of their ingredients." And in the page first quoted, he wrote: "In the descending section to the west of Dalhousie, the schistose characters become again more and more developed; at Banketra we find decided mica schists."

I think we have here the clue to the interpretation of this section. Broadly speaking, we have slates next the granitoid gneiss, and then silicious and slaty rocks passing into decided mica schists, resting on a broad band of gneiss, from 400 to 500 feet thick. In other words, we have a descending series, beginning with the representatives of the "Simla slates" and passing into the lower silurians[1];—this descending series resting on gneiss on the one side, and faulted against gneiss on the other.

Mention is made in the *Manual of the Geology of India*,[2] on the authority

[1] In my paper on the Chamba and Dalhousie section (Records XIV, p. 308), I have stated the grounds which exist for holding the Simla slates to be middle, and the beds below them lower silurians.

[2] Page 633.

of Dr. Stoliczka's observations in Ladak, of a "newer gneiss" of syenitic mineral character. I do not think that the second band of gneiss described in these pages represents the newer gneiss. In the first place it is not syenitic, and in the second place I think there are difficulties in the way of believing that we have one series of rocks from the granitoid gneiss of Dainkund to the band of foliated gneiss to the west of it. Were this supposition to be adopted, the granitoid gneiss would of course come in near the bottom of the series, whilst the "newer gneiss" would form the top, the whole being inverted.

This view would require a concealed anticlinal flexure in the granitoid gneiss of Dainkund—a fold so compressed as to produce conformity of dip on both sides of the anticline. I have kept the possibility of this being the case before me, but have not, as yet, discovered any evidence to support the hypothesis. I met with no trace of a newer gneiss between the gneiss of Dainkund and that of Pángi, though in this long synclinal flexure rocks from the "carbo-triassic" to the 'central gneiss' are exposed.

Again, on the supposition that the granitoid gneiss of Dainkund is "older" than the band of gneiss to the west of it, we should have to explain the total absence of the lower silurian beds between the "Simla slates" and the older gneiss; and the very remarkable phenomena would be presented to us of highly metamorphosed rocks at the top and bottom of the series with very slightly metamorphosed rocks in the middle.

The study of Himalayan rocks has led me to the conviction that the only way out of the labyrinth is to keep in view the principle that, as a general rule, the extent of metamorphism affords an indication of the relative age of ancient rocks. Undoubtedly there are numerous exceptions to this general rule. "Selective metamorphism" is a powerful factor, and its operations must ever be kept in mind. The right interpretation of the facts observed in Himalayan geology is surrounded by many difficulties, inasmuch as every possible kind of metamorphism is rampant in this region; but still, I think, the principle advocated above is the one that will, if followed, lead to the fewest mistakes.

Having arrived at this conviction by independent study, I was interested to find it fortified by Dr. Callaway's remarks in his recent paper in the *Geological Magazine* on "How to work in the Archæan rocks." He writes[1]:—

"In studying the lithology of a formation, its *degree of metamorphism* is an important factor in the evidence. Sufficient material has not been collected to form the basis of a theory; but, so far at least as England and Wales are concerned, the researches of the last few years lend some support to the opinion that regional metamorphism is found only in Archæan rocks, and that the degree of alteration is proportional to the antiquity of the group."

* * * * * * * *

"There would also appear to be no *a priori* reason why regional metamorphism should not also occur in rocks of any age; and in the above remarks it is only contended that there are some grounds for constructing an empirical rule applicable only, so far as present observations go, to a certain area."

[1] *Geological Magazine*, Vol. VIII. (1881), pp. 423, 425.

Professor Bonney's observations in Vol. VII of the *Geological Magazine*, page 542, are also pertinent. He writes :—

"With our present knowledge, extreme caution is doubtless required in drawing an inference as to the age of a rock from its stage of metamorphism. At the same time all the evidence which we possess points to the conclusion that extensive regional metamorphism has only taken place in rocks of great geological age, and that the current statements about highly altered secondary and even tertiary rocks in the Alps are in many cases entirely erroneous and in all need confirmation. Thus, in the case of the Alpine schists, which as a rule are more highly altered than any rock in Britain known to be of Cambrian or post-Cambrian age, I should agree with some of the more modern continental geologists in regarding them as very old and possibly pre-Cambrian."

Holding the views expressed above, I think it improbable that we have presented to us here a normal sequence of beds beginning with a rock of perfect granitic structure, followed by clay slates and other little altered rocks and ending with decided mica schists and gneiss as its top beds. I think the more probable and reasonable explanation is that a descending series of rocks from the slates to the gneiss has been faulted against the granitoid gneiss.

The supposition that the two beds of gneiss form the sides of an anticlinal flexure, seems inadmissible on similar grounds; for in this case the slates and other slightly altered beds would have to be put below the perfectly metamorphosed granitoid gneiss.

The hypothesis that the two beds of gneiss form a synclinal flexure, seems to me to be objectionable; for in this case the rocks next the gneiss on both wings of the flexure ought to be similar, whereas they are unlike each other. I am ready to admit the possibility of an anticlinal fold having taken place, in which case the western outcrop of gneiss would form the western wing of the corresponding syncline; but if this hypothesis were to be adopted, we should have to suppose that the inverted wing of the syncline had been squeezed out of the section. It does not seem necessary to call in the aid of a very complicated fault of this nature; a simple step-fault will, I think, in some respects best explain the section.

The fault hypothesis is the only one that, in my opinion, satisfactorily explains the facts. We have, I think, a repetition of what we have found reason to believe took place in the case of the carboniferous series, namely, a normal sequence of rocks faulted against the gneiss.

And if we accept the existence of these great faults immediately over a region of ancient volcanic activity, evidenced even in our own day by an occasional earthquake and by the presence of numerous hot springs in the trap and gneiss areas, may we not explain the hypometamorphism of the silurian and carboniferous slates along these lines of fault, by the action of superheated steam and water and acid vapours finding access to them along these fissures for some time after the faulting had taken place? No microscopist who has studied the metamorphism of igneous rocks can doubt the power of heated water or steam to effect gradual changes in the rocks subjected to their action; and the fact that the hypometamorphism of the silurian and carboniferous rocks, as a rule, runs with lines which, on other grounds, I have seen reason to believe to be lines of fault, strongly favours the supposition that the hypometamorphism described is due to these agencies. It would be a curious coincidence, indeed, if tangential pressure produced metamorphism along these lines and left the intermediate rocks untouched.

The "Central Gneiss."

Between Dalhousie and Chamba the granitoid gneiss attains a thickness of 6½ miles. It retains this breadth in its south-easterly extension; but, in the opposite direction, it rapidly narrows as the river Rávi is approached. In the Memoirs of the Geological Survey,[1] it was noted that down the spur, running between Panjao and Chata towards the river, "the band contracts, and to all appearance, as seen from this place, it becomes extinct before reaching the Rávi, on the right bank of which there seems to be a continuous section of thin-bedded crumbling strata;" and the conclusion was drawn that the "central gneiss" had there "ended completely and abruptly.[2]"

The trans-Rávi section has now been explored for the first time, and I find that though the gneiss dwindles to a very thin band, it does not die out. Above the road, running from Júnd (Juind) to Bhale (Balai), the outcrop actually visible is not more than 100 feet in thickness. Where the outcrop crosses the river above Bhale, I measured 250 feet of it. In its north-westerly course the gneiss forms the crest of the high ridge above Sere (Serai). The last I saw of it was at Kandan Devi, where it leaves the crest of the ridge and strikes in the direction of Sapra (Sípra). Along this ridge it attains a width of about 500 feet. The outcrop looks thicker on the map because the N E dip of the gneiss coincides with the slope of the N E side of the ridge.

Speaking generally, the gneiss is an ordinary foliated gneiss along both margins of its outcrop, and here the bedding, which conforms to the normal dip and strike of the rock series associated with it, is quite distinct. The gneiss gradually passes into a granitoid rock, in which evidence of foliation may usually be traced; and, although joints are numerous, true bedding is often obliterated. The granitoid gneiss is highly porphyritic, and is undistinguishable from, and doubtless is identical with, the "central gneiss." Towards the centre of the mass the porphyritic appearance dies out, and along the ridge of Dainkund the rock passes into a fine-grained and perfect granite. There are transitional forms between this and the porphyritic granitoid gneiss; that is to say, we have here and there a more or less porphyritic rock which is perfectly granitic. On the road to Chil the matrix becomes so fine-grained in places that the rock assumes almost the outward aspect of a felspar porphyry.

Where the mass begins to narrow in its north-westerly direction, the rock at the same time gradually loses its granitoid character and passes into an ordinary foliated gneiss, in which porphyritic crystals are, generally speaking, sparse or wanting.

At times the porphyritic granite obliterates the foliated, stratified gneiss, even at the margins of its outcrop, and intrudes into the adjoining schists. Instances of intrusive veins at Dalhousie were described by Mr. Medlicott in the passage

[1] Memoirs, III, 64. [2] Manual, page 633.

already quoted from page 65 of his Memoir. I may mention another instance at Dalhousie, on the cart road near the Bulls Head hotel, where the granite is seen to cut through the beds in contact with it for 2 or 3 feet. How deep it goes, cannot be seen owing to the dense vegetation below the road.

Trans-Rávi, on the ridge north of Banatu, intrusive veins are also to be seen in the schists close to the gneiss, and here these veins are distinctly porphyritic, indicating that the intruded rock was squeezed into the schistose beds in a viscid and imperfectly fused condition. But it was in the Chuári section that I observed the most numerous instances of the intrusion of the schists by the porphyritic granite. Here the latter has been profusely squeezed between the beds of schists for a considerable distance from their junction with the crystalline rock, and in some instances the porphyritic granite has cut through them.

The mineralogical characters of the gneiss will be described more in detail in a subsequent paper on the microscopic petrology of Dalhousie; but I note in passing that, viewed microscopically, the rock is seen to contain orthoclose, quartz, biotite, and muscovite. In the granitic varieties, schorl, in minute or moderate-sized crystals, is pretty abundant. I have also noticed some small garnets, in which respect the rock also corresponds with the "central gneiss" of the Sutlej valley.

The rock varies very much in texture within short distances. Some of it breaks without much difficulty, and then the workman passes suddenly to an indurated mass that defies the power of the hammer. The weathering of the rock, also, is often peculiar. Judging from superficial appearances on road sides, one might readily imagine that intrusive dykes were frequent, and that they had caught up boulders and blocks of gneiss in their passage. Dykes I believe there are, but the appearances I allude to are, I think, due to weathering and arise from variations in the texture of the rock.

Having described the general stratigraphical and lithological characters of the "central gneiss," I pass on to consider the causes of the great changes observable in its texture and structure. I allude principally to its passage from an ordinary foliated gneiss through a somewhat coarse-grained porphyritic rock (in which the porphyritic crystals of felspar attain a length of 3½ inches) into a fine-grained non-porphyritic granite.

It has been somewhat fashionable in the geological world of late years to attribute the metamorphism of mountain regions to the heat developed by the compression of strata which accompanies mountain formation. That metamorphism, to a certain extent at any rate, is produced in this way I do not doubt, and to this cause may possibly be due (though I have suggested another explanation in the preceding pages) the hypometamorphism of some of the silurian and carboniferous beds; but I do not see sufficient grounds for believing that the perfect metamorphism of the rocks now under consideration can be attributed to this cause.

If you bend a stick across your knee with sufficient force, it will break along the axis of greatest strain, which will be over the region of the knee. Now, a glance at the map will show that, where the Rávi and Siul rivers cut across them, the gneiss bands, with the included silurians, have been bent, as you would bend a stick across your knee. The strain at this point must surely have been at its maximum, and yet the westerly band of gneiss preserves its normal thickness with a steady indifference to the Mallet theory, whilst the easterly band of gneiss narrows from 6½ miles to 250 feet!

But if it be objected that the differences observable in the degree of metamorphism is due rather to innate conditions—variations in the amount of water contained in the beds and the like—rather than to fluctuations in the intensity of the squeeze, I reply that there are difficulties in the way of explaining the metamorphism of the particular rocks before us—the granite, gneiss, mica schists and trap of the Dalhousie area—by this theory. The tangential pressure which caused the geosynclinal to assume the folds and contortions now to be seen in the Himalayas is generally believed to have been caused by disturbances in later tertiary times, but we have seen that the trap and granitoid gneiss existed as such when the Siwaliks were laid down, and Mr. Lydekker found granitoid gneiss boulders, which he believed to be identical with the central gneiss, in slates of the Pángi valley of presumably upper silurian age.

But a still more serious objection to the application of the Mallet theory to the facts before us occurs to me. It is usually noted in text books that crystallization is of coarser grain in the centre of igneous masses than at their sides, and the reason assigned is that these masses cooled more rapidly at the sides than in the centre. The following extracts are taken from recent papers by experienced observers. Professor Geikie in his memoir on the Carboniferous Volcanic Rocks of the Firth of Forth writes as follows of intrusive sheets and dykes[1]—"A diminution in the size of the crystalline constituents may be traced not only "at the base, but also at the top of a sheet, or at any intermediate portion which "has come in contact with a large mass of the surrounding rock."

Again Professor Heddle in his 5th Chapter on the Mineralogy of Scotland,[1] as the result of his extensive experience, states that in the case of the plugging of pre-existent rents with the same ingredients as the rock mass itself, the structure is *smaller* than that of the rock mass in the case of *contemporaneous* plugs; whilst in veins of *exfiltration* the structure is *larger* than that of the containing rock. These generalizations were, of course, made with special reference to the rocks of Scotland, but they are important and suggestive.

I presume that those who would attempt to explain the metamorphism of the "central gneiss" by the application of the tangential pressure theory would argue that those parts of the gneiss at Dalhousie which exhibit the most perfect granitic structure are those in which the greatest heat was developed. These places coincide, in the main, with the centre of the mass; and as the parts where the greatest heat was developed must have cooled the slowest, the crystals of which the resulting rock is composed ought, according to our present information on these subjects, to have been larger in the centre of the mass than towards the sides, whereas the reverse is the case.

A precisely similar objection to that taken above seems to me to stand in the way of the hypothesis that the extreme metamorphism of the central parts of the

[1] Transactions of the Royal Society of Edinburgh, Vol. XXIX, 475, and p. 1.

mass and the comparatively imperfect metamorphism of the margins, is due to the plutonic heat from below having been greater at some points than at others. The structure of those parts which received the greatest heat and cooled more slowly ought, in masses whose granitic structure shows that there was perfect freedom of molecular and crystallographic action, to have been of coarser grain than those portions which received less heat and consequently cooled more rapidly; but this is not the case.

The explanation that satisfies my mind the most is that the intense metamorphism of the "central gneiss" has been principally produced by granitic intrusion at a great depth below the surface; and that the perfectly granitic portion is the intrusive granite itself.

In Auvergne[1] we know that, in the case of the numerous volcanoes in the neighbourhood of Clermont Ferrand, the lava pierced through a stratum of granitic gneiss before it overflowed at the surface. I can see no reason why what took place near the surface in Auvergne may not have taken place, in other localities, at a greater depth below the surface. It is freely admitted by many leading geologists that an acid igneous rock consolidated at a great depth below the surface would form granite, for a perfect transition may be traced from granite, on the one hand, to acid lavas, on the other. "No one," writes Professor Judd at page 145 of his recent work on volcanoes, "who has carefully "studied the appearances presented by volcanic mountains in different stages "of dissection, by the action of denuding forces, can avoid recognising these "great granitic masses, as the cooled reservoirs from which volcanoes have in all "probability been supplied during earlier periods of the earth's history." And again, at page 256 he writes:—"A careful consideration of all the facts of the case "leads to the conclusion that when pumice, obsidian, and rhyolite are now being "ejected at the surface, the materials which form these substances are, at various "depths in the earth's interior, slowly consolidating in the form of quartz-felsite, "granite porphyry and granite."

Now, if we suppose that the Dalhousie gneiss was buried at great depth and was in consequence exposed to considerable heat when an acid igneous rock passed through it in its passage upwards, it seems to me that when they cooled down they might become so welded together as to render it impossible to say when the one began and the other ended. In the case supposed we should have, acting on the gneiss, not only the heat caused by contact with the intrusive igneous rock, and the plutonic heat of the earth itself, but the gneiss would probably be permeated by steam at high pressure or intensely heated water holding some of the mineral constituents of the igneous rock in solution. I can, therefore, readily imagine that under the conditions described a blending together of the granite and the gneiss would result, and that the latter would, for some distance from its contact with the granite, partake of its mineral character.

For this reason I do not think that the fact that I have not observed muscovite, schorl or garnets in the westerly band of gneiss proves that the latter does not really represent the more perfectly crystallized gneiss further east.

[1] See p. 361, "Scrope on Volcanoes" and his "Volcanoes, Central France," at large.

The westerly band is a comparatively imperfectly metamorphosed rock and had its metamorphism proceeded further, and had it been brought into closer contact with the rising granite, it would probably have developed all the minerals found in the granitoid gneiss. Even in some portions of the latter the muscovite, schorl and garnets are sparse or wanting.

One of the principal characteristics of the "central gneiss" of the Satlej and lower Spiti valleys, and elsewhere in the Himalayas, is that it is everywhere more or less riddled by intrusive dykes and veins of white oligoclase granite. Sometimes these veins and dykes are most profuse. I remember one spot in particular on the Para river, between Lari and Chango, near the border of Chinese Tibet, regarding which I made the following entry in my journal:—"Before starting 'I examined the rocks at Jangzam. Those up the river I found to be gneiss, "nearly obliterated by granite;" the partial obliteration having been caused by the number and close proximity to each other of the intrusive veins. The only difference in the two cases seems to me to be this, that in the area now described the granitic intrusion was probably more intense, the gneiss was more heated and rendered more plastic, and the two rocks were better blended together. The white oligoclase granite of the Satlej and Spiti areas possibly marks a somewhat later stage of the eruptions which effected the conversion of the gneiss into a granitoid rock.

Even in the Dalhousie area there is sometimes a sharp line of division observable between the fine-grained and the porphyritic granite. A good example of this is to be seen at the top of the Chuári pass.

I am not only disposed to hold that the fine-grained, non-porphyritic portions of the "central gneiss" seen at Dalhousie is as truly an "igneous" rock as any igneous rock can be; but I have been gradually forced into the conviction that portions, at any rate, of the porphyritic variety are to *some extent* intrusive.

In the case of a gneiss exposed to sufficient moist heat to allow of a certain freedom of molecular action, I can imagine the felspar "eyes" growing by the accretion of felspar molecules into more or less perfect crystals with well-developed faces and angles; but I think it would be difficult to account for the principal axes of these crystals pointing indifferently in all directions, as they do in the granitoid gneiss, without supposing that the plastic mass had been set in motion. The supposition that this peculiarity has been produced by motion is supported by other facts. In the Chuári section I noticed that, not only in the veins intruded into the schists, but also in the granitoid rock, the solid angles of what had apparently once been well-formed crystals of felspar were rounded off as if by abrasion; whilst there were numerous instances of other orthoclase crystals having been rolled up into masses, sections of which were about the size and shape of a crown piece. These seemed to me to be indications that after the orthoclase crystals had been formed, they had subsequently been subjected to great heat and pressure, and had been rolled along in a viscid stream containing numbers of similar crystals.

That porphyritic crystals have often been transported from one place to another after their formation has long been known to microscopists. The evident fragmentary condition of some porphyritic crystals in lavas is held to be evidence of this; whilst the liquid and other cavities they sometimes contain are also evidence in favour of the porphyritic crystals having been formed before they reached the surface.

I may mention, in connection with this subject, that, when I visited the crater of Vesuvius in 1878, I obtained some red-hot lava by pushing a stick into the flowing stream. This I cooled suddenly by pouring claret over it, water not being at hand; and I found, on having slices made for microscopic examination, that the lava contained numerous good-sized crystals of augite and leucite imbedded in the glassy base. Doubtless, the large crystals had been transported from hidden depths below the crater.

Another piece of evidence which goes to prove that much of the porphyritic granite of the Dalhousie area is (to a certain extent, at any rate) intrusive, is that fragments of schists are included in it. For some time I regarded these objects as concretionary in origin; but the conclusion was ultimately forced on me that they are true fragments of the adjoining schists, caught up by the granite in its passage through them. They are more numerous close to the schists than away from them; they closely resemble the schists in colour and material, and in the Chuári section, where the porphyritic granite has been squeezed into and between the schistose beds, fragments of schists may be seen caught in the act, so to speak, of being broken off.

Some of the included pieces—even those seen a long way from the junction of the granite and the schists—seemed to me of undoubted fragmentary origin. One, for instance, which I noticed in the Chuári section, was a long splinter 2 feet 4 inches long and 5½ inches wide at the thickest end. In its splintery ends it seemed to give clear evidence of having been torn from its parent rock. It stood out sharply from the granite, and it was fractured transversely in several places, the cracks not penetrating into the granite.

Whilst, however, I think there are many good reasons for believing that the extreme metamorphism of much of the "central gneiss" is due to granitic intrusion, and that intruded masses have been dovetailed into the gneiss, I do not think the sudden expansion of the gneiss from a width of 100 feet to nearly 7 miles is wholly due to the protrusion of viscid masses of an acid igneous rock into beds of pre-existing gneiss. Considering that the granitoid gneiss retains its great thickness in its south-easterly extension for so great a distance, its sudden attenuation north of the Rávi is remarkable. The silurian beds between the two outcrops of gneiss maintain much the same average thickness throughout; and, as I have seen reason to believe, on other grounds, that a fault occurs along the margin of the gneiss at its junction with the slates, it seems to me probable that the sudden attenuation of the gneiss towards the north-west may be due primarily to faulting.

Glaciation.

The spur on which the Mámul travellers' bungalow stands, near the military station of Bakloh, at an elevation of about 4,740 feet above the sea, puzzled me for some time. The crest of this ridge is principally composed of granitoid gneiss absolutely identical with that of Dainkund. The trap bounds it on the south, but it is completely surrounded on other sides by the limestones and slates of the carboniferous series. Further investigation showed that the crest of the opposite spur is also covered with large boulders of granitoid gneiss, resting on carboniferous rocks. After several careful examinations of the locality, I found that the facts could not be explained by intrusion or faulting, and I came to the conclusion that we can have here nothing else than the remains of an old moraine.

The supposition of a landslip seems inadmissible, for the deposit is on the very crest of a spur, and high ridges and peaks intervene between it and the granitoid gneiss of Dainkund.

The fragments of granitoid gneiss of which the crest of the Mámul ridge is principally composed, are of considerable size, being as much as 12 feet high by 12 feet long. They are evidently fragmentary, and some have apparently been more or less rounded before they fell into place. Sometimes the blocks are closely packed together, and look like rocks *in situ*. In other places the fragments are evidently embedded in earth. A small landslip near the tollbar exposed a good example of this. The granitoid gneiss, moreover, is not alone; fragments of schists and quartzites, of various sizes, up to 3 feet in diameter, are scattered in profusion over the surface, and are fixed into the hillside. They are all fragments of rocks found between Mámul and Dainkund. A roadside cutting at one place gives an instructive section. It is about 10 feet high, and is cut down straight as a wall. The crest of the spur there is seen to be composed of boulders of granitoid gneiss and of schists and shales of various sizes buried in a matrix of unstratified earth.

The Mámul moraine is not the only decided instance of ice action I have seen within the Dalhousie area. In the valley formed by the small stream that runs down from Kud to Hubár, below Bariara, countless huge blocks of granitoid gneiss are thickly scattered on the surface of the ground. One of them, which I measured, I found to be 29 feet long, and thick and high in proportion. Higher up the valley, but still a long way from the granitoid gneiss, I noticed another, 42′ × 25′ × 30′ or 40′. The puny stream that takes its rise at the head of this small valley could not have transported such blocks had it formerly been fifty times as large as it now is. At Kud itself, the jutting ends of the strata, which crop out nearly at right-angles to the course of the stream, have been evidently sculptured by ice action, and stand out like the rounded bastion of a fort. The rounded portions are high above the stream, and are quite inaccessible, so that I could not see whether they are scored and striated.

Conclusion.

Professor Judd, in his recent work on volcanoes, suggests the existence of a general correspondence between the course of events which ushered in the birth of the Alps and the Himalayas; and I think the study of the geology of Dalhousie furnishes some additional evidence of this correspondence.

Professor Judd's sketch of the history of the Alps may be briefly epitomised as follows :—"The first stage was the opening of a number of fissures running

along a line near to that at which, at a long subsequent period, the elevation of the mountain masses took place."[1] * * * "From the great fissures opened in Permian times along this line of weakness, great quantities of lava, scoriæ and tuff were poured out, and these accumulated to form great volcanic mountains, which we can now only study at a few isolated spots.

"The 2nd stage consisted in a general sinking of the surface along this line of weakness in the earth's crust, the existence of which had been betrayed by the formation of fissures and the eruption of volcanic rocks." * * * The volcanic energy which had been manifested with such violence during the Permian period, does not appear to have died out altogether during the succeeding Triassic period.

"The subsidence was continued almost without interruption to the Nummulitic period.

"The third stage commenced in Oligocene times. It consisted in a series of movements affecting the parts of the earth's crust on either side of the line of weakness which had first exhibited itself in Permian times. By these movements a series of tangential strains were produced, which resulted in the violent crushing, folding, and crumpling of the sedimentary materials composing the geosynclinal."

If the views I have propounded in this paper are correct, it follows that a series of grand volcanic movements took place along a line coinciding with the direction of the axis of the Himalayas. These movements commenced probably in early silurian times, and continued until the close of that period, after which they became comparatively insignificant. There followed a long period of subsidence during which a great series of limestones were laid down, which extended from the carboniferous to the triassic period. In the Spiti region the subsidence appears to have lasted until the cretaceous period, whilst part of the Simla area was under the nummulitic sea in eocene times. Then followed the final series of movements which threw the strata, old and new, into a series of folds, the axes of which have a general N. W. and S. E. trend.

I have not attempted to enter into any details in the above brief sketch, as my only object in making it, is to draw attention to the fact that, as in the Alps, so in this region of the Himalayas, a long period of subsidence was preceded by great volcanic activity.

Note on remains of palm leaves *from the* (tertiary) Murree *and* Kasauli beds in India, *by* OTTOKAR FEISTMANTEL, M.D., *Palæontologist, Geological Survey of India* (with plate).

There is as yet very little on record upon tertiary plants from India. The only attempt at an identification of such fossils is contained in Mr. H. B. Medlicott's Memoir on Sub-Himalayan rocks of North-Western India,[2] wherein,

[1] Page 292. [2] Memoirs, G. S. I., Vol. III, pt. 2.

on pp. 97—99, Dr. Kane communicated the results of his examination of a small collection of tertiary leaves collected by Mr. Medlicott in the Kasauli beds.

There is also in our collections a small series of tertiary leaves from Burmah, which, so far as I know, have not yet been identified. All these leaves will have to be thoroughly examined and compared with extra-Indian tertiary plants before they can be figured and described.

On the present occasion it is my object to notice especially one form, about the identification of which there appears very little doubt, and which is of peculiar interest on account of its wide distribution in extra-Indian tertiary rocks. My attention was directed to it by a specimen brought last season by Mr. Lydekker from the Murree beds in Northern Punjab,[1] consisting of red sandy shale and containing leaf impressions, which are easily recognised as being of palm leaves. My first note (given to Mr. Lydekker) about them was that they are "very close to, probably identical with, *Sabal major*."

There are impressions on both sides of the specimen, both belonging apparently to the same kind of leaf. On one side the impression represents the lower portion of the leaf (see fig. 1), and exhibits distinctly the fan-shaped form, as can be seen from the radiating arrangement of the ridges and furrows of the plaited leaf, the parallel simple veins on the plaits also being distinctly seen. The impression on the other side (fig. 2) represents more an upper portion of the leaf, showing, however, also the same characters as the other one.

If we now turn to the identification of the fossils, we find that they agree best with the fossil palm, now generally known as *Sabal major*, Heer, of which good figures are given in Prof. Heer's Flora tert. Helvetiæ[2] and in Prof. Ettingshausen's fossil Flora of Bilin in Bohemia.[3] It is figured as *Flabellaria major* in Unger's Chloris protogæa[4] and in Ettingshausen's fossil Flora of Hæring.[5]

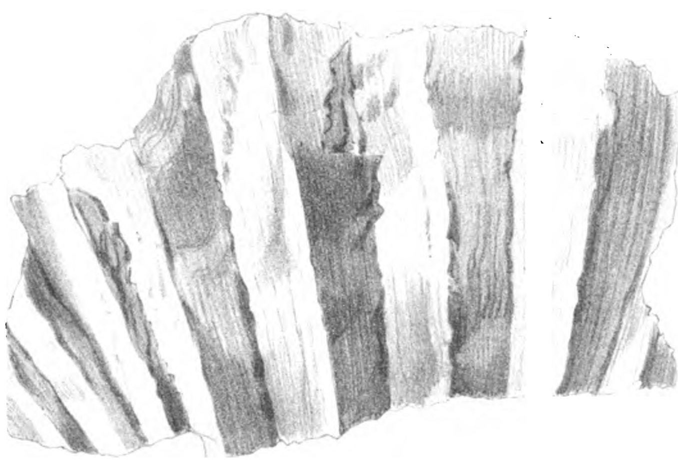
Count Sternberg's *Flabellaria rapifolia*[6] is by Schimper placed with this species also, while Ettingshausen's *Sabal rapifolia* differs from Sternberg's form, and is classed with *S. hæringiana*.

No idea can be formed from our specimens about the character of the rhachis, though all the other characters agree with those of *Sabal major*, Heer.

We have, however, some other fragments of palm leaves amongst the fossils from the Kasauli beds. Amongst them is especially one good specimen (fig. 3) which though of a very small size, yet exhibits a portion of the stalk and also the rhachis. The stalk widens somewhat at the upper end, whence the rhachis originates as a long pointed process, on both sides of which the leaf plaits are inserted, which are distinctly keeled. It belongs most probably to a very young plant, considering its small size; but if we compare it with the various figures of fossil palm leaves, it again agrees best with *Sabal major*, Heer, especially with

[1] The locality is Chakoti, Jhelum valley, above Murree.
[2] Flora tert. Helvetiæ, Vol. I, 1855. p. 88, Tabs. XXXV, XXXVI, fig. 12.
[3] Denkschriften d. Kais. Akad. d. Wiss. in Wien, Vol. XXVI, 1867, p. 108, Pl. VIII, IX.
[4] 1847. p. 42, Pl. XIV, fig. 2.
[5] Abhdl. d. k. k. Geol. Reichsaustalt, Vol. II, p. 33, Tab. III, figs. 3-7.
[6] Fl. d. Vorw. 1, 2. p. 32, Pl. XXI.

1



2

5

4

3

[illegible]

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some of those specimens figured by Ettingshausen in his fossil Flora of Hæring, Tyrol (*l. c.*), but best with the restored figure of *Sabal major*, given by Heer in his tertiary flora of Switzerland (*l. c.*), pl. XLI, fig. 7. This view is further confirmed by the circumstance that, together with this specimen, there were found fragments of the plaits of a larger leaf (figs. 4, 5), very nearly approaching in size the first described specimen brought by Mr. Lydekker from the Murree beds and classed by me with *Sabal major*. The presumption is only natural that these latter fragments belong to leaves of the same plant as the specimen just described from the Kasauli beds. Dr. Kane (*l. c.*) referred these specimens to *Flabellaria rapifolia*, Sternberg, which, as we have seen, is a synonym for *Sabal major*, Heer.

This identification of the palm leaves from the two localities is also fairly in accordance with the geological horizon of the strata at the said localities (Murree beds north of Murree and Kasauli beds near Kasauli); and even if there were a slight difference in age of the respective beds, in which this species occurs here, in India, yet its occurrence in both would find sufficient explanation in an analogous distribution of *Sabal major* in extra-Indian tertiary beds. It is known from many localities in the European tertiaries, *i.e.*, of Austria, Germany, Italy, France, and England; and as to the horizon, it begins in the tongrian stage (lowest miocene) and lasts till middle miocene.

In the botanical system, *Sabal* is classed with the *Coryphinæ*, subtribe *Sabalineæ*, to which belong amongst others the genera *Corypha* (*C. umbraculifera*—the Talipot of Ceylon, and two other species of Bengal) and *Chamærops* (one species of which lives in the Punjab).

Sabal itself is a North-American genus in the living flora.

EXPLANATION OF PLATE.

Figs. 1 and 2. Portions of a palm leaf, referable to *Sabal major*, Heer, from the Murree beds at Chakoti, Jhelam valley, above Murree.

Fig. 3. A portion of a small palm leaf, exhibiting part of the stalk and the rhachis, agreeing in all its characters with *Sabal major*, Heer. From the Kasauli beds at Kasauli.

Figs. 4 and 5. Fragments of plaits of a palm leaf occurring with the preceding (fig. 3) at the same locality and belonging apparently to the same species.

On Iridosmine *from the* Noa-Dihing River, Upper Assam, *and on* Platinum *from* Chutia Nágpur, *by* F. R. MALLET, F.G.S., *Geological Survey of India.*

Assam.

In 1855 Captain E. T. Dalton and Lieutenant-Colonel S. F. Hannay, who had previously been engaged in researches on the mode of occurrence of gold in Upper Assam, were deputed by Government to undertake a further examination of the auriferous deposits there. A summary of their report, which was submitted in October of that year, is published in the Memoirs of the Geological Survey, Vol. I, p. 90.

Amongst other rivers examined was the Noa-Dihing, the sand of which was found to contain platinum as well as gold.

The samples of gold obtained by the above-mentioned officers were eventually deposited in the Geological Museum, and having recently had occasion to examine them with some care, I detected in that from the Noa-Dihing, besides the platinum already mentioned, iridosmine also.

Of the entire sample (weighing about 75 grains) the great bulk, probably over 90 per cent., is gold in scales or flattened grains. The remainder consists of quartz and other silicious grains, including a few red ones like garnet and some black which are probably schorl, with magnetic iron; and besides small and minute flattened grains of platinum, a not inconsiderable proportion of lead-grey scales with metallic lustre. They are of high specific gravity, as is shown by the ease with which they can be separated by a fine jet of water from most of the other non-auriferous matter, and are hard enough to scratch glass. They are insoluble in aqua regia, and infusible before the blowpipe, but lose their lustre when heated. Fused with nitre in a platinum spoon they give the odour of osmic acid, and, mixed with the violet potassium flame, a yellow streaky luminous one. Their dark colour, and their loss of lustre before the blowpipe, point to their being sisserskite, the variety of iridosmine containing a high percentage of osmium in comparison to that of iridium. The largest scale of iridosmine weighs ·06 grains, the largest of platinum weighing ·095.

It will be seen that the proportion these metals bear to the gold in the sample under discussion is comparatively trifling. But it is possible that if they were specially looked for in the Dihing river they might be found in greater abundance. It appears that in Burmah, where also platinum is found in conjunction with gold, it is the latter only on which much value is placed. "Mixed "with the gold dust, found to the northward of Ava, are a quantity of grains of "metal having every appearance of iron[1] * * * . The Burmese "look chiefly for the gold dust, separating and bringing that alone generally to "Ava."[2] It is not impossible that the gold washers employed by Captain Dalton, in ignorance of the value of the platinum and iridosmine, may have treated them in the same way as the Burmese, and picked out by hand any grains sufficiently large to attract the eye.

With reference to the origin of the platinum and iridosmine, it can scarcely be doubted that they are derived from some of the crystalline rocks which are known to form a portion at least of the mountainous mass towards the head of the Dihing river. In the not very numerous cases in which platinum has been traced to its parent rock in other parts of the world, it appears to have been found in most instances either in auriferous quartz veins traversing crystalline rocks, or

[1] The platinum. Asiatic Researches, Vol. XVIII, pt. II, pp. 280, 281. Jour. As. Soc., Bengal Vol. I, p. 17.

[2] In the Indus Valley also, where, according to Mr. Baden Powell, platinum is found in smal quantity with gold, the former is said to be rejected as useless. (Economic Products of the Punjab Vol. I, p. 14.)

(accompanied frequently by chromite), in serpentine. As serpentine is known to exist largely in the hills to the east of Assam,[1] and in Upper Burmah also, it might perhaps be suspected to be the platiniferous matrix in those provinces. But the intimate association of the platinum with gold in both countries (coupled, it might perhaps be added, with the fact that chromite has never been observed in the Assam or Burmese auriferous sands) points rather to the rocks in which gold is usually found as those from which the platinum has been derived.

Chutia Nágpur.

We are indebted to Messrs. Schoene, Kilburn and Co. for a sample of stream gold from the Guram River, near Dhadka, Mánbhum, lately presented to the Museum. The specimen weighs about 57 grains, and includes four comparatively large pieces of gold, aggregating 26·5 grains, of which the heaviest weighs 9·0 grains. The remainder is gold in much smaller scales and fine dust, with a little black iron sand (chiefly ilmenite, with some magnetite) and a few minute grains and scales of a steel-grey colour. These are malleable; infusible before the blowpipe; insoluble in hydrochloric or nitric acid, but soluble in aqua regia. The solution when evaporated to dryness, mixed with water and a drop of a dilute solution of ammonium chloride, and allowed to evaporate over oil of vitriol, deposits minute yellow crystals of apparently octahedral form. The scales are evidently platinum. They occur in extremely small quantity however, the platinum being only 'a trace' in comparison to the gold. The largest scale in the whole sample weighed only ·005 grains.

On subsequently examining other samples of Indian stream gold in the Museum, I found similar, but still smaller, scales, which behaved in the same way with reagents, &c., in gold from Lándu, Chaibássa. Scales of the same appearance were also observed in a specimen of gold from Mánbhum, the exact locality of which is not given, and in another from the Bráhmini River, Tributary Mehals, Orissa. There can scarcely be much doubt that these are platinum also, but they were not examined with reagents, the scales from the Bráhmini being indeed almost too minute to admit of such treatment.

It seems therefore not improbable that platinum is somewhat widely diffused in the southern part of Chutia Nágpur, &c., and perhaps throughout a larger area. But the specimens alluded to do not in themselves give ground for believing that it occurs in more than minute quantity. It is, however, possible that the gold washers may sometimes find grains sufficiently large to attract their attention, and that they reject them as useless.

[1] Mr. H. B. Medlicott informs me that quantities of serpentinous boulders are washed down to the plains by the Dihing and Brahmaputra (Brahmakund) rivers. Captain Hannay found similar rolled fragments in the Digáru, and there is in the Museum a rolled pebble of the same rock from the Dihing.

On (1) *a* Copper Mine *lately opened near* Yongri Hill, *in the* Dárjiling District; (2) Arsenical Pyrites *in the same neighbourhood;* (3) Kaolin *at* Dárjiling; *being 3rd Appendix to a Report "on the Geology and Mineral resources of the Dárjiling District and the Western Duárs;*[1]*" by* F. R. MALLET, *Geological Survey of India.*

Yongri copper mine.

During the present year a new copper mine has been opened on the western flank of Yongri hill, in the Kálimpung sub-division of the Dárjiling district. The Government of Bengal having requested that an officer of the Geological Survey should be sent to report on it, and the duty having been assigned to me, I proceeded to the locality at the end of October.

For a general account of copper mining and smelting in the Dárjiling hills, I would refer to my report on the mineral resources of the district, published in the memoirs of the Geological Survey, Vol. XI, p. 69. The present note refers to the Yongri neighbourhood alone.

The new mine is situated on the left side of a small *jhora* (stream), about three-quarters of a mile west of Yongri Hill (N. lat. 26° 57′, E. long. 88° 31′), at an elevation of about 2,500 feet above the sea. The rock in which the metalliferous band occurs is gray clay slate, of the ordinary type in the Dáling series, which is rather broken and contorted, but which has an average dip at the mine of 60°—80° to S. 30 W. I obtained no clear evidence of there being more than one metalliferous seam. This was first worked by an adit driven in from the hill-side at the spot where the ore originally revealed itself by its rusty, gossan-like, appearance at the surface, and subsequently by two other adits within a few yards of the first one, and by galleries sunk from the above along the dip of the beds. The principal gallery having been sunk to a depth at which the influx of water was too great to allow of its being profitably carried further, an adit was driven in, across the strike of the rocks, somewhat lower down the hill-side, which cut the cupriferous seam about 100 feet from the entrance. The miners then worked upwards towards the old workings, and at the time of my visit were working downwards along the dip of the seam. The driving of this adit through 100 feet of unproductive rock, in order to reach the cupriferous bed, showed a knowledge of the principles of mining, and an enterprise, of which I have not seen any equal example in the Sikkim mines, unless perhaps in that at Rattu.[2] The cupriferous seam at the spot where the miners were working at the time of my visit was about 7 or 8 inches thick, consisting of irregular quartzose layers (interbanded with some clay-slate) through which the ore is disseminated. The latter is copper pyrites, with a large proportion of mundic (iron pyrites), and accompanied by some ochreous oxide of iron and a little black copper as results of alteration.

It will be remarked, therefore, that the Yongri seam, like all the other known cupriferous seams in the Dárjiling District,[3] (1*stly*) occurs in the rocks of the

[1] Memoirs Geol. Surv. Ind., Vol. XI, Pt. I. The second appendix is contained in Vol. X of the Records, p. 143.

[2] Memoirs, Geol. Surv. Ind., Vol. XI, p. 75.

[3] Memoirs Geol. Surv. Ind., Vol. XI, p. 72.

Dáling series; (*2ndly*) is a bed, not a true lode; and (*3rdly*) that the ore is copper pyrites.

As is commonly the case in the Dárjiling mines, the seam is not of constant thickness, expanding in some places, as I was informed by the miners, to a foot or so, and in others thinning to only 1 or 2 inches. A sample of the ore, as it was being brought out from the mine, yielded on assay 1·5 per cent. of copper, while a sample of picked ore gave 6·6 per cent.

On the whole I should be inclined to consider the Yongri cupriferous seam as scarcely on a par with that at Mangphu[1] on the Tísta, and certainly not equal to that at Rattu[2] in Sikkim. The band is not very thick; there is a large amount of mundic in the ore, and the assays show a rather low percentage of copper. Of course this opinion is founded on the state of the different mines *at the times I visited them* respectively, but the productiveness of the same seam varies considerably, owing to fluctuations, both in its thickness, and in the proportion of ore contained in the gangue.

One hundered and fifty or 200 yards S. 30 E. of the above mine, a trial drift was carried in some distance, at a spot where the usual gossany indications were observed. It did not turn out well, however, and is now abandoned and filled with water.

Taking the general strike of the rocks into account, it is not impossible perhaps not improbable, that the Yongri cupriferous band is on the same horizon as the metalliferous strata at Mangphu. The chance is at least sufficiently great to suggest a somewhat promising clue towards the discovery of new outcrops, between the two positions, to any one with sufficient geological knowledge to apprehend the bearing of the facts, but such knowledge is unfortunately not possessed by the native miners.

Smelting was being carried on at the Yongri mine when I was there. As the methods of dressing the ore, and subsequent reduction, are, however, quite similar to those I have already described at some length,[3] it would be useless to enter into the details here. The copper was being sold at Rs. 2-8 per three sers, a portion of it being worked up into cooking vessels, &c., at Surung, a village in the neighbourhood.

Arsenical pyrites at Sampthar Hill.

On the western flank of Sampthar Hill, about half a mile W 20° S. from the highest summit, and a mile and a half north-east from the Yongri mine, at an elevation of about 4,000 feet, the outcrop of a metalliferous band dipping north-east at 50° is exposed for five or six yards. The seam is about a foot thick, of which perhaps two-thirds is ore, the remainder being rusty quartzose schist, which divides the band into two layers, of which the upper is much thicker than the lower. Both consist almost entirely of ore, with but little gangue intermixed. Beneath the metalliferous seam a foot or so of rusty quartz schist is visible. No other rock is exposed close by, but a little lower down the hill the ordinary gray clay-slate of the Dáling series is seen. The ore is arsenical pyrites, with a somewhat considerable proportion of mundic, and a little copper pyrites.

As white arsenic and orpiment (arsenious acid and arsenious sulphide)

[1] Memoirs Geol. Surv. Ind., Vol. XI, p. 76. [2] *Ibid.*, p. 75. [3] *Ibid.*, p. 69.

are both easily prepared from arsenical pyrites, and orpiment is used to a considerable extent in India in connection with the preparation of hides, it seems likely that if some of the copper miners were to learn the way of making the above-mentioned products, they could profitably work the Sampthar ore, especially as some copper could be subsequently extracted from the spent pyrites. Whether Government would consider it advisable to allow the manufacture of arsenical compounds is of course a separate question.

Kaolin at Dárjiling.

The site of the intended European hospital at Dárjiling is on a small hillock, the apex of which has been removed, and the earth, &c., thrown to the sides to form the requisite level space. The stuff cut through is clay and partially decomposed gneiss, the latter of which includes a bed, about 6 feet thick, of a white rock composed of quartz and decomposed felspar verging towards kaolin. The stone is soft when first extracted, and easily broken between the fingers. It bears a close resemblance in appearance to the decomposed granite, found in Cornwall, from which 'China clay' is so largely prepared, by elutriation, for use in the English manufactories of porcelain and the finer kinds of pottery. 'Cornish stone' is a similar material in a less decomposed state. The Dárjiling rock could undoubtedly be used in the manufacture of ceramic ware, but a trial would be needed to ascertain whether it is sufficiently pure for porcelain-making. Tested on a small scale, it was found to fuse *per se* at a white heat into a translucent white, or grayish-white, enamel. There are dark spots scattered through it here and there, due to more or less completely decomposed garnets. These, however, could be picked out by hand to some extent if the rock were used raw. If washed for kaolin, such impurities would of course be removed during the elutriation. A considerable quantity of the stone has been quarried in lowering the hospital site, but no further supply can be obtained there after the building has been commenced. Similar stuff, however, is probably to be obtained elsewhere from the gneissose rocks of the Dárjiling hills, and may perhaps be found capable of local utilisation.

Analyses *of* Coal *and* Fire-clay *from the* Makum *Coal-field*, Upper Assam.

We are indebted to Messrs. Shaw, Finlayson and Co. for permission to publish the following analyses, which have been lately made, of coals from the Makum field:—

From RICHARD SMITH, ESQ., *Metallurgical Laboratory, Royal School of Mines, London, to the Assam Railway and Trading Company, London,—dated 12th September 1881.*

The ten samples of coals from the "Makum Coal Fields," Assam, marked Nos. 1, 1*a*, 2, 2*a*, 3, 4, 5, 6, 7 and 8 respectively, and one sample of clay, have been submitted to examination according to the instructions of your Secretary, Mr. W. Tudor Johns.

PHYSICAL CHARACTERS.—The various coals do not differ much in external appearance; they are brownish-black or black, hard, bright, do not soil the fingers when touched; the fracture is uneven, and some of the samples have flat, somewhat conchoidal patches; the fragments or lumps are more or less cubical, or have irregular bedding cleavage, and some of them exhibit a peculiar form, resembling an imperfectly columnar structure.

CHEMICAL COMPOSITION.—In the following *Table A* are the analyses of the coals, made on the samples as received, and inclusive of the water present:—

TABLE A.

	1	1a	2	2a	3	4	5	6	7	8
Carbon . .	74·63	76·81	75·90	76·36	75·40	74·54	78·00	77·90	74·66	74·81
Hydrogen .	5·03	5·17	5·22	5·31	5·22	5·13	5·27	5·30	5·17	4·95
Oxygen . . } Nitrogen . }	14·25	12·88	11·85	11·12	11·50	11·87	12·18	11·75	14·49	12·36
Sulphur . . .	1·38	1·03	1·73	2·71	2·58	3·81	1·40	2·30	2·88	3·40
Ash (red) .	2·66	1·66	3·00	2·00	3·00	2·50	1·00	1·10	1·00	2·33
Water (hygroscopic) . .	2·05	2·45	2·30	2·50	2·30	2·15	2·15	1·65	1·80	2·15
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

The following *Table B* represents the composition of the coals calculated on 100 parts, and exclusive of sulphur, water and ash, and are added for comparison. There is a marked similarity between them, but Nos. 1 and 7 contain less carbon and more oxygen and nitrogen:—

TABLE B.

Carbon. . .	79·47	80·97	81·64	82·08	81·83	81·43	81·72	82·05	79·15	81·21
Hydrogen . .	5·35	5·45	5·61	5·72	5·66	5·61	5·41	5·58	5·48	5·37
Oxygen . } Nitrogen . }	15·18	13·58	12·75	12·20	12·51	12·96	12·87	12·37	15·37	13·42
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

The nitrogen is generally present in coals to the extent of 1 to 2 per cent. It was not separately determined, as it was not considered necessary.

The sulphur is present in the coals partly in organic combination (with carbon) and partly in combination with iron as iron pyrites, and probably to some extent as sulphate of protoxide or peroxide of iron, resulting from weathering action upon the pyrites. Patches of iron pyrites (a pale brass-coloured mineral) were observed in two of the coals.

The ash present in the coals is small in quantity, averaging 2·03 per cent. This is an advantage, as the proportion of "clinker" produced during burning would be relatively smaller than produced from many varieties of coals. Compared with other varieties of Indian coals which have been examined, the ash is considerably less.

When a portion of each of the coarsely powdered coals respectively is heated in a closed vessel, the gases given off burn with a yellow smokey flame, and the residual coke is coherent, firm, somewhat dull, more or less porous, and increased in bulk. No marked difference was observed in the character of the gases evolved, or of the residual cokes produced from any of the coals.

The percentage results obtained are given in *Table C*:—

TABLE C.

Coke . .	56·50	59·00	58·25	58·50	57·40	56·40	58·10	56·85	57·20	56·50
Volatile Gases .	41·45	38·55	39·45	39·00	40·30	41·45	39·75	41·50	41·00	41·35
Water . .	2·05	2·45	2·30	2·50	2·30	2·15	2·15	1·65	1·80	2·15
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·0

The gases given off from the various samples of coals during the coking experiments are highly illuminating; they may, therefore, be applied for purposes of gas-making.

As the samples submitted to examination have been taken from the "outcrop" or surface ground, the coals may probably be found to improve in character and have a less proportion of sulphur and ash when worked lower down.

In our experimental trial, the lumps of coal, when first heated, do not appear to soften or stick together to any extent, afterwards they burn freely, and the "fire" remains open, which is favourable as regards coals required for steam purposes.

The coal burns well, but would at first give off a quantity of smoke while putting on fresh fuel. This could be avoided to a certain extent by pushing back the ignited fuel and feeding in the fresh coal at the front of the furnace. It would also be advisable at first to admit a good supply of air to burn the gases produced in the furnace and prevent loss of heat by their escape unburnt up the funnel. The supply of air would afterwards require to be regulated in order to prevent a too rapid combustion of the coke. If local and other circumstances permit, an advantage might be gained by admixture of the coal with a certain proportion of Anthracite or other smokeless coal.

In conclusion, I am of opinion that the coals may be regarded as valuable fuel for various purposes. As steam coals, and also for gas-making, coking or manufacturing and household use, I also think that they may compete successfully with many British coals.

CLAY.—The sample was more or less laminated or shaly in character. It was tested, and found to be a "fire-clay," containing some iron pyrites and coaly matter. Fire-clays often occur in association with coal. When the crude clay is exposed to the highest temperature attainable in an air furnace (sufficient to melt wrought iron), the external surface becomes glazed, and it exhibits other indications of softening to a certain extent. The fire-clay might probably be used for some purposes to which clays of a refractory character are applied, but it would not be of best quality or stand exposure to a long continuous heat. If the clay is previously submitted to a "washing" process to separate the iron pyrites and coaly matter, it may probably diminish its liability to softening when exposed to high temperatures. As this sample was from the "out-crop" or surface ground, it may be possible that clay of improved quality may be found when the working of the coal is more developed.

(*Signed*) RICHARD SMITH.

Analysis of "Assam" Coal (Makum Field), by the Gas Light, and Coke Company.

Gas, per ton	10,900 Cubic Feet.
Illuminating power	17·2 Sperm Candles.
Coke	11 Cwt. to the Ton.
Volatile Matter	46·5 per cent.
Ash in Coal	2·0 per cent.
Ash in Coke	4·3 per cent.

NOTE.—The coal contains a small percentage of ash, and produces a coke of very fair quality, lthough not quite equal to that from Newcastle Coal, yet would be readily saleable.

LONDON, August 27th, 1881. (*Signed*) ALFRED KITT.

The above analyses, coupled with those given in Vol. X, p. 156, furnish data for comparing the Makum coals with those from the Ráníganj field. The comparison is of especial value, as it is against the Ráníganj coal that that of Assam has to compete at present for use on the Upper Brahmaputra. And the fuel from the two sources will doubtless be brought into much greater competition on the railways of North-Eastern Bengal, when the completion of the line, now being constructed from the Makum field to the river at Dibrugarh, shall have rendered the systematic working of the Assam coal practicable.

Taking the mean of the ten analyses given of Makum coals, and comparing it with the average composition of 31 Ráníganj coals, as determined by Mr. Tween, we have—

	Mean composition of 10 Makum coals.	Mean composition of 31 Ráníganj coals.
Carbon	75·90	66·20
Hydrogen	5·18	4·64
Oxygen and Nitrogen	12·42	11·30
Sulphur	2·32	·85
Ash	2·03	17·01
Hygroscopic water	2·15	[1]
	100·00	100·00

It is scarcely necessary to remark that the heating power of coal depends on the high percentage of carbon and (available) hydrogen it contains, and on the low percentage of the remaining constituents. It will be seen, then, that the Makum compares most favourably with the Ráníganj, containing as it does 10 per cent. more carbon, about the same amounts of hydrogen, and of oxygen plus nitrogen, and less than one-eighth the quantity of ash.

[1] The hygroscopic water contained in the Ráníganj coals is not separately given. They were possibly dried before analysis. The average amount of water found in the same coals during their proximate analysis was 4·8 per cent.

If the highest and lowest percentages of the different constituents be compared, the result is equally favourable to the Assam coal.

	Highest percentage amongst 10 Makum coals.	Highest percentage amongst 31 Ráániganj coals.	Lowest percentage amongst 10 Makum coals.	Lowest percentage amongst 31 Ráániganj coals.
Carbon	78·00	73·39	74·54	57·09
Hydrogen	5·31	5·06	4·95	3·46
Oxygen and Nitrogen ...	14·49	14·27	11·12	4·35
Sulphur	3·81	1·63	1·03	·37
Ash	3·00	25·80	1·00	13·00

The following figures, giving the mean proximate composition of the coals from each locality, enable a comparison to be made of a somewhat different kind.—

	Mean composition of 23 Assam coals.[1]	Mean composition of 31 Ráániganj coals.[2]
Fixed carbon	56·5	53·20
Volatile matter (exclusive of water)	34·6	25·83
Hygroscopic water	5·0	4·80
Ash	3·9	16·17
	100·0	100·00

or, exclusive of water—

	Mean composition of 27 Assam coals.	Mean composition of 31 Ráániganj coals.
Fixed carbon	60·0	55·88
Volatile matter	36·2	27·13
Ash	3·8	16·99
	100·0	100·00

Taking the nitrogen at 1·5 per cent., and calculating the theoretic calorific power in centigrade heat units, we have—

	Mean calorific power.
31 Ráániganj coals	6526
10 Makum coals	7447

or as 7 to 8. It appears from Mr. Hughes' remarks[3] that the calorific power of none of the 31 samples of Ráániganj coal exceeded 7040.

The one point in which the analyses show an inferiority in the Makum coals is in the proportion of sulphur they contain. This is without doubt a somewhat serious defect. Most of the Assam, however, cannot be considered a "brassy" coal. There are at present in the Geological Museum specimens from twelve different localities in the Makum, Názira, and Jángi fields, which were collected in 1874, 1875, and 1876. The majority contain no pyrites visible to the eye, and,

[1] Memoirs Geol. Surv. India, Vol. XII, p. 349. [2] Records Geol. Surv. India, Vol. X, p. 156.
[3] *Ibid.*, p. 158.

after six or eight years' exposure to the heat and damp of Calcutta, seven do not show even incipient signs of alteration, while the other five are more or less disintegrated through the oxidation of the pyrites contained in them. It remains to be seen, therefore, whether by proper care the more and less sulphureous coals cannot be worked separately, and used for different purposes.[1]

With reference to gas manufacture, Mr. Hughes has stated[2] that the best known gas coal in the Ráníganj field is that from Sánktoria, which yields about 9,000 cubic feet per ton. Mr. Kitt's analysis gave 10,900 feet from that of Makum. In this connection it will be observed, on comparison of the ultimate and proximate analyses of Makum and Ráníganj coals given above, that a large proportion of the excess of carbon in the former is contained in the volatile portion of the fuel.

F. R. MALLET.

Experiments on the Coal *of* Pind Dadun Khán, Salt-range, *with reference to the production of* Gas; *made April 29th,* 1881, *by* MR. C. H. BLACKBURN, *Superintendent of the Ráwalpindi Gas-works.*

There is reason to believe that the sample of coal on which the experiments were made was a picked one, and that it is improbable that similar results would be obtained from an average sample of the general bulk.

The coal was rather small, having been much broken up in transit by rail. On the whole it was very dull and heavy, but there were a few "shiny" pieces here and there. At 12 noon, the three retorts were charged, each with one maund:—

Time.	State of Meter.	Gas made.	Total Production.
		C. ft.	C. ft.
12 noon	9,342,100	...	...
12-30 P. M.	9,342,540	440	...
1 "	9,342,780	240	680
1-30 "	9,342,960	180	860
2 "	9,343,100	140	1,000
2-30 "	9,343,190	90	1,090
3-00 "	9,343,250	60	1,150
3-30 "	9,343,270	20	1,170
4 "	9,343,290	20	1,190
4-30 "	9,343,300	10	1,200
5 "	9,343,300	*Nil*	1,200
5-10 "	Retorts drawn.		

3 mds. produced 1,200 c. ft. = 400 c. ft. per maund.

$400 \times 27\frac{1}{4} = 10,900$ c. ft. per ton.

The coke produced is very small indeed—like fine ash, and smells excessively of sulphur.

Total produce of coke = mds. 1-34.·.

3 mds. coal produced 74 seers coke = seers $24\frac{2}{3}$ per maund.

$\therefore 24\frac{2}{3} \times 27\frac{1}{4}$ = mds. 16-29 of coke per ton of coal.

The gas was roughly tested photometrically the same evening; the burner used was London D., and the light given was very good.

The result of the testing showed the gas to be equal to about $12\frac{1}{4}$ standard candles.

The amount of sulphur however is excessive, as shown by the test papers hereto attached, and which were exposed only during the period of testing; and the smell in the close Photometer house was very pungent.

[1] Memoirs, XII, 349.

[2] Vol. X, p. 15

Report on the proceedings and results of the International Geological Congress *of* Bologna. BY W. T. BLANFORD, F.R.S., *Senior Deputy Superintendent, Geological Survey of India.*

The origin of the Bologna Geological Congress may be stated in very few words. A number of geologists of various nations, after visiting the Universal Exhibition of Philadelphia in 1876, met at Buffalo and nominated a Committee to make the necessary preliminary arrangements for an International Geological Congress at Paris in 1878. The object of this Congress was to decide upon rules for the construction of geological maps, and for geological nomenclature and classification.

The Geological Congress of Paris, the first of a series that may very possibly be further extended, met on the 29th of August 1878 at the Trocadero Palace, and, having elected M. Hébert President, proceeded to a discussion, which lasted for seven days, on the various subjects included in the general-programme. Little more was done than to determine upon the course to be adopted in future, to nominate two International Committees who should report upon the two important questions of (1) geological nomenclature, and (2) the colours, signs, and other marks to be used in geological maps, to entrust a third Committee with the task of reporting upon the rules of nomenclature to be used in palæontology, and to determine that the second meeting of the Congress should take place at Bologna in Italy in the present year 1881. A fresh Committee was appointed to make arrangements for the Bologna Meeting or Second International Geological Congress, which met on the 26th September last.

The Committee on geological nomenclature (*commission pour l'unification de la nomenclature en géologie*), with the addition of representatives of some nations not included in the original list, finally comprised the following:—

Professor F. RÖMER	Germany
Prof. JAS. HALL	United States of America.
Dr. STERRY HUNT	Canada.
Professor A. LIVERSIDGE	Australia.
Dr. M. E. MOJSISOVICS	Austria.
Professor G. DEWALQUE	Belgium.
Prof. HÉBERT	France.
Prof. J. VILANOVA	Spain.
Mr. C. RIBEIRO	Portugal.
Professor T. McK. HUGHES	British Isles.
Prof. J. SZABO	Hungary.
Prof. J. CAPELLINI	Italy.
Prof. STEPHANESCO	Roumania
Prof. INOSTRANZEFF	Russia.
Prof. LUNDGREN	Scandinavia.
Prof. A. FAVRE	Switzerland.

The members mentioned, with very few exceptions, formed a national Sub-Committee, exclusively composed of geologists of his own nationality. Of these different Sub-Committees, 7, *viz.*, those for Belgium, France, Spain and Portugal (jointly), Great Britain and Ireland, Hungary, Italy, and Switzerland, reported more or less fully to the general Committee. No reports were received from the other Sub-Committees, but a separate communication was sent by Prof. J. D. Dana of the United States, and this was printed with the others in the general report drawn up by Prof. Dewalque, and furnished to each member of the Bologna Congress.

The Committee on colours and signs for geological maps (*unification des figurés ou des procédés graphiques en géologie*) consisted of the following members, the majority of whom, as in the case of the Committee on nomenclature formed Sub-Committees of their own countrymen:—

A. Selwyn, Director of the Geological Survey of Canada, for Canada.

J. P. Lesley, Director of the Geological Survey of Pensylvania—United States.

A. Liversidge, Professor at the University of Sidney—Australia.

A. Ramsay, Director of the Geological Survey of Great Britain and Ireland—British Isles.

Otto Torell, Director of the Geological maps of Sweden—Scandinavia.

V. von Moeller, Professor at the Institute of Mines, St. Petersburgh—Russia

M. v. Hantken, Director of the Geological Institute at Buda-Pesth—Hungary.

Freiherr v. Hauer, Director of the Imperial and Royal Geological Reichsanstalt at Vienna—Austria.

G. W. Gümbel, Director of the Geological map of Bavaria—Germany.

F. Giordano, Inspector-General of Mines at Rome—Italy.

J. B. de Chancourtois, Professor at the School of Mines in Paris—France.

E. Dupont, Director of the Royal Belgian Museum at Brussels—Belgium.

C. Ribeiro, Chief of the Geological Section of Portugal at Lisbon—Iberian Peninsula.

E. Renevier, Professor at the Academy of Lausanne—Switzerland.

Mr. Selwyn was President and M. Renevier Secretary, and the latter drew up the report of the general Committee. He had previously published two memoirs with résumés of the Sub-Committee's reports. The first and most important question was the adoption of an international scale of colours to represent the geological series, each colour in the scale corresponding to one of the great sub-divisions, such as Carboniferous or Jurassic, under which, by the common consent of geologists, sedimentary rocks have been classified. The other questions considered were (2) the colouration to be adopted for igneous rocks; (3) the lettering to be employed for the distinction of beds of different geological ages; (4) various signs and marks for the representation of petrological, palæontological and other characters; (5) the scale for general maps; and (6) the organisation of future work.

There can be no doubt that for all the geological surveys of the world, and perhaps for geologists in general, the questions affecting geological colours and signs were the most important of all those submitted to the Congress. They had the enormous advantage of being entirely independent of language,—a difficulty which must always interfere with the adoption of a general nomenclature, for terms in one language are far from being exactly equivalent to corresponding terms of the same etymological derivation in another tongue. But, unfortunately, so many widely-diverging systems of colouration have been adopted by geologists in various countries, that any general compromise must produce a difference between maps coloured on the scale adopted, and all those previously issued. And, as will be seen in the sequel, although the Congress came to a decision on several points, a far larger number were left undecided.

The importance and difficulty of the question of map colouration and signs induced the committee of organisation to offer a reward of five thousand Francs (£200) for the best memoir on the subject. Several memoirs[1] were received, but none, in the opinion of the judges, merited the full prize, which was distributed amongst the three best dissertations.[2]

The third committee, on the nomenclature of species, consisted of MM. Cotteau, Douvillé, Gaudry, Gosselet, Pomel, and De Saporta for Palæontology, and M.M. Des Cloizeaux and Jannettaz for Mineralogy. The palæontological committee, of which Mr. Gaudry was President and Mr. Douvillé Secretary, furnished a report; but this report has not the same importance as the others already mentioned; for, despite the high position occupied by several of the members, the circumstance of all belonging to one nation deprives the Committee of the representative character possessed by the other two; and with regard to palæontological nomenclature, there can be no doubt that the rules to be adopted for all biology, both of living and fossil forms, must be determined by a general consensus of botanists and zoologists,—palæontologists being admitted as biologists and not as geologists. It is manifest that for a geological congress to attempt to settle rules for biological nomenclature would be as ineffectual as for a congress of biologists to attempt to define geological terms. However excellent the rules adopted might be, they would not receive general acceptance, because the legislators would not be considered competent to decide on matters with which many of them could have but an imperfect acquaintance.

Indeed, it may here be stated, once for all, that although a geological congress, as at present constituted, has great advantages for the discussion of various questions proposed to it, it also suffers from great disadvantages in endeavouring to decide upon difficult points. The majority of the members necessarily belong to the nation in whose country the meeting is held, and although all are qualified who have the right to vote (none being admitted as effective members who are not either geologists by profession or else the authors of geological memoirs), still there is sometimes a preponderance of particular views amongst geologists of one nation, which may not be as generally held by those in other countries. For some of the very delicate and difficult points involved in questions like that of nomenclature, it would be far more satisfactory, if practicable, that the voting on disputed questions should be limited to the representatives of geological societies and geological surveys.

The difficulties of language appear more formidable than they have been found in reality to be. The sole language employed at the Paris and Bologna

[1] Six I believe, but I am not quite sure of the number.

[2] These were by MM. Heim of Zurich, Carpinski of St. Petersburg, and Maillard of Lausanne

Congresses was French, and almost necessarily so, since it is the only one that is easily understood by nearly all the members. A slight advantage was doubtless afforded to the French and Belgian, and to some of the Swiss, members, who used their native tongue, but all, however imperfect their powers of expressing themselves, were heard with equal patience; and it is not quite certain that the abridgement of the discussions, owing to the imperfect power of many speakers to express themselves with fluency, was not a gain that counterbalanced many disadvantages.

As already mentioned, the second Geological Congress, which I attended by order of the Government of India, met at Bologna on the 26th September 1881. Altogether about 200 members were present, of whom 130 were Italians and 70 foreigners. Professor Capellini was elected President, and the following were made Vice-Presidents, as representatives of the different countries named:

Austria	M. Mojsisovics.
Bavaria	„ Zittel.
Belgium	„ Dewalque.
Canada	„ Sterry Hunt.
Denmark	„ Waldmar-Schmidt.
Spain	„ Vilanova.
United States	„ J. Hall.
France	„ Daubrée.
Great Britain	„ McK. Hughes.
Hungary	„ Szabo.
India	„ Blanford.
Italy	„ Meneghini.
„	„ De Zigno.
Portugal	„ Delgado.
Prussia	„ Beyrich.
Roumania	„ Stefanesco.
Russia	„ v. Moeller.
Sweden	„ Torell.
Switzerland	„ Renevier.

M. Giordano was elected General Secretary; Messrs. Bornemann, Delaire, Fontannes, Pilar, Taramelli, Topley, Uzielli, and Zezi, Secretaries; and M. Scarabelli, Treasurer. M. Hébert, the President of the first Congress, attended the second Congress throughout, and M. Q. Sella was Honorary President.

The above names are merely given to show that the Congress was fairly representative. The greater number are well-known geologists, and amongst the other members of Congress were several distinguished men. All those named, with the addition of Messrs. Bioche, Bosniaski, Briart, De Chancourtois, Cocchi, Cossa, Fischer, Gemmellaro, Guiscardi, De Hantken, Hauchecorne, Issel, Inostranzeff, Jaccard, Malaise, Mayer-Eymar, Omboni, Pellati, Pirona, Schmidt, Seguenza, Silvestri, Stoppani, and Trautschold, formed the Council or General Committee of the Congress.

The first meeting, that of September 26th, was chiefly formal, and devoted to the election of officers and delivery of addresses. The meetings of September 27th and 28th were devoted to geological nomenclature, those of the 29th and 30th to geological maps (*unification des figurés*), that of October 1st to palæontological nomenclature, and on October 2nd the Congress was formally closed and Berlin chosen as the seat of the next meeting in 1884. The following account of the results of the Congress will show what has been done. The principal of them are contained in the "*Procès-verbaux Sommaires*" already printed, giving short accounts of the business transacted each day.

In the sittings of September 27th the following resolutions were adopted by a large majority. They were taken from the report of the French Committee on nomenclature :—

Geology *is the history of the earth.*[1] *The facts which enable us to retrace* (restaurer) *this history are contained in the* mineral masses *constituting the crust of the earth.*

Mineral masses.—*Mineral masses may be considered under three aspects; that of their nature, or of their composition, that of their origin, and that of their age.*

Rocks.—*Considered with regard to their composition, mineral masses take the name of* Rocks. *Thus we may say—*

Granitic rocks.
Calcareous rocks.
Argillaceous rocks, &c.

Formations.—*With reference to their origin, mineral masses are called* Formations, *a word used by several nations, but which belongs to the French language.*[2] *This term is only an abridged form of 'mode of formation,' and consequently implies of itself the idea of origin.*

The translation of the paragraph on the word *formation* in M. Dewalque's general report is the following. This paragraph was not adopted specially, but it agrees entirely with the preceding:

"The word *formation* implies the idea of origin and not of time. It should nots be employed as a synonym of system (terrain) or of stage (étage). But we may very well say: *eruptive formations, granitic, gneissic, calcareous formations, marine* or *lacustrine formations, chemical* and *detrital formations, &c.*"

After accepting the four paragraphs translated above from the French report, the meeting took up the consideration of the résumé and conclusions contained in the general report, adapted by M. Dewalque, Secretary of the Committee for the Unification of Geological Nomenclature, from the separate reports of the different national committees.

The opening paragraphs of this résumé deal with terms applied to mineral-masses in general with regard to age. After a very brief summary, the conclusions are stated in twenty-eight paragraphs, consecutively numbered; and of these paragraphs a certain number were discussed, altered, or amended, in several instances, and voted seriatim.

The following paragraph of the preliminary summary is essential to the clear comprehension of the various paragraphs. M. Dewalque writes:—

"Let us first examine that which concerns classification proper.

"All geologists agree in admitting about ten great series of strata, usually distinguished in French under the name of *terrains*, which are classed together

[1] That is of the planet, on which we live.

[2] That is, in this especial signification. It was agreed to give up the use of the term in the sense of rocks of any particular geological age.

in four or five groups of a higher grade, and which are daily being divided and sub-divided to a greater extent. What are the terms to be employed for the different grades of this classification? The following table, in which the second column corresponds to those divisions which we have just called "terrains," records the opinions of the different committees. In the absence of the American report, it has appeared useful to insert the proposition recently made by one of the members. In this case, as in that of the English propositions, we have considered that we might put in the first column, but between parenthesis, the expressions which it appears to us would be employed by the authors of the reports."

	1	2	3	4	5
"America[1] (Dana)	(Terranes)	Terrane	Group	Stage	Beds, Sub stage.
Belgium	Terrains	Terrain	Système	Étage	Sous-étage, assise
France	Terrains	Terrain	Étage	Sous étage	Assise.
Spain and Portugal	Série	Terrain	Membre	Étage	Zone.
Great Britain	(Systems)	System	Formation	?	?
Hungary	Formations	Formation	Étage	Assise	Couches,
Italy	Terreno	Systema	Piano	?	?
Switzerland	Série	Terrain (Gebilde)	Système	Étage (Stufe)	Assise.

It is unnecessary to translate at length the resolutions originally proposed by M. Dewalque, since nearly all were modified by the Congress. The terms he ultimately proposed for adoption, and those accepted by the Congress, were the following:—

1. For the first grade, that is, for a division of the whole series corresponding to palæozoic or mesozoic, no separate term was proposed. It was suggested that the plural of the 2nd grade should be used, and that geologists should write, e.g., *the secondary terranes*. The Congress, however, by a large majority adopted the term *groupe* (group).
2. For the second grade, the most important of all, that corresponding to such sub-divisions as Silurian, Carboniferous, Jurassic, &c., the term *terrain* was proposed in French, *terrane* in English, *Gebilde* in German. After a long discussion, however, the word *système* (system) was adopted by a considerable majority.
3. For the third grade, corresponding to such sub-divisions as upper and lower silurian, lias, dogger, neocomian, &c., the term *groupe* or *système* had been proposed in M. Dewalque's report. Both these terms having been otherwise defined, he next proposed *division*. This led to a long discussion and much difference of opinion, and another term, *série*, was supported by a large section of the members. The show of hands leaving the result doubtful, a ballot was taken, in which 52 votes were given for the word *série*, and 35 for *division*. The former term was consequently adopted; but, as it was shown that the corresponding expressions in German and Russian were inadmissible, it was finally agreed, after the subject had been reconsidered by the Council, that two terms,

[1] This is merely, it should be remembered, Mr. Dana's personal suggestion, and I was assured by the American geologists present at Bologna that the adoption of the term terrane would no more be approved by American geologists in general than by English.

série and *section*, might be employed, the German equivalent of the latter being *Abtheilung*.[1]

4. For the next lower grade of divisions, equivalent to associations of strata like those distinguished in the jurassic system by the names of Purbeck, Portland, Kimmeridge, Oxford, Bath Oolite, &c., the term *étage* in French and its equivalents (*stage* in English, *Stufe* in German, *piano* in Italian, *piso* in Spanish) were recommended in the report and accepted almost unanimously.

5. For the next sub-division the term *assise* was adopted by a large majority. In the report it was suggested that the corresponding terms should be *beds* in English, *Schichten* in German, *strata* in Italian. The choice of terms was, however, left open.

Paragraphs 7 and 8 of M. Dewalque's report were unanimously accepted. They run thus—

7. *The case may occur in which a geologist thinks it desirable to group together a certain number of assises into intermediate sub-divisions, which united together would form an étage. In such cases the intermediate sub-divisions would bear in French the name of* sous-étage.

8. *The lowest element of stratified systems is the* strate (*stratum*) *or* couche (*bed*).

The remaining paragraphs of M. Dewalque's report on terms of classification were not discussed, but, as they contain some valuable suggestions, a translation is appended.

9. The word *banc* (*bank*[2]) is applied to beds that are thicker or more coherent than those in the neighbourhood, or between which they are intercalated.

10. Inversely, thin or slightly coherent beds will be distinguished in French by the word *lit*.[3]

"11. The English plural *rocks*, and its corresponding terms *roches*, *roccie*, will have the same signification as *assise*: Ex.—*Llandovery rocks*, *roccie a Globigerine*.

"12. A *zone* is an assemblage of beds of inferior order, characterised by one or more special fossils, after which it is named.

"This expression is, therefore, synonym of the preceding one, from which it differs by the necessary addition of one or two names of fossils.

[1] Section is, of course, inapplicable in English, as it has another signification, which would lead to confusion. Division might be used, as it is the equivalent of Abtheilung.

[2] It is not clear whether this term is supposed to be applicable in English; but, if so, the supposition is erroneous. The English term *band* might be used, but it may be questioned whether the distinction is necessary.

[3] In a foot-note, M. Dewalque remarks that he has not attempted to propose the exact limitation of the English terms *bed* and *layer*. He admits that, whilst the exact English equivalent of *lit* is *bed*, the latter word is employed, as a rule, in the sense of the French word *couche*. If the distinction be really of sufficient importance to deserve recognition, there would probably be no objection to the use of *layer* as an equivalent term to *lit*.

"It may also happen that a 'zone' may be an 'assise,'[1] although the former is more frequently a division of the 4th order.

"13. The name of *horizon* is given to a bed or to a set (série) of beds which possess well-marked characters, by means of which they may be easily distinguished over large tracts of country.

"14. The word *depôt* (deposit in English) should only be applied to a mass produced during a period of time, or within an area limited and characterised by a certain petrographical homogeneousness."

It is as well that these various terms should undergo further consideration before any attempt is made to define them exactly.

Before proceeding further, it may be as well to show the application of the terms agreed upon to some of the Indian rocks. Taking, for instance, the cretaceous deposits of Trichinopoly, all belong to the upper *series* of the cretaceous *system*, which is part of the mesozoic *group;* and near Trichinopoly three marine *stages* are distinguished,—the Arialur, Trichinopoly, and Utatur *stages.* Similarly, the jurassic *system* of Cutch comprises four stages,—Umia, Katrol, Chari, and Patcham. Again, the great Gondwana *system* is divided into several *series*, of which the Damuda is one, and the Raniganj, Iron-stone shales and Barakar are the *stages* constituting that *series.* As an example of an "*assise*," the Talchir boulder bed might be quoted.

The next question for discussion was the use of chronological terms corresponding to the various divisions already defined. After much discussion the following were adopted :—

1. *Era*, corresponding to *group.*
2. *Period*, corresponding to *system.*
3. *Epoch*, corresponding to *series.*
4. *Age*, corresponding to *stage.*

All these were voted either unanimously or by large majorities, except the word epoch, which was only preferred to cycle by a single vote, the numbers on a ballot being 47 to 46.

It has, consequently, been determined that the correct expressions to use are—

Palæozoic or mesozoic *era.*

Silurian, jurassic, or eocene *period.*

Lias or neocomian *epoch.*

Kimmeridge or Purbeck *age.*

Of all the decisions, those which will probably appear least judicious are the significations given to the two words, *group* and *series.* Loosely as these expressions have hitherto been employed in English, the term *series* has, as a rule, been understood to imply a higher grade in geological classification, and to embrace a greater range of rocks than *group.* However, there is no insuperable objection to the reversal of these significations.

It had been proposed to consider the application of a systematic terminology to groups, systems, series, and stages; to let all names of systems, for instance,

[1] There appears to be some mistake here; I can only say that the above is an exact translation of the original.

terminate in...*ique* in French, and...*ic* in English, like Jurassic and Triassic, and to employ Cretacic, Carbonic, and Siluric, instead of the ordinary terminations. The Congress, however, very wisely refused to discuss the question.

It has already been stated that the meetings of September 29th and 30th were devoted to the colours and signs for geological maps. The greater part of the first day, however, was taken up by a discussion on the proposed general geological map of Europe. It is needless to enter into particulars on this subject, and it is sufficient to state the conclusions adopted. It was agreed that the map should be prepared at Berlin, and that the work should be under the supervision of a committee thus composed:—

MM. Beyrich and Hauchecorne, Executive Directors, for Germany.
M. Mojsisovics for Austria-Hungary.
M. Daubrée for France.
Mr. Topley for England.
M. Giordano for Italy.
M. de Moeller for Russia.
M. Renevier as the Secretary of the original Committee on map colouration.

The scale is to be $\frac{1}{1,500,000}$ (between 23 and 24 miles to the inch). The Committee to meet yearly at certain fixed times and places.

It may be added that the great delay that would be involved prevented the adoption of a larger scale. It is well to bear the scale of this map in mind, as it may be useful to prepare maps of other parts of the world, where practicable, on the same scale and with the same system of colouration, so that eventually all may be combined in one general geological atlas.

The next subject was that of the colours to be employed for systems of different ages. It may here be observed, that although no list of geological systems was approved, that upon which the scheme of colouration proposed in Prof. Renevier's report was based, comprised the following:—

Recent.–	
Pliocene and Plistocene.	Tertiary or Cenozoic.
Miocene.	
Eocene.	
Cretaceous.	Secondary or Mesozoic.
Jurassic.	
Triassic.	
Carboniferous (including Permian ?)	Primary or Palæozoic.
Devonian.	
Silurian (including Cambrian ?)	
Precambrian.	

The following resolutions were first passed. Both are considerably modified from that originally proposed. All mention of the spectrum, on which the scheme adopted was originally said to have been founded, was omitted, and very justly, since neither the sequence, nor in some cases the colours proposed, are really those of the solar spectrum.

1. *The Geological Congress of Bologna consider that there is occasion to adopt an international agreement for the application of colours to the representation of geological formations. The series of colours adopted will be recommended to all countries and all geologists, especially in view of general works, but without any retrospective action upon maps in process of publication.*

2. *Rose-carmine* (pink) *will be preferred* (sera affectée de préférence) *for crystalline schists, whenever there is no certain proof that they are of Cambrian or post-Cambrian age.*

Bright rose colour may be reserved for rocks of pre-Cambrian age, and pale rose for crystalline schists of indeterminate age.

Both these resolutions were discussed at considerable length. The second resolution originally commenced thus: "Rose-carmine will be especially applied (*sera affectée spécialement*) to crystalline schists," and it was objected that the phrase should be modified so as to permit the application of the colour to other rocks in case of need. Another objection, that some pre-Cambrian beds may not be crystalline schists, was partially met by the form above adopted for the second part of the resolution. There is, however, some reason to suppose that further modification, and the use of additional tints, may become necessary in countries like North America and India, where several systems of rocks, known or believed to be of pre-Cambrian age, require distinction.

The third resolution was not discussed, as it was considered that further consideration was necessary before the classification of the palœozoic rocks, and the colours to be adopted for them, could be decided upon. The resolution ran thus.

3. Three colours will be applied to palæozoic systems:—

1*st*—Violet for silurian.
2*nd*—Brown for Devonian.
3*rd*—Dark grey for Permian and Carboniferous.

There was great divergence of opinion as to the claims of Cambrian and Permian to be distinguished by different colours, and also as to the tints to be employed. Thus the English Committee, whose report was received after the general report had been printed, recommended the following scale:—

Permian—Chalons brown.
Carboniferous—dark grey.
Devonian—Indian red.
Silurian—violet.
Cambrian—purplish violet.
Pre-Cambrian—purplish carmine.

The same committee proposed to distinguish altered (metamorphic) rocks, of whatever age, by lines or marks of red above the colour of the system.

The question of the colours to be used for palæozoic rocks was finally referred to the International Committee appointed to supervise the map of Europe.

In Resolution 4 on the colours for mesozoic rocks, an alteration was made on the proposal of M. Renevier himself in the adoption of violet instead of brick-red, the colour first proposed, for trias. The resolution thus modified was passed. It runs thus:—

4. *Three colours are applied to the secondary or mesozoic systems.*

1st.—Violet for trias.

2nd.—Blue for jurassic (lias may be distinguished by a darker blue).

3rd.—Green for cretaceous.

The cenozoic rocks were quickly disposed of. In M. Renevier's reports the colouration proposed was: bright yellow (gamboge) for eocene, chamois yellow (a kind of buff) for miocene, and pale sepia yellow with a light orange tint for pliocene and plistocene; modern formations to be left white, or represented by various signs on a white ground. The modified resolution proposed by M. Renevier and adopted was the following:—

5. *The tints of yellow will be applied to the cenozoic group, the higher beds being represented by paler shades.*

This was almost unanimously agreed to, but there was considerable discussion as to the selection of a special colour for quaternary beds. The question was ultimately left to the decision of the Map Committee.

The following three resolutions were then unanimously adopted:—

6. *The sub-divisions of a system may be represented by shades of the colour adopted, by white spaces being left* (réserves de blanc), *or by various markings* (hachures) *according to the particular requirements of each map, the only condition being that these markings be not opposed to the orographical characters, and that they do not render the map confused.*

The shades, either full or broken tints (pleines ou par réserves) *should be applied in the direct order of age, the darkest always representing the oldest beds.*

7. *The litteral notation (lettering) for rocks shall be based upon the Latin alphabet for sedimentary and the Greek alphabet for eruptive formations.*

The monogram of a system shall be formed as a rule by the initial capital letter of that system. The sub-divisions may be distinguished by adding to the capital initial letter, either the small letter that begins the name of the sub-division or a numerical exponent, or either one or the other as most convenient.

The numbers of numerical exponents ought always to be used in chronological order, one signifying the lowest, that is, the oldest sub-division.

8. *The use of palæontological, orographical, chronological, petrographical, and geotechnical signs, is recommended. Those which are, at the same time, the simplest, the most distinctive and the most easily remembered, should be preferred.*

It may be useful to give an illustration of Resolution 7. Taking, for instance, the Triassic system which would be represented by T, the three principal stages, Bunter, Muschelkalk, and Keuper, into which it is sub-divided, would be indicated by Tb, Tm, and Tk. The different associations of beds or "assises" in the Bunter would be represented by Tb_1, Tb_2, Tb_3, &c., Tb_1 being employed for the oldest.

This terminated the portion of the work relating to geological maps. The important question of the colouration of igneous rocks was reserved for further consideration.

The sitting of October 1st was occupied with the consideration of the rules, for palæontological nomenclature, and was of less interest than the meetings of the previous days. It will be sufficient to give a translation of the resolutions voted.

1. *The nomenclature adopted is that in which each being is indicated by a generic and a specific name.*

2. *Each of these names is composed of a single word, of Latin, or Latinised; written according to the rules of Latin orthography.*

3. *Species may present a certain number of modifications connected together in time or space, and indicated under the names of* mutations *or* varieties[1]*; modifications, of which the origin is doubtful, are simply called forms.*

These modifications will be indicated, if necessary, by a third term, preceded according to circumstances, by the words variety, mutation *or* form, *or by corresponding abbreviations.*

(*a*) *A specific name should always be followed by the name of the author who established it. The author's name is placed between parentheses, when the original generic name is not preserved; and in this case it is useful to add the name of the author who changed the generic title.*

The same arrangement is applicable to varieties raised to the rank of species.

4. *The name assigned to each genus and each species is that under which it was first indicated, provided that the characters of such genus and species have been published and clearly defined. Priority does not go back beyond the twelfth edition of Linnæus,* 1866.

5. *In future, for specific names, priority will not be irrevocably acquired, except when the species is not only described, but figured also.*

It was thought undesirable to proceed further, most of the details being matters requiring regulation by biologists generally. The few rules passed differ principally from those adopted by M. Douvillé's report in refusing to acknowledge pre-Linnæan names.

At the closing meeting on October 2nd, Prof. Beyrich was named President of the committee of organisation for the next Congress at Berlin, and a fresh International Committee was appointed to continue the work relating to the unification of geological nomenclature. This committee consists of Messrs. Zittel for Germany, Neumayer for Austria, Dewalque for Belgium, Sterry Hunt for Canada, Vilanova for Spain, James Hall for the United States, Hébert for France, Hughes for Great Britain, Szabo for Hungary, Blanford for India, Capellini for Italy, Delgado for Portugal, Stefanesco for Roumania, Moeller for Russia, Torell, for Scandinavia, Ch Mayer for Switzerland. This committee is to meet next year, 1882, together with the Map Committee, at the place and on the day fixed for the

[1] That is to say, (and the distinction is of great importance for geologists,) a mutation is a modified form of a species found in a bed of different age from that containing the typical form. A variety is a modification due, not to difference of geological age, but to geographical distribution. The distinction between these terms may be very usefully employed in geology. The original proposal of the term mutation, to express secular variation, is attributed to our old colleague, Dr. Waagen.

provincial meeting of the Geological Society of France; in the subsequent year, 1883, at the meeting of the Swiss Society of Natural Sciences.

Considering the work of the Congress as a whole, it cannot be stated that very much has been done towards the unification of nomenclature or of colouration and signs for geological maps. But still something has been effected; and if the extreme slowness of all legislative action in countries where the legislators are really a representative body be taken into consideration, the resolutions passed will not seem so meagre as at a first glance they appear to be. A commencement has, at all events, been made towards effecting both the main objects of this and similar congresses, and it is far better to pause and collect further evidence before coming to any final determination than to attempt to lay down rules, which, not being supported by a majority of geologists, will be generally disregarded. With reference to questions of nomenclature it should be remembered that many continental nations, and especially the French, aim at greater exactitude in the choice and use of words than is customary in English, and the importance of precise definition is therefore greater to them than to ourselves. Each system has its advantages, precision may be carried to excess, and so may laxity, even in the use of words; over-refinement, and the use of terms that do not express facts, may result from excess on the one side, and confusion from excess on the other, but unquestionably there is need for the definition of a considerable number of terms in addition to those already adopted whilst it can scarcely be said that any now accepted are unnecessary. The body of geologists throughout the world is large, and very widely scattered, and much time is necessary before the general feeling of the whole body can be ascertained; Moreover, the use of a congress like that of Bologna is by no means limited to making abstract resolutions. It is of vast importance, especially to those who have passed a great part of their lives in distant parts of the world like India, to meet the geologists of other countries and to exchange ideas.

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THE SOCIETY.

January 16th, 1882.

NOTICE.

SIWALIK FOSSILS FOR EXCHANGE.

Specimens of the teeth or bones of the following genera of Siwalik vertebrata are available at the Indian Museum in exchange for named teeth or bones from the pliocene, miocene, or eocene of Europe or America. Specimens of *Dinotherium*, *Mastodon longirostris*, or *Hippotherium gracile* are not required. Apply to R. Lydekker, care of Superintendent, Geological Survey of India, Indian Museum, Calcutta.

Dinotherium.
Mastodon (2 or 3 sp.)
Stegodon (2 sp.)
Loxodon.
Sus (2 sp.)
Hippohyus.
Hippopotamus.
Rhinoceros.
Acerotherium.
Hippotherium (2 sp.)
Equus.
Antilope.
Portax.
Crocodilus.
Gharialis.
Batagur.
Trionyx.
Emyda.

RECORDS, GEOLOGICAL SURVEY OF INDIA,

Vol. XV, Part 1.

CORRIGENDA.

Page 25, line 2 from bottom, *for* 'in Chutia Nagpur,' *read* 'at Maleri.'
" 26, " 7, *for* 'lower,' *read* 'higher.'
" 45, " 15, *for* 'microscopically,' *read* 'macroscopically.'
" 45, " 15, *for* 'orthoclose,' *read* 'orthoclase.'

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1882. [May.

General sketch of the Geology of the Travancore State —*By* W. KING, D.Sc., *Deputy Superintendent (Madras), Geological Survey of India.*[1]

My last season's work (1880-81) was devoted to a general examination of the geology of the southern half of Travancore, and to a particular study of a small area of deposits which have been long known as occurring on the sea-coast, on the history of which I have written a separate paper (*infra*).

The development of the gold industry of Southern India having raised hopes of a similar auriferousness of the mountainous and coffee-planting districts in Travancore to that in Wainád, I was, at the very urgent request of the Travancore Government, induced to devote a considerable portion of my time to the examination of the region supposed to present the most favourable indications of gold-bearing rocks. The result of this was a report on the quartz outcrops of Parmand, in which I showed that the supposed reefs are to all appearance beds of nearly pure quartz-rock occurring with the other strata of the gneiss series, and that, though they locally give the very faintest traces of gold, there is no reason to expect that better results will be obtained. Practically, there are no auriferous quartz-reefs, as usually understood, in the area pointed out; neither do I expect that such will be found of any extent or richness in so much of Travancore as I was able to visit.

The geological examination of the country may be said to have extended over more than half of the territory—in reality, it consisted of various traverses over the country between Cape Comorin and the 9° 35′ parallel of north latitude; but I can generalize as to the lie and character of the very few rock formations over the country far to the northward, through visits which I had made in previous years in the Coimbatore and Malabar districts, and this season at Cochin, to which place I was called in connection with a commission of enquiry on the harbours, conducted by Colonel R. H. Sankey, C.B., in the hopes of being able to elucidate something regarding the well-known tracts of smooth-water off the coast at Narrakal and Poracaud.

[1] See map attached to the following paper on the Warkilli beds.

The Travancore State, though it has long had a very irregular eastern frontier, has now been settled as lying practically to the westward of the main water-shed of the southern portion of the great mountainous back-bone or mid-rib of Southern India, which stretches from the low-lying gap of Palghat, below the Nilgiris, to within some 15 miles of Cape Comorin. Between this southern extremity of the mountain land and "The Cape," as it is distinctively called, there is an outlying hill mass which carries the water-shed rather to the eastward of the extreme southern point of India; but a low rocky spur does terminate the and, and outside of it, or a little to the eastward again and somewhat higher, are two rocky islets.

In the northern part of the country the mountain mass is very broad, but just south of the Parmand parallel (the northern limit of my proper work), the hilly back-bone narrows considerably, and becomes a lengthened series of more or less parallel ridges with lower and lower intermediate valleys. These are striking with the gneiss, or about west-north-west and east-south-east, there being at the same time a line of higher masses and peaks culminating the main ridge, from which the ribs run away, as indicated, to the low country.

The mountain land does not, as may be seen by any good map, run down the middle of the peninsula, but keeps to the westward; so that there is a broad stretch of low country on the Madura and Tinnevelly side, while that of Travancore is narrow. Then the mountains drop rather suddenly to the east; while they send long spurs down to within a comparatively short distance of the western coast. There is thus still, in Madura and Tinnevelly, a southerly prolongation of the wide plains of the Carnatic, which stretch round by Cape Comorin and join the narrower, though rather more elevated, low country of Travancore, Cochin, and Malabar.

This narrower and somewhat higher land of the west coast presents also unmistakable traces of a plateau or terraced character, which is best displayed about Trivandrum and northwards past Cochin into the Malabar country. South of Trivandrum these marks gradually disappear, the last trace being in the flat upand or plateau bordering the sea-shore at Kolachel. This more or less even surfaced tract of country has an elevation in its most typical parts of 150 to 200 feet above the sea; and it touches the shore in cliffs or headlands at two or three points, particularly at Warkilli, and in the Paupanchery hill south-west of Trivandrum.

To an observer travelling to Trivandrum across the Ariankow pass from Tinnevelly, the change from the parallel ridges and broken form of the lower hilly country to the comparatively smooth downs of Trivandrum is striking; though he would hardly see the generally terraced or plateau character until a more extended acquaintance had been made with the country.

Northwards from Trivandrum, there are narrow strips of absolutely low land, that is on the sea-level, marked by sandy and alluvial flats and long back-waters or lagoons. These widen out northwards from Quilon, until at Allepy (Aulapolay) there is a width of about 12 miles of such formations, with the very extensive back-water which stretches far past Cochin.

The rock formations are: first, and most prevalent and foundational, the gneiss series; and then on it, but only in a very small way, the *Quilon beds*, which are supposed to be of eocene age. These last are overlapped by the *Warkilli beds*, which certainly appear to belong to a different series, and are thus perhaps of upper tertiary age; they appear also to be equivalent to the Cuddalore sandstones of the Coromandel. Finally, there are the recent deposits.

The gneisses are generally of the massive grey section of the series, that is, they are nearest to the rocks of the Nilgiris, though they differ from them in being coarser-grained or more largely crystallized, and in being generally quartzose rocks.

So quartzose are they, that there are, locally, frequent thin beds of nearly pure quartz-rock which are at times very like reefs of vein-quartz. Often these beds are strongly felspathic, the felspar occurring among the quartz in distinguishable grains, or larger crystalline masses, giving the rock rather a granitic appearance. The only other region where I know of somewhat similar beds of quartz-rock occurring with other gneisses, is in the schistose region of the Nellore district. There, however, the quartz-rock becomes often a fine, compact quartzite; here, in Travancore, there are no approaches to such compact forms.

The common gneisses are felspathic-quartzose varieties of white or grey colours, very largely charged with garnets. A particular form of them is an exceedingly tough, but largely crystallized, dark-grey or greenish felspathic rock.

Massive hornblendic gneisses are not common. Indeed, hornblende may be said to be a comparatively rare constituent of the Travancore gneisses.

All the gneisses are more or less charged with titaniferous iron in minute grains; they are likewise, only more visibly, as a rule, highly garnetiferous. In fact, one might say that Travancore is essentially a country of garnetiferous gneisses. The garnets themselves are only locally obtainable, it being impossible to break them from the living rock, while they are generally decomposed or weathered. They are generally of small size, but are very rich in colour, the precious garnet being very common. Other minerals, such as red, blue, and yellow sapphire and jacinth, are found among the garnet sands so common on the sea-shore at certain places. The sea sands are also full of titaniferous iron grains. While on this subject, I may instance the beautiful and long known constitution of the shore sands at Cape Comorin, where, on the beach, may be seen the strongest coloured streaks or ribbons, of good width, of bright scarlet, black, purple, yellow, and white sands of all these minerals and the ordinary silica.

As will be seen further on, an enormous quantity of ferruginous matter is collected among certain forms of weathered gneiss and other rocks, the source of which is hardly accounted for in the apparent sparse distribution of iron in the gneisses. After all, however, an immense supply of ferruginous matter must result from the weathering of the garnets, when we consider that they are so generally prevalent in all the gneisses, and crowdedly so in very many of them.

The general lie of the gneisses is in two or three parallel folds striking west-north-west to east-south-east. There is, perhaps, rather a tendency of the strike more to the northward in the broad part of the hills, about Parmand, and on towards the Cochin territory. Thus, between Trivandrum and Tinnevelly on the west coast, or for some 12 to 20 miles inland, the dip is high to the south-south-west; inland of the terraced or plateau country, or among the first parallel ridges, there is a north-north-east dip; then, on the mountain zone, there is again a high dip generally to the south-south-west. Thus the inclination of the beds is generally high, right across the strike with a crushed-up condition of the folds; but they are often at a low angle, and the anticlinal on the western, or the synclinal on the eastern side, are plainly distinguishable. About Kurtallam (Courtallum), on the Tinnevelly side, the rise up from the synclinal is very well displayed, and in their strike west-north-westward into the broad mountain land, the beds of this place clearly take part in a further great anticlinal which is displayed in a great flat arch of the Parmand strata. With this widening out of the mountain mass, there is rather an easier lie of the strata.

Southwards from the Ariankow traverse just detailed, there is much crushing up of the beds; but they roll out flatter again towards the southern extremity, and there are good indications of a further synclinal to the south-south-west, in the northerly low dipping beds of Cape Comorin.

Foliation is very strongly developed: indeed it is here, practically, bedding and lamination, of which there are some wonderful exhibitions. At Cape Comorin, indeed, some of the gneiss in its weathered condition (not lateritized) is scarcely to be distinguished, at first, from good thick-bedded and laminated sandstones and flaggy sandstones.

There is no special development of igneous rocks either in the way of granites or greenstones, though small veins and dykes are common, generally running nearly with the strike of the gneiss. In southern Travancore, or north of the parallel of Trivandrum, there are stronger occurrences of granite, in which the mica is abundant and in largish masses.

The great feature about the gneisses in Travancore, and indeed also in Cochin and Malabar, is their extraordinary tendency to weather or decompose generally into white, yellow, or reddish felspathic clayey rocks, which, in many places and often very extensively, ultimately become what is here always called *laterite*. The evidences of this are, after all, only well seen in the field; but it may be stated here that these are seen principally in the constituent minerals, mainly the quartz, being still identifiable in much of the rock—in the lamination or foliation being also traceable—in the gradual change from the massive living-rock to the soft and finally hard, scabrous, and vermicular ferruginous clayey resultant called laterite—and in the thin, pale, and poorly ferruginous form exhibited by the weathering and alteration of the more felspathic and quartzose gneisses.

This altered form of the weathered gneiss occurs over a definite area which I have laid down approximately in the map. At the same time, the change from unweathered gneiss to this belt is not sharp; for long before the eastern limit of the more generally lateritized belt is reached, approaching it from the mountain zone, the great change has begun.

Very soon after one begins to leave the higher ribs of the mountains, and to enter on the first long slopes leading down to the low country, the gneiss begins to be weathered for some depth into a clayey rock generally of pale colours, streaked and veined with ferruginous matter, and having always an appreciable upper surface of scabrous or pisolitic brown-iron clay, which is, of course, probably largely the result of ferruginous wash and, less so, of ferruginous infiltration. Also, the ferruginous and lateritoid character is developed to a certain extent according to the composition of the gneisses; but, on the whole, there is no doubt that the upper surface generally over large areas is lateritized to a certain depth, irrespective of the varying constitution of the strata.

Then, as the rocks are followed, or crossed, westward, the alteration becomes more frequent, decided, and deeper seated; though still, all over the field, ridges, humps, and bosses of the living rock rise up from the surrounding more or less decomposed low-lying rock areas.

This generally irregular and fitfully altered condition of the gneisses begins at an elevation of about 400 feet above the sea, and thus it extends as a sort of fringe of varying width along the lower slopes of the mountains.

At a yet lower level, say from 200 to 150 feet, and so nearer the sea-coast, there is a better defined belt of more decidedly lateritized form of weathered gneiss, in which the unaltered rock occurs less frequently, and then always in more or less flatly rounded humps and masses, which never rise above a general dead level. This belt is, in fact, a country of undulating downs (where free from thick and lofty jungle), or tolerably uniform level stretches of forest land. Occasionally, it also shows a plateau surface, or it is broken into small and low flat-topped hills. Always it is very deeply indented by river and stream valleys, or even by some of the back-waters which have high and steep shores.

Further northwards, the plateau character of the lateritic gneiss belt is very well developed in Malabar.

It is remarkable of this coastal belt of country that its laterite (an altered, or ferruginously infiltrated condition of weathered or decomposed gneiss) is not to be distinguished from any other laterite, except that which is made up of obviously detrital material.

Whatever the laterite of Travancore or Malabar may have been originally, it is an useless form of the rock, being crumbly and soft as a general rule, and oftener of a red colour than brown. The character of the climate does, in fact, appear to militate against the changing of the red peroxide of iron in the rock, to the brown peroxide, during which change the proper cementing and hardening of the sound rock, such as that on the east coast or in the Deccan, is evidently brought about.

The next succeeding rock formations, namely, the Quilon and Warkilli beds, occur as a very small patch on the coast between the Quilon and Anjengo back-waters.

The Quilon beds are only known through the researches of the late General Cullen, who found them cropping out at the base of the low laterite cliffs edging the back-water of that place, and again in wells which he had dug or deepened for the purpose. I was myself not able to find a trace of them. They are said to be argillaceous limestones, or a kind of dolomite, in which a marine fauna of univalve shells, having an eocene *facies*, was found; and they occur at about 40 feet below the laterite of Quilon, which is really the upper part of the next group.

The Warkilli beds, on the other hand, are clearly seen in the cliffs edging the sea-shore some 12 miles south of Quilon, where they attain a thickness of about 180 feet, and have the following succession in descending order:—

Laterite (with sandstone masses).
Sandy clays (or lithomarge).
Sandy clays (with sandstone bands).
Alum clays.
Lignite beds (with logs of wood, &c.).

The bottom lignite beds rest on loose white sand; and nothing is known of any lower strata.

It will be seen how this set of strata has an upper portion, or capping of laterite, which is however clearly detrital. On the landward edge of the field of those Warkilli beds, there is in places only a thin skin, representative of these upper beds, of lateritic grits and sandstones lying directly on the gneiss, which is itself also lateritized; and it is very hard, as may be supposed, to distinguish the boundary between the two, unless the detrital character of the former deposits is well displayed. Thus, the upper part of the formation has overlapped the gneiss. It is also this upper portion which overlies the Quilon beds, which are also apparently overlapped.

These Warkili beds constitute, for so much of the coast, the seaward edge of the plateau or terraced country above described, and they present similar features. The Warkilli downs are a feature of the country—bare, grass-grown long flat undulations of laterite, with, about Warkilli itself, small plateau hills forming the higher ground—180 to 200 feet above the sea. These downs too and the small plateaus or flat-topped hills, are partly of the Warkilli laterite and partly of the lateritoid gneiss.

Whatever form of denudation may have produced the now much worn terrace of the gneissic portion of the country, the same also determined the general surface of the Warkilli beds. Indeed, it gradually dawned on me while surveying this country, having the remembrance of what I had seen of the plateaus and terraced low-land in Malabar in previous years, that here, clearly, on this western side of India is an old marine terrace, which must be of later date than the Warkilli beds.

These are, as I have endeavoured to show in another paper, of probably upper tertiary age, and equivalent of the Cuddalore sandstones of the Coromandel. Hence this terrace must be late tertiary or post-pliocene, and it marks, like the long stretches of laterite and sandstones on the eastern side of the country, the last great or decided elevation of Southern India, prior to which, as is very probable, the Indian land rose almost directly from the sea by its Western Ghâts and had an eastern shore line which is now indicated very well by the inner edge of the Tanjore, South Arcot, Madras, Nellore, and Godavari belts of laterite and sandstone.

Mr. Foote has already generalised in this way for the eastern side of Southern India in particular; but I think he makes the elevation too great, including, as he does in his laterite deposits, patches of lateritized gravels and rock masses ranging up to a height of 500 feet at least, which are not so definitely part and parcel of the proper coastal developments.

The plateau form of the Coromandel areas has often already been commented on; but their connection with a terraced form of marine denudation is more clearly brought out, now that the evident conformation of the Travancore and Malabar low-land is ascertained.

The somewhat different level of the surfaces of these plateau lands on each side of the peninsula is also interesting in so far as there is an evident general very slight inclination of the whole to the south-eastward.

One more very small patch of variegated sandstones, but associated with scarcely any laterite, occurs in the Travancore country at Nagarcoil, about 12 miles north of Cape Comorin. I should certainly take this to be representative of the Cuddalore sandstones, so long as no positive evidence to the contrary turns up; and it may be the nearest connecting link between these rocks on the eastern coast and the Warkilli beds.

The recent deposits are the usual blown-sands and alluvial deposits of the low flats along the coast; an exceptional form occurs at Cape Comorin in the shape of a hard calcareous sandstone, which is crowded with true fossils and casts of the living *Helix vitata*. It appears to be simply a blown-sand, modified through the infiltration of calcareous waters. Loose blown sands are heaped over it now in places, among which are again thousands and thousands of the dead shells of the past season. The examination of this deposit has, however, been left to Mr. Foote, who has likewise reserved for his study other remarkable fossiliferous rocks of very late age which occur in this neighbourhood.

The Warkilli Beds *and reported associated deposits at* Quilon, *in* Travancore, *by* WILLIAM KING, D.Sc., *Deputy Superintendent (Madras), Geological Survey of India (with a map).*

The rocks to be treated of in this paper are some lateritic sandstones, alum clays, and lignite beds, and other fossiliferous strata, which occur in the following order of succession :—

The Warkilli[1] *Beds :* apparently equivalent to the *Cuddalore sandstones* of the survey nomenclature.

The Quilon Beds: reported as having yielded fossils of presumably *eocene* age, and only known through the researches of the late General Cullen.

The Travancore low country, that is, so much of the western coast of southern India, as extends from Cape Comorin to within a short distance of

[1] Otherwise Wur-kullay or Varkalay.

Cochin, is slightly elevated and broken into low hills and ill-defined terraced land; thus differing very strongly from the far-stretching plains of the Carnatic, which touch the sea merely by a low bank of sand-hills to nearly as far north as Vizagapatam. At the same time, there is a narrow strip of the northern portion of Travancore which is just on the sea-level, and marked by a chain of extensive and lengthened back-waters or lagoons, the canal communication between which has, until lately, been barred by one small range of low hills between Cochin and Trivandrum. This barrier is the most important of the few approaches of the low terraced upland close on to the sea-shore; and it presents—looking at the absence of such features along the Coromandel, or their rarity along the west coast, the remarkable line of low and beautifully coloured cliffs of Warkilli. This barrier has now, however, been tunnelled so as to allow of complete and unbroken water communication, by which chance fresher sections—though unfortunately not deeper—were displayed of the rocks already so long exposed in the cliffs.

I believe the first idea of thus opening up a complete system of water communication may be attributed to the late General Cullen, then British Resident of Travancore; at any rate, he it was who first drew attention to the geology of this Warkilli barrier, and the occurrence of similar deposits near Quilon. General Cullen did not, it is to be regretted, publish any of his experiences, but he forwarded collections to Bombay, and communicated his observations to Mr. H. J. Carter, then Assistant Surgeon on the Bombay establishment, who embodied them in his well-known "Geological Papers on Western India." The previous literature is therefore, as far as is known, these writings of Mr. Carter; and his conclusions on the occurrence of these rocks, and the fossils said to have been obtained from them, were that they are preferably of eocene age. The following extracts from Mr. Carter's work (*l. c.* p. 741) give the information afforded by General Cullen, beginning with that for Warkilli itself:—

"The laterite and lignite cliffs of Varkalay, which are also near Quilon, that is, about 12 or 14 miles south, extend along the coast about 6 miles, varying in altitude from 40 to 60 feet. Below the laterite is a series of very beautifully variegated coloured sands and clays, and below them again the carbonaceous clays or shales and lignites. At the north end of the cliffs, where they are only 80 feet high, the lignite bed is level with the beach; but to the south, where the cliffs attain an altitude of 140 feet, there appear to be three or four successive deposits of lignite, each of which is from 4 to 6 or 8 feet thick. To ascertain, also, if this lignite bed extended inland, I sunk a well 20 feet in diameter, at a distance of about 100 yards from the cliff; and, after passing through 22 feet of laterite only (because the well was here sunk in a hollow), came to the lignite clays. I then sunk a small well, about 5 feet in diameter, on one side of the large one, to determine the thickness of the lignite bed, which was penetrated after 7 feet, meeting then with a bed of loose, white sand, from which the water immediately sprung up so rapidly as to oblige the people to leave off working. I have not found any traces of organic remains in these cliffs, nor any traces of limestone. The carbonaceous lignite beds abound with resin and iron pyrites (white), both, in lumps of considerable size. I have a lump of resin 10 inches in diameter.

"The variegated coloured sands that I have spoken of as lying between the laterite and lignite beds, are exceedingly beautiful—at least fifteen different and perfectly distinct tints.

It has strongly reminded me of what I have often heard, but never seen, except in geological drawings, *viz.*, the strata of Alum Bay in the Isle of Wight."

The next place of examination was near Quilon; and it may as well be stated here at once, that I have myself only been able to carry on the uppermost member alone of the Warkilli beds so far north. It will be seen by the next extract (*l. c.* p. 740) that General Cullen was more successful in so far as he found other very important rocks, which were also fossiliferous.

"The first well I opened was on a laterite cliff or point, 4 or 5 miles north-east of the town of Quilon. Having observed some yellowish slabs of dolomite [argillaceous limestone?] at the base of the cliff or strand of the back-water, which there suddenly deepens to 40 feet, and therefore prevented my tracing it further downwards, I laid open several feet of the face of the cliff, and, still finding the dolomite slabs apparently passing under it, I then went above, for about 100 feet inland, and there sunk a large well, and met with the dolomite at the depth of about 38 feet.

"I then ascertained that the dolomite appeared everywhere to prevail below the laterite round Quilon, at a depth of about 40 feet from the surface.

"This was determined by the examination of wells in different localities, and by further sinking several which had not been carried down to that depth.

"I think there was a loose rubbly bed or stratum, of exactly the same composition as the compact limestone both above and below the slabs, and in which the greater number of the organic remains were found; but the limestone itself (though extremely hard and tough) also contained numerous specimens in the most perfect state of preservation.

"The limestone is of a bluish-grey inside, but externally, where exposed to the weather, of a dull yellowish colour."

This is all that is given of General Cullen's own descriptions; but Mr. Carter subsequently, in his notes, states that further information was furnished in one way or other about these Quilon deposits. Thus (*l. c.*, p. 741)—

"The specimens of limestone, too, which General Cullen formerly presented to the Society through Dr. Buist, not only bear the colour of the clay, but, with its imbedded tertiary shells, also contain portions of lignite indicating its intimate connection with it."

Again, in his discussion of the fossiliferous evidence of the tertiary deposits of Western India, Mr. Carter writes (*l. c.*, p. 743):—

"In this structure it will be seen that they resemble *Orbitolites Malabarica*, H. J. C. (Ann. and Mag. Nat. Hist., 2nd Ser., XI, p. 425, 1853), of the blue, clayey, argillaceous limestone of the coast of Travancore[1] * * ."

[1] On reference to this paper, I find that the locality of Orbitolites is moved further north, thus: "*Locality*—Abounding in an impure, bluish-green limestone (of the Pleiocene of [*sic*] formations), about 30 feet beneath the surface at Cochin on the Malabar coast, the shells of which, though deprived of their animal matter, are still white and pulverulent, or semi-crystalline." Mr. Carter, who is now residing in England, has very kindly allowed me to communicate with him on the subject of these Travancore fossils, and as regards this variation in locality, writes (7th November 1881):—"As regards the discrepancy in *locality* evidenced in my account of *Orbitolites malabarica*, it should be known that the specimens bearing this *Foram.* came into my hands while I was Conservator of the little museum of the Bombay Asiatic Society, as you may see by the extract, through the late Dr. Buist. This was some time before I began to correspond with General Cullen, and therefore long before I knew anything of the Quilon and Verkallay deposits; so it is not improbable that they, the specimens, were labelled "Cochin." At all events it is a mistake, for which I can offer no other explanation."

And at page 744:—

"Lastly comes the argillaceous limestone of the Malabar coast, not only abundantly charged with the Orbitolite just mentioned, but there again in company with *Strombus Fortisi*, together with *Cerithium rude*, *Ranella bufo*, *Cassis sculpta*, *Voluta jugosa*, *Conus catenulatus*, and *C. marginalus* (Grant, Geol. Cutch, Tert. Foss.); also *Natica*, *Turbo*, *Pleurotoma*, *Fasciolaria*, *Murex*, *Cancellaria*, *Ancillaria*, and *Cyprea*, all (new species?) closely allied in form to the figured shells of the eocene period. The orbitolite differs very little, except in size, from *Orbiculina angulata*, Lam. (Encyclop. Méthodique, pl. 468, fig. 3), from which I infer that the latter should also be included among *Orbitolites*, Lamarck."

I have given the above extracts here, because they go far to show that these fossils, or some of them, are those which were forwarded by General Cullen as having been procured from the beds underlying the Quilon laterite.

General Cullen's description of the occurrence of this "dolomite" and its fossiliferousness is so circumstantial that we must, until better negative evidence than that afforded by my unsuccessful search can be obtained, perforce believe that the rock and the fossils exist as described; hence, I will so consider this deposit in its relations with the Warkilli rocks.

The Warkilli beds consist of a series of sands and clays capped by laterite, giving the range of cliffs touching on the sea-shore. The highest part of the sea-face is at the southern end, between Warkilli village and Naddangúndi (Neddungunday), on the Anjengo back-water. Northwards the high ground runs down with the dip of the rocks, which is very gentle to the north, and thus the range of cliffs soon ceases in that direction until only a low scarped edge of rocks meets the sea at the Parravur[1] (Purra-ur) back-water. Thence, in the same direction, representative strata of the capping beds show only at some distance inland until Quilon is reached, where such rocks approach the shore and form at Tangacheri (Tungumshery) point a very low scarped headland, beyond which out in the sea are barrier reefs of the same rock.

It is not very easy to give the exact limits of the area of the Warkilli rocks, owing to the confusing way in which that peculiar form of rock alteration which gives rise to laterite,[2] or a rock resembling laterite, is developed, not only in these deposits themselves, but in the crystalline rocks or gneisses on which they lie and in the superficial rain-wash and debris covering both. Indeed, an ordinary

[1] A peculiarity of the Travancore topography is that there are few well-marked assemblages of dwellings answering to the villages of the eastern side of South India. The names given in the map apply rather to town lands, the cottages or farms being scattered and independent.

[2] The origin of laterite being still unsettled, it is as well that no opportunity should be neglected for keeping certain points in the investigation well to the fore. Only lately, I see that my colleague, Mr. F. R. Mallet, in his paper "On the ferruginous beds associated with the basaltic rocks of North-Eastern Ulster, in relation to Indian laterite" (Records Geol. Surv. of Ind., XIV, p. 148) writes with reference to a generalisation of Mr. W. J. McGee of Farley, Iowa, U. S. A.:—"But that laterite is a product of the alteration *in situ* of the underlying rocks is a view open to serious objections, which has been fully discussed by Mr. Blanford." Now this is striking at actual facts, against which no local or theoretical objections can be taken into consideration: for,—to put it plainly, and as long as we are unable to define strictly what shall and what shall not be called *laterite* among the strange ferruginous rocks which go by that name,—certain forms of this rock are actually and really an altered condition of the rock *in situ*. Such is the case

observer would say, that not only are the Warkilli downs composed of laterite, but that the greater part of the country far inland also consists of the same rock. Practically, there are thus three forms of rock here and in the neighbourhood which usually go by the name of laterite:—

1. Superficial ferruginously cemented debris.
2. The ferruginous, clayey, reddish or brown coloured, irregularly vesicular and vermiform scabrous rock forming the uppermost portion of the Warkilli beds, which is unmistakably detrital, and which I will call *laterite* in this paper.
3. The altered form of decomposed gneiss (called 'kabuk' in Ceylon), which I shall here write of as *lateritized* gneiss. This form always eventually shows traces of original crystalline structure and constitution.

Owing, then, to similarity of appearance and general ferruginous infiltration of these different rocks, it may be conceived how difficult it is to give close boundaries to the Warkilli beds. There is little trouble about their southern limit; but the eastern boundary is badly defined, it may range a short distance east or west of the line given in the annexed map, and particularly it may be much more sinuous than I have shown, and there may be a few insignificant outliers. About Quilon, I am exceedingly doubtful as to whether a good deal of lateritized gneiss may not be included in my field: thus it would be no easy task for me to persuade any one who had not had great experience of the behaviour of lateritic metamorphosis, that all the lateritic cliffs edging the Quilon backwater are not just as much laterite as those of the portion laid down on the map.

With these qualifications, the Warkilli rocks form a lenticular patch for about 22 miles along the coast, with a breadth, in the middle of the field, of about 5 miles; laterite alone at the Quilon end, and—by their gentle hade up to the south—laterite with underlying beds to a thickness of about 180 feet at the Anjengo end.

The series, as displayed in the cliffs at this end, is in descending order—

	Feet.
Laterite.—Ferruginous clays and sandy clays, in which are occasional, ill-defined masses and bands of coarse sandstone and incoherent sand, more or less vesicular, with irregular hollows and pipe-like or vermiform passages (discontinuous), very many of which are filled with white and pinkish fine clay; brown coloured, shading downwards to red, white, and yellow mottled; banded. Any bedding which may have existed is now much obliterated, and the upper brown band, which is more properly laterite, is not recognisable as a separate bed or capping	30 to 40

in Travancore, Malabar, and Ceylon, where I have over and over again traced the laterite (as it is called in Travancore) or the 'kabuk' (the Singalese synonym) into the living gneiss rock. I have held this view of what may be called the lateritization of gneiss with Mr. R. Bruce Foote (my colleague in Madras) for the last 20 years: our conclusions having been based on observations on the Nilgiris, Shevaroys, and other elevated regions in the Kurnool and Cuddapah districts; and my enlarged experience of the western coast and Ceylon have only confirmed it. Our experience of the Deccan laterites is not so extended, but we are agreed also that some of these must be products of alteration of the rock *in situ*.

	Feet.
Sands and sandy clays.—Red, yellow, white, and purple variegated sandy clays, with rather more distinct bands and masses of sandstone. Mottled in colour, but not so vesicular as the rock above, though still marbled with vermiform runs of finer clay (lithomarge of some writers). ... about	40
Pale red and white variegated and laminated sandy clays ...	10
Alum Clays.—Dark-coloured purple grey, compact clays with thin, scarcely appreciable, laminæ of iron pyrites, giving bright yellow alum efflorescence	5
Various coloured alum clays and sands; dark grey and buff at the bottom and yellow towards the top	20
Lignite beds.—An incoherent sandy bed of varying thickness, much laminated with brown loamy and clayey material, in which are many lumps and even logs of wood in various conditions of preservation. The wood is mostly blackened, and much in the condition of the 'bog-oak' of the Irish peat bogs	2 to 10
Dark, nearly black, clay; often rather peaty, or having patches of fine black vegetable matter, with particles and small masses of iron pyrites; containing, here and there, big logs of spongy, rotten, and, as it were, charred wood, and lumps of coarse resin . . . . about	5
Loose sands.—Coarse and white-coloured; only a few inches exposed.	

Thus, for the sea-cliffs, the section is in general terms:—

	Feet.
Laterite	30 to 40
Sands and sandy clays, or lithomarge	58
Alum clays	25
Lignite beds	7 to 15
Sands	...
Total .	120 138

Strong springs of clear fresh water issue at several points along the base of the cliffs from above the alum clay band. These are supposed to possess curative properties, and are accordingly of frequent resort.

The sections exposed in the cuttings and tunnelling of the barrier, which lie from a few hundred yards to half a mile inland, give a thickness of 30 to 70 feet for the laterite. This shades down into red, yellow, and whitish clayey sandstones, which are generally soft and wet, though at times hardened in bands and patches, and which have a variable thickness of from 40 to 90 feet owing to a wavy and uneven bottom. The alum clays are beautifully exposed in good beds, and for a long time they presented a fine display of colours—reds, blues, and greys, with strong bright yellow efflorescence, which have now, however, become blurred through exposure. In their lower sandy portion there is a good deal of wood. The thickness of the alum beds is about 20 feet. The proper lignite seam has about the same thickness as on the shore; but as the base of the tunnel does not run below them, there is no knowledge of the subjacent rock.

The outer and inner sections are thus substantially the same,—the differences being that the beds below the laterite, in the cuttings, are rather clayey sandstones than sandy clays; while logs of wood are found in the alum clays also.

As these beds are followed northwards along the shore, the dip gradually carries the lignite band below the beach, which is next bordered, for some hundred yards, by the alum clays, the upper edge of which is marked by the bamboo spouts let in above them at convenient places for carrying off the water of the sacred springs.[1] Then the clays, in their turn, run under a long flat beach, over which the water of the springs now flows directly, and about a quarter of a mile further on, the lowering cliffs are simply of the laterite, which rock finally ceases to show on the shore near Purravur.

The Warkilli capping is, however, continued inland in a north-eastward direction to the narrowing of the Purravur lagoon at Mailakád (Mylaked), but here all that exists of it is a very thin skin of coarse ferruginous grits and sandstones, which is lying directly on weathered and lateritized gneiss, the lower portions having thus been overlapped. Hence, if the clays, &c., are continued northward, they must lie deep under the lagoon and the sea.

From Mailakád other sandstone outcrops, associated with laterite, are traceable up to Quilon, under which place it might naturally be expected that either some trace of the Warkilli beds should be found, or that the laterite should overlie the gneiss directly. The only deposits, however, which I could find differing from the prevalent laterite, or its underlying lithomarge (common at the base of the low cliffs edging the back-water) is a loose, very coarse, yellow sand, occurring in a dried-up stream bed, or wide ditch, near the mosque between the civil town and the parade-ground, which is like some of the loose sands below the laterite band at Warkilli. I saw no limestone[2] or other calcareous rock answering to that described so circumstantially by General Cullen as cropping out at the base of the low cliffs north-east of Quilon.

Only representatives therefore of the upper portions of the Warkilli beds

[1] The water seam supplying the springs on the sea-shore was tapped by the tunnel operations, and there was a slight temporary decrease in the discharge. The leaking of the water in the tunnels and at the cuttings over the freshly opened alum clays, and the mixture of ferruginous wash from above, thus gave rise to considerable surmise as to the existence of natural chalybreate and other waters. Such are, however, only produced temporarily, though they will be collecting for a long time, and they might be found efficacious in some cases of the skin diseases so common on this coast.

[2] This reported occurrence of limestone and fossils by General Cullen is one of the strangest incidents of recorded observation which has taken place in India; for his account of it, and of his reasons for concluding that such a deposit underlies the Quilon laterite, is so clear that one can hardly suppose him to be mistaken; and yet there is no other evidence of its occurrence than the general statement as given by Dr. Carter. Not only have I not been able to find it, or the least trace of any calcareous debris—itself a very strange thing when we recollect that wells had been sunk inland—but the same disappointment had been already experienced by the District Engineer, Mr. Horsley, who is perfectly capable of distinguishing a calcareous rock, and, under the very urgent requirement of the works at Quilon for mortar, most diligent search for this argillaceous limestone or dolomite had been made. I believe, also, that Mr. Horseley had the advantage of employing the only guide left in a servant at the Residency, who used to accompany General Cullen in his excursions, and to work for him. This man, unfortunately for me, was at the time of my visit paralysed in his speech through continued fever and rheumatism, or other ailments, and unable to be moved.

occur at Quilon resting upon and apparently overlapping a set of fossiliferous beds only known through the researches of General Cullen.

The Warkilli strata are clearly of fresh-water or lagoon origin, being in fact very much after the style of the deposits now being laid down in parts of the present back-waters into which, at flood times, a great deal of drift wood and decaying vegetable matter is being carried along with silt clays and sands and ferruginous matter.

The fossiliferous argillaceous limestones under the laterite at Quilon are apparently very thin; and as the fossils described as having been obtained from them constitute an essentially marine fauna, they can hardly be considered otherwise than as belonging to a separate and somewhat older group than that which has thinned out over them. Each of them may be groups of a series or of a formation, or they may not; but the important feature is that they are separate groups; and thus I would differentiate the Quilon beds.

Reference to the "Geological Papers on Western India" already quoted will show how the whole series of Travancore deposits has been correlated with very similar deposits on other parts of the coasts of the Peninsula; as on this side going northwards, at Ratnagiri, Bombay, Broach, Kattiwar, Cutch, and Sind, and, on the other side, through the sandstones and laterite of the Coromandel, and the fossiliferous intertrappean beds near Rajahmundry. This correlation went too far, however, partly through this separate grouping not being known, and by a very natural straining at the comparison of a series of laterite and fossiliferous beds with the lateritic beds and limestones of Rajahmundry, which last now appear to be most reasonably of upper cretaceous age[1]: while the fossiliferous beds of Bombay northwards are of tertiary age.

Mr. Carter's correlation of the Quilon fossils with those of the Kattiwar, Cutch, and Sind beds, still stands, however, and he thus makes them out to be preferably of eocene age.

The Warkilli beds must then be either of the same age, or, if different conditions of deposition and apparent overlap go for anything, of perhaps a later tertiary age.

The evidence given by the wood at the base of the alum clays and in the lignite seam, is of little significance considering that perfectly fossilised wood occurs in the older alluvial deposits of the Godávari valley, which certainly appear to be far later deposits than these; though the very unaltered condition of the logs implies that they must be much newer than those containing the perfectly bleached and dull shells said to have been obtained from the Quilon diggings. To all appearance, indeed, this wood is very like the black-wood now growing in the Travancore forests; and it is so unaltered in good specimens that large pieces of furniture have been made from it which are scarcely distinguishable from that made out of the modern timber.

Again, taking up the original generalisation of Carter and other observers, but leaving the intertrappean beds of Rajahmundry out of count, there does not

[1] See Memoirs Geological Survey of India, XVI, pt. 3, and Manual of the Geology of India, Chapters XIII & XIV.

appear, so far as is yet known, to be any representative of the Quilon beds on the Coromandel, at least as far south as Madura. On the other hand, there is a strong lithological likeness between the upper portion of the Warkilli beds and the upper portion of the Cuddalore sandstones as at Vellum, in Tanjore, in the Red Hills of Pondicherry and Madras, and in the Nellore and Godávari districts; while they are all similarly situated as low-lying or not very elevated fringes bordering the sea-coast. There is also a possible link to this chain of coastal deposits on either side of India, in a small patch of red and variegated sandstones, with, however, very little show of laterite at Nagercoil, about 12 miles north of Cape Comorin.

Irrespective, however, of any argument from the association of the Warkilli laterite and sands with fossiliferous limestone having eocene affinities, a generally tertiary age has been given by us to the Cuddalore sandstones, through their discordant lie on the cretaceous rocks in South Arcot and on the traps and intertrappean beds of Rajahmundry. Hence, on the ground of lithological likeness, similarity of position, and, as far as it goes, general approximation of age, it may be assumed that the long supposed contemporaniety of the coastal laterite and sandstones is now fairly made out. Thus, as they are so continuously developed over large areas and occur in detached positions over so lengthened a coast line, without apparently being accompanied by or associated with these strange Quilon rocks, except in this one locality, they are indeed strongly separable from the latter and thus presumably of much later, or even upper, tertiary age.

I have had opportunities in previous years, and this season again, of examining the West Coast for some considerable distance further north, past Cochin and on to a few miles beyond Calicut; but so far there is no further representative of the Warkilli beds in particular, or the Cuddalore sandstones in general. It is quite true, however, that there are very extensive tracts of what is called laterite, as well as a remarkable terraced and plateau form presented by many of the low hills of these tracts. My examination of these showed, however, that all this lateritic country is merely one of a decomposed form of gneiss, and that the capped character of the plateaus in the neighbourhood of Beypur and Calicut, for instance, is due to the denudation of an originally planed-down terrace of gneiss into detached plateaus, the upper surfaces of which are altered and lateritized to a certain depth.

There may be detached patches of the Warkilli beds north of Calicut as yet unknown, but the first occurrence of rocks resembling them, of which there is any record, is in the neighbourhood of Ratnagiri, of which the following section is given by Dr. de Crespigny (1856)[1]:—

"Soil and detrital conglomerate	(a few feet).	
Laterite (soft below)	35	ft.
Compact iron stone	1½	„
Lignite	27 (with Blue clay)	„
Blue clay		
Water, yellow gravel		
Trap."		

[1] Carter's Papers, *op. cit.* p. 722, foot note.

Mr. C. J. Wilkinson, when attached to the Survey (in 1863), visited this part of the country, and thus describes[1] tho occurrence of these rocks:—

"At Ratnagherry, &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 exposed in the deep sections and at the base of the cliffs."

It cannot, I think, be doubted that here is a true representative of the Warkilli beds; and as the traps on which the rocks lie are generally flat, it is not to be expected that any representative of the Quilon beds shall be found.

Note on some Siwalik *and* Narbada Fossils *by* R. LYDEKKER, B.A., F.Z.S., *Geological Survey of India.*

1. *The Narbada Hippopotamus.*

In Falconer and Cautley's great work on the fossils of the Siwaliks, there are figured numerous remains of hippopotami from the pleistocene deposits of the Narbada valley. Among these remains all are referred to a species named *Hippopotamus palæindicus*, with the exception of four lower jaws,[2] which are referred to a second species under the name of *H. namadicus*. Unfortunately neither of these species was ever described, so we are compelled to rely upon Falconer's figures and occasional notes. It is stated[3] that *H. palæindicus* is allied to the living African hippopotamus, but is distinguished by the median pair of incisors being slightly smaller than the outer; the reverse being very markedly the case in the living species. This species had only two pairs of lower incisors, and was accordingly referred to Falconer's sub-genus *Tetraprotodon*. These teeth are of large size.

In *H. namadicus*, which, as already said, is known only by the lower jaw, there are always six incisors, which in some specimens (F. A. S., pl. LVIII, figs. 1, 3,) are sub-equal in size, and placed in the same horizontal line; while in others (*Ibid*, pl. LVII, fig. 12; LVIII, fig. 2), the second pair of incisors is rather smaller than the others, and thrust somewhat above their line. All the incisors of this form are smaller than those of the tetraprotodont form.

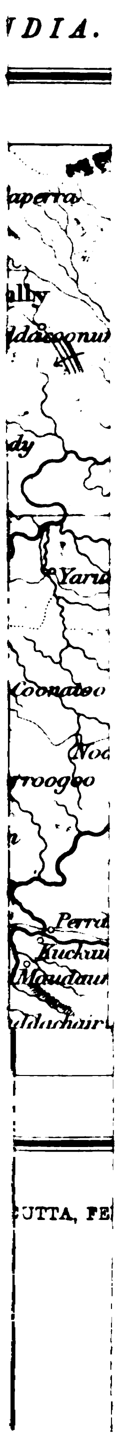
If no other specimens than those figured in the "Fauna Antiqua Sivalensis" were in existence, I should have little, if any, doubt as to there being two species of Narbada hippopotami. There are, however, two specimens of the mandibles of hippopotami in the Indian Museum, from the Narbada deposits, which lead me to have very grave doubts on this subject.

The first of these specimens (F. 147) has three pairs of incisors of sub-equal size, and must therefore be referred to Falconer's *H. namadicus*. The second

[1] Records G. S. of Ind., IV, p. 44.

[2] Pl. LVII, fig. 12; LVIII, figs. 1, 2, 3.

[3] "Pal. Mem." Vol I, pp. 21, 147, 497.



pair of incisors are, however, more raised above the line of the others than in any of Falconer's specimens.

The second specimen (F. 148) has two pairs of very large and closely approximated incisors, and therefore agrees with Falconer's *H. palæindicus*. In the upper angles between these large teeth, there are, however, wedged in, two very minute teeth, corresponding to the second pair of incisors in *H. namadicus*. The vertical diameters of the first, second, and third incisors in this jaw are respectively 1·96, 0·59, and 2·0 inches; while in the other specimen they are 1·2, 0·9, and 1·33 inches. The specimen No. F 143 must certainly be referred to *H. palæindicus*, but the presence of the minute pair of second incisors connects it so closely with those forms of *H. namadicus* in which that pair of teeth is, so to speak, partly squeezed out of the way by the others, that it becomes a question whether the latter species can be maintained.

It is true that in the typical tetraprotodont forms, and in No. F 18, the first and third incisors are much larger than in typical hexaprotodont forms; but this might be accounted for by the greater space for growth which these teeth obtain in the tetraprotodont form.

On the whole, it would perhaps be rash to say positively that there is only one species of Narbada hippopotamus; but, taking into account that only one form of skull could be distinguished by Dr. Falconer, and the variations above noticed in the lower incisors, such was not improbably the case.

The tetraprotodont form of the Narbada hippopotamus seems to be distinguished from the African species by having the two pairs of incisors of sub-equal size, or the outer larger than the inner. In the living species the inner incisors are generally very much larger than the outer. The hexaprotodont form in which the lower incisors are of sub-equal size, and placed in the same horizontal line, seems to agree very closely with the older *H. sivalensis*, and I am not aware how they can be distinguished.

The Narbada hippopotamus, whether belonging to one or more species, shows a clear instance of the evolution of a tetraprotodont from a hexaprotodont form, after the general law of progression from the generalised to the specialised. These animals, further, most clearly connect the Siwalik with the living form, and may thus indicate the line of descent of the latter.

The above conclusions indicate decisively that Falconer's sub-genera *Hexaprotodon* and *Tetraprotodon* must be abolished, as their distinctive characters are found in the same species. They further indicate that it is almost certainly the second pair of incisors which is suppressed in the African hippopotamus; a fact which may prove of some importance in determining the homologies of the incisors in other ungulate mammals (*e.g.*, *Rhinoceros*) in which the whole of the typical series is not developed.

2. *Structure of molars of Mastodon sivalensis.*

A much worn molar tooth of *Mastodon sivalensis* from the Punjab in the collection of the Indian Museum,[1] which has been recently cut and polished, shows

[1] No. A. 258.

a peculiarity in the arrangement of the enamel, not previously observed, as far as I am aware, in the teeth of the Proboscidia. The enamel, in place of simply investing the cones, or denticles of the crown, as a regular cap, is thrown into numerous folds, placed at regular intervals from one another, penetrating deeply into the dentine of the cones, and converging towards their centres. The horizontal section of one of these cones exhibits a structure intermediate in respect to the depth of the foldings of the enamel, between that of the teeth of *Ichthyosaurus* and *Labyrinthodon*.[1] The infoldings are considerably deeper than those in the former genus, and if the symmetry of the cones were not interfered with by mutual adpressure, these infoldings would present a regular convergence towards the centre as in *Ichthyosaurus*. A second cut specimen exhibits a similar structure.

I have not observed this structure in the molars of any other species of mastodon; and from the statement of Professor Owen, that "there is no instance in the mammiferous class of these [enamel] folds converging at regular intervals all round the circumference towards its centre,"[2] it would appear that the molars of *Mastodon sivalensis* are quite peculiar in this respect, and exhibit a homology between the teeth of mammals and reptiles not previously known to exist.

3. *Captain Searle's Perim Fossils.*

A small collection of vertebrate fossils from Perim Island, collected by the late Dr. Wilson, has recently been presented to the Indian Museum by Captain Searle, Superintendent of Marine, Calcutta, which may be appropriately noticed here. The collection comprises a tooth of *Mastodon perimensis*, and a broken one of *M. latidens*. A lower jaw of *Acerotherium perimense*, and one of another member of the same family, showing the symphysis, and identical with the mandible referred to *Rhinoceros sivalensis* in the "Palæontologia Indica":[3] this form is new to Perim Island. Several limb-bones of elephants and rhinoceroses are also among the collection. There is a horn-core of a large ruminant, generically indeterminable. There are also two fine specimens of the cranium of *Gharialis gangeticus*, and the imperfect humerus of a large species of tortoise (not *Colossochelys*), new to these deposits.

With these additions the fossil vertebrate fauna of Perim Island includes the following forms[4] :—

Mastodon latidens, Clift.
" perimensis, Falc. and Caut.
" pandionis, Falc.
Dinotherium indicum, Falc.
Hyotherium, sp.
Sus hysudricus, Falc. and Caut.
Bramatherium perimense, Falc.
Camelopardalis sivalensis, Falc. and Caut.

[1] See Owen's "Odontography," pl. LXIV B.
[2] *Loc. cit.*, p. 201.
[3] Series X, Vol. II, pt. I.
[4] This list may be taken to supersede that given on page 343 of the "Manual."

Antilope, sp., and other ruminants.
Capra perimensis, Lyd.
? Rhinoceros sivalensis, Falc. and Caut.
Acerotherium perimense, Falc. and Caut.
Hippotherium theobaldi, Lyd.
Crocodilus palustris, Less.
Gharialis gangeticus, Gmel.
Colossochelys atlas, Falc. and Caut.
Testudo, sp.
Emyda, sp.
Trionyx, sp.

4. BAGARIUS YARRELLI, *from the Siwaliks.*

In the sixth volume of the "Journal of the Asiatic Society of Bengal"[1] a portion of a fossil ichthyopsidan skull is described and figured by Dr. Cantor as that of a gigantic batrachian. It was discovered by Colonel Colvin in the Siwaliks of Náhan, and is now in the collection of the Indian Museum.[2] In 1844 this specimen was again described and figured by Dr. M'Clelland,[3] who showed that it belonged to a siluroid fish, and probably to *Pimelodus.*

At a subsequent date reference was made by myself to the specimen,[4] when it was argued that it was improbable that it belonged to *Pimelodus*, since that genus is confined to the West Indies and Africa. In Dr. M'Clelland's time, however, the genus was less strictly defined and comprehended many Indian forms, and it will be shown below, that in this wider sense Dr. M'Clelland's determination was correct. It was suggested in my notice that the specimen might belong to the genus *Chaca.*[5]

Thus the matter remained till a few weeks ago, when a huge siluroid, caught in the Hughli, was brought to the Indian Museum by its captors. On seeing this gigantic fish I was at once struck with the resemblance of its head to the fossil skull, and accordingly made arrangements for comparing the two skulls as soon as the recent fish was macerated. This comparison I have lately made, and I find that the fossil (of which Dr. Cantor's figure gives a very good idea) comprehends the preorbital part of the skull and agrees precisely in every detail, both of shape and size, with the skull of the recent fish. The agreement between the two is so close that I have no doubt but that they are specifically identical.

An examination of the recent fish shows it to be *Bagarius yarrelli*, Sykes, which according to Dr. Day,[6] inhabits "the large rivers of India and Java, des-

[1] P. 538, pl. XXXI.

[2] No. E, 155.

[3] "Calcutta Journal of Natural History," Vol. IV, p. 83, pl. IX.

[4] Journal of Asiatic Society of Bengal, Vol. XLIX, pt. II, p. 15.

[5] This suggestion was mainly made on the supposition that the fragment of the skull was more complete than it is, and consequently that the skull was very broad and short.

[6] "The Fishes of India," Vol. II, p. 495, pl. CXV, fig. 3.

cending to their estuaries. It attains 6 feet or more in length." The present specimen was just under 7 feet in length. The old name of this fish was *Pimelodus bagarius*. The identity in size of the recent and fossil skulls probably indicates that the two specimens had attained the full development of which the species is capable. The extreme length of the recent skull is 21·4 inches.

The determination of another existing species of vertebrata in the Siwalik fauna is a matter of extreme interest, and confirms the inferences previously drawn as to the geological age of this fauna. The living species now identified from the Siwaliks are *Crocodilus palustris*, *Gharialis gangeticus*, *Pangshura tectum*, *Emyda vittata*, and *Bagarius yarrelli*. We shall see below that *Python molurus* may not improbably be added to this list.

5. *The Siwalik Python.*

On page 20 of my paper in the "Journal of the Asiatic Society of Bengal" already quoted, reference was made to some ophidian vertebræ in the Indian Museum[1] from the Siwaliks of Sind and the Punjab, which were said to resemble those of *Python*. I have lately submitted these vertebræ to a careful comparison with those of the living Indian *P. molurus*, and can detect no difference between the two. Most of the fossil vertebræ belonged to pythons of not more than 5 or 6 feet in length, but an early dorsal [2] indicates an animal of upwards of 15 or 16 feet in length. It would, perhaps, be rash to say positively, from the evidence of these vertebræ, that the Siwalik python was specifically identical with *P. molurus*, but it is quite probable that such was really the case.

6. Narbada and Siwalik Mollusca.

Mr. Geoffrey Nevill, our specialist on Indian terrestrial mollusca, has been kind enough to examine the small collection of land and fresh-water shells from the pleistocene of the Narbada and Jamna, and also from the Siwaliks, contained in the Indian Museum. It may be observed that lists of shells from the Narbada beds have already been published by Mr. Theobald in two separate papers,[3] and that the specimens mentioned in the second of these papers are those submitted to Mr. Nevill, whose determinations differ somewhat from those of Mr. Theobald. Of Siwalik shells the Indian Museum has but three species.

A note on shells from these deposits is given in the "Palæontological Memoirs,"[4] but the knowledge of living Indian terrestrial mollusca was then so imperfect that the note is practically valueless. It would appear from this note that a considerable variety of Siwalik shells were obtained, which are probably now in the British Museum, and it is much to be desired that they should be submitted to the examination of some competent authority for determination.

[1] Nos. E205-206.

[2] No. E 206.

[3] Mem. Geol. Surv. India, Vol. II, p. 284, *et seq*. *Supra*, Vol. VI, p. 54, *et seq*.

[4] Vol. I, p. 389.

The shells from the Jamna pleistocene mentioned in the following list were collected, and presented to the Indian Museum by Mr. John Cockburn :—

Name.	Narbada.	Jamna.	Siwalik.	REMARKS.
Melania tuberculata, Mül., v. pyramis, Bens.	+	+	...	
Planorbis compressus, Bens.	+	...	...	
" convexiusculus, Hut.	+	...	...	
" exustus, Desh — ? var.	+	...	...	
Paludina bengalensis, Lam.	+	...	...	
" dissimilis, Mül.	+	+	...	
Helix proxima, Eish	+	...	...	
" asperella, Pfr.	+	...	...	
Buliminus (Cylindrus) insularis, Ehr.	+	...	+	
Corbicula, sp. 1	+	...	...	Referred by Mr. Theobald to *C. cor.*
" " 2	+	...	...	Very small, with large ridges.
" " 3	...	...	+	Large: Mr. Nevill cannot identify with any living form.
Unio marginalis, Lam.	+	...	+	
" favidens, Bens., var. 1	...	+	...	Near *U. marcens*, but cannot be identified with any living variety.
" " " var. 2	+	...	...	Near *U. wynegangensis*, Lea.
" " " var. 3	...	+	...	Near *U. triembolus*, Bens.
" wynegangensis, Lea	+	...	...	
" shurtlefianus, Lea	+	...	...	
" indicus, Sow., var.	...	+	...	
" macilentus, Bens., var.	+	...	...	
" corrugatus, Mül., var.	...	...	...	

The most important fact to be gleaned from this list is that two species, *viz.*, *Buliminus insularis* and *Unio marginalis*, can be traced without variation from the Siwaliks, through the Narbada to the present time: both are still living in the Narbada valley. A Siwalik species of *Corbicula* is considered by Mr. Nevill to be probably extinct, while a probable variety of *Unio favidens* from the Jamna seems to differ from any living variety, though great stress cannot be laid on this point owing to the uncertainty of the specific character of the members of this genus.

7. GIGANTIC HYOPOTAMUS, *from Sind.*

From the lower Manchhars of the Bhugti hills, north of Sind, Mr. W. T. Blanford has lately procured some upper and lower molars of a gigantic species of *Hyopotamus*. These teeth are far larger than those of any described species, nearly equaling in size the molars of *Anthracotherium magnum.* They will be described subsequently in the " Palæontologia Indica."

On the Coal-bearing rocks *of the valleys of the upper* Rer *and the* Mand *rivers in Western Chutia Nagpur.* (*With a map.*)

By V. BALL, M.A., F.G.S., *Geological Survey of India.*

The following is a record of observations made in the season 1870-71 during a traverse of the areas of coal measures which intervene between those of the Bisrampur field on the north and the Raigarh and Hingir coal-field on the south. Fuller and more detailed examination of these last mentioned fields in subsequent seasons enabled separate accounts of them to be published,[1] but as the details, now about to be given, were of incompleted areas, their publication was held over until such time as the whole area between Raigarh and Korba could be thoroughly explored and described as a united coal-field. Except a brief summary in the Manual of Geology[2] taken from the following notes, nothing has been published regarding these areas, so that in view of the present importance attaching to the existence of coal in this region and in anticipation of future more detailed work, it is thought that the following instalment of information may be of value as it serves to link together the coal measures of Sambalpur, Central Sirguja, and Korba, in Bilaspur.

Lakhanpur Field.

This field, as at present known, is a small area of about 50 square miles, situated in the south-west corner of central Sirguja and to the south of the Pilka hills.

On the north it is bounded by the Pilka fault, described in the Bisrampur report; on the north-east by metamorphic rocks, the boundary being probably natural. On the south-east also by metamorphic rocks, the boundary being here faulted; on the south partly by metamorphic rocks and partly by Talchirs which connect it with the Rampur field. The western extension has not yet been examined.

Within the limits of this area there are no hills; a thick covering of alluvium obscures all the rocks except in the river sections, of which, however, there are fortunately a good many.

The rivers are the Rer or Arand and the Goinghata with 5 or 6 direct and indirect tributaries, all of which afford sections.

The rocks exposed all belong either to the Talchir or Barakar groups, there being no representative of the upper sandstones found in this area.

TALCHIRS.—A strip of Talchirs, not very distinctly seen, occurs on the north-east boundary of the Barakars; the only clear section of these rocks occurs in the Goinghata west of the Satpara and Mendra road; they consist there of green sandstones, shales, and the boulder bed.

Some Talchir rocks are also exposed in the bed of the Goinghata near the

[1] Raigarh and Hingir, Rec. Geol. Surv. of India, Vol. IV, pp. 101 to 107; Vol. VIII, pp. 102 to 121, Vol. X, pp. 170 to 173, Bisrampur *op. cit.* Vol. VI, pp. 25 to 41.

[2] Part I, p. 207.

deserted village of Rukra, their relationship to the Barakars on the north and south I had not time to ascertain.

In the Rer or Arand on the south-west, Talchirs crop up, and passing southwards connect this field with the one further south (Rampur), which is traversed by the higher reaches of the same river.

In the jungle near the village of Mudesa, east of this field a small outlier of Talchirs was noted. Its limits were not traced out.

BARAKARS, *Goinghata section.*—North-east of Mahadeopara there are some slates and quartzites apparently of sub-metamorphic age. South of these there is an interval through which the fault, already mentioned, probably passes. Nearly east of the village there are Barakar sandstones which include a seam of carbonaceous shale, and from under which the Talchir rocks, just alluded to, crop out and continue in the bed of the stream for about half a mile, after which they are again covered by apparently the same section of Barakars.

The repeated seam appears to contain a small quantity of poor coal, after which there are two seams which contain carbonaceous shale only. In the reach north-west of Parsori there is a seam containing about 3 feet of stony but burnable coal. The base is hidden. North of Ambera there is a seam badly seen in the bed of the river; it contains at least 2′ 4″ of tolerable coal.

South of the mouth of the Khekra stream the only rocks which are exposed are sandstones and grits, save a very fine trap dyke which crosses the river with a strike of 15° N. of E.—15° S. of W. and maintains that direction steadily as far as the Rer, being seen in all the intervening streams, but not in the intervening alluvium-covered high ground.

Khekra section.—In the Khekra river from its junction with the Goinghata to the point north of west of Lapatra, where it is intersected by the boundary of the gneiss there are exposed a few sandstones, the trap dyke, and about a foot of coaly shale.

Chandnai river.—This river and its tributary, the Chulhot, have not been plotted in detail on the map. Instead of the peculiar winding courses which they follow, they are represented as consisting of long rectangular reaches and bends. It is consequently difficult to represent faithfully the position of the coal seams.

Between the mouth of the Chandnai and the village of Kutkona, there is a much broken section of sandstones in which three outcrops of coal seams occur. In the first, 1′ 6″ of coal is exposed; some of the blocks derived from it consist of very good coal. Neither of the others are of very promising character, but the one near the mouth of the Gumgara is evidently of some size and may contain good coal, though it is not now exposed.

Trap occurs in the bed of the river about one-third of a mile from Kutkona. Just below the village the large trap dyke mentioned above crosses the stream disturbing in its passage, but not to a detrimental extent, the finest coal seam which occurs in this area.

Where most clearly seen, this seam (the base being hidden) consists of about equal parts of good, fair and burnable shaly coal, in all a thickness of 5′ 6″ capped by a massive bed of about 30′ of sandstone.

Whether the position of the dyke is coincident with a fault which has flung the coal on the south, I could not ascertain, but even if it has, the seam in all probability extends throughout a considerable area on the north and west.

The branches of the river which meet close to this traverse a broken section of sandstones for about 2½ miles, after which the gneiss rocks come in. In the eastern branch, near the village of Sirkotonga, the boundary is seen very clearly and is clearly faulted. In the western the boundary is completely obscured by alluvium.

The Rer or Arand section.—In the Rer river west of Jamgula there are some sandstones, apparently of Talchir age. From this northwards many of the reaches expose no rocks whatever; but those which are seen are Barakar sandstones and grits; they are for the most part horizontal. The above-mentioned trap dyke is again seen in the bed of the river to the south-west of Bagdari.

Should coal ever be required in this neighbourhood, I think there is a good prospect of its being found of fair quantity and quality at no great depth and in approximately horizontal beds.

Borings made within a mile radius of Ambẹra and Kutkona would probably give a fair test of the capabilities of the area.

Rampur Coal-field.

The area for which the above name is proposed is bounded on the north by the Lakhanpur gneiss, on the east by the Mainpat, on the south it passes into the Mand area described below, on the west it is connected with the great area of coal-measure rocks which stretches to Korba.

I do not attempt to make any estimate of area, as my observations were simply confined to the vicinity of the route-track from Lakhanpur to Matringa.

Passing west and south from the Lakhanpur granitic gneisses, which run under the sandstones and trap of the Mainpat, the valley of the Rer or Arand is reached. At Patrapali, west of Lakhanpur, and following it up to its source, the river at first alternately traverses Talchir and Barakar rocks; but in the highest reaches the upper sandstones are exposed.

TALCHIRS.—In the Arand between Chainpur and Jajgi there is a broken section of Talchirs consisting chiefly of sandstones; shales and the boulder bed are, however, not absent. Above (*i.e.*, to the south of) Jajgi for about 2 miles, no rocks are seen, but beyond Ubka, there are some Barakar sandstones, and an indistinct outcrop of Talchirs (?) appears at the road crossing to Lachmanganj. This apparently rests on some quartzite gneiss which strikes into the bed of the river a little further on.

For 5 miles beyond this the river shows no signs of any Talchirs, but it is of course possible that some may exist as there are many long sand-covered reaches.

South-west of Lipingi there are Talchirs, and they crop out at widely separated intervals for about 3 miles.

The boundary of the Talchirs strikes the river again a little above its junction with the Sagar stream, and crosses it a little beyond the high road ghât. The

Talchir rocks occur from this point for about a mile eastwards, after which they are covered by some sandstones which may be either Barakars or upper sandstones. This point remains still to be determined.

Beyond the village of Kesma again Talchirs (or rocks lithologically so like them as to be undistinguishable) re-appear. Fragments of coal or coaly shale occur sparingly in the bed of the river, but there is no trace of Barakar rocks in the main stream and the trap-capped hills on either side of the valley appear to be altogether comprised of the upper sandstones, so that I am inclined to believe that the coal, &c., must be derived from layers in the latter.

BARAKARS.—The first or most northern outcrop of Barakars is exposed in the reach of the Arand south of Ubka, where there are sandstones resting on coaly shale. Several other outcrops occur in the river up to the road crossing.

In the country west from this there are several peculiarly shaped hills, notably one called Ramgarh. The summit of this hill is 3,206 feet above the sea. The upper portion consists of a massive rectangular block of the upper sandstones, which are here from 550 to 600 feet thick; these rest on a pedestal of Barakar rocks, the highest bed of which is a coal seam containing about 4′ 6″ of rather stony coal. The summit of the hill is capped by trap. Owing to the antiquities, cave temples, &c., several notices of it have been published, and the existence of the coal seam has been referred to by Colonels Ouseley[1] and Dalton.[2] A description of the hill has also been published by the present writer.[3]

Returning to the Arand section. In the vicinity of Tunga, there are some slabs of coaly shale which appear to have been derived from no very distant source. As no seam appears in the Arand close by, it is probable that one is exposed in some of the tributary streams, possibly the Gerua, as some fragments of coal shales were found in it. I had heard previously from the Lakhanpur Raja that coal did occur somewhere in the neighbourhood of Tunga, but I had not time to hunt up all the surrounding country.

These Barakars continue up to a point north-west of Lipingi, but there is no trace of coal. Westwards from this, the same rocks were traced to Lachmanganj, their existence under the alluvium there being proved by the debris from a well in the compound of the Raja's shooting lodge.

Barakars are next met with in the Arand, south-east of Kumrewa. They consist chiefly of massive felspathic sandstones and grits often much iron-stained.

In a reach to the east-south-east of Sair, there is a seam consisting of coaly and carbonaceous shale, apparently not containing any good coal. This is the locality marked '*coal-field*' on the old maps.

It is probably the source of the coaly fragments seen in the bed many miles northwards, but cannot possibly be that of the large slabs seen near Tunga. Shaly fragments of coal may, I believe, be carried in rivers for enormous distances; even in the present sluggish state of the river, fragments may often be seen incessantly rolling over and over along the bottom.

[1] J. A. S. B., Vol. XVII, p. 66.
[2] *Op. cit.*, Vol. XXXIV, pt. II, No. 1, p. 24.
[3] Indian Antiquary, 1873, p. 243.

Sandstones, as before mentioned, continue up to the Sair and Kesma ghât; west of the river they extend into the peculiar raviny country beyond Sair.

There the rivers have cut down to a considerable depth; in the massive sandstones producing a perfect maze, very difficult to traverse.

A locality for coal on the Chornai river is marked on the map, but this I did not visit.

I have above alluded to the doubtful character of the sandstones at Kesma.

UPPER SANDSTONES.—West of the Arand valley there are a number of flat-topped and sharply scarped hills, which are evidently formed of sandstones identical with those of the Pilka hills. On the east, too, similar scarped faces show under the trap of the Mainpat. The first locality at which these rocks were actually examined was in the hill east of Kesma. They are coarse grits, presenting no striking contrast in lithological characters to some Barakar rocks. About 3 miles north of Matringa the Talchirs are covered by sandstones, which seem to belong rather to this group than to the Barakars. But they still require much close examination.

In the streams which constitute the head of the Arand, there are fallen masses of trap and laterite which have been brought down from the tops of the hills.

The Matringa ghât is an almost sheer descent of 900 feet into Udepur. At the top of the ghât there is laterite *in situ*, and below it a succession of argillaceous shales, and pink, white, and yellow sandstones, which become somewhat pebbly towards the base. If 600 feet is added for the thickness of the sandstones in the hills above the ghât, then we should have a minimum total of 1,500 feet for the thickness of this group.

Between the foot of the ghât and Amuldih there are some trap dykes, which are probably continuations of some observed in the Kairja valley, near Bakulo, by Mr. W. T. Blanford.

The evidence afforded here of disturbance of the coal-bearing rocks is very strong, there being a difference of level between the Barakars and Talchirs of Sair, &c., and those of Udepur, in the Mand section, of at least 1,000 feet.

That they occupied these relative positions at the time of deposition is most difficult to believe; it seems much more probable that they were once connected, and that the difference of level was produced subsequently, possibly at the period of the outpouring of the Mainpat trap. The discovery of coal measures on the Hazaribagh plateau has already pointed to the probability of the present level of the plateaus as contrasted with that of the surrounding valleys, being at least to some extent due to local upheavals.

The Mand Coal-field.

The connection of the Udepur coal-measure (Barakar) rocks westwards with the great spread which includes the Korba field, has been pointed out by Mr. W. T. Blanford.' My observations were confined to the Udepur area, *i.e.*, to the valley of the river Mand, and the areas to the north and east of it.

This is a very irregular shaped area, extending from north to south, for a distance of 35 miles. On the north it is connected by upper (Hingir) sandstones with the Rampur field. On the south and south-east it is bounded by Vindhyan and metamorphic rocks which strike steadily in the direction of Korba. On the east the coal measure rocks are covered by the upper sandstones, and it is uncertain whether the former appear in the valleys beyond the ranges formed of these sandstones. On the north-east, besides the overlapping sandstones, a portion of the boundary is formed of granitic gneiss rocks.

TALCHIRS.—So far as is known at present, the areas of Talchir rocks occurring in this field are of small size. Proceeding from north to south, the first Talchirs encountered with occur detached from the field, in the valley of the Kairja river, north of Rabkob.

In the section north from Mirigurha, granitic gneisses with, for the most part, an E. W. strike, occupy the bed of the river nearly up to the Kumhar road-crossing where Talchirs come in. These, especially the boulder bed, continue up to half way between Bajpar and Bakulo, where there are some hills of yellowish or grey sandstone which seemed to be of Talchir age.

At Rabkob several of the reaches of the Mand river are occupied by Talchirs, blue and grey sandstones and the boulder bed.

North-west of Rabkob, in the valley of the Samasota (or Gopal) river, there is an area of Barakar rocks, showing evidence of extreme disturbance. On the borders of this there are some outcrops of Talchirs, and in the centre of it, at the broken crest of a very remarkable anticlinal, rocks of the same group are exposed.

From this to the south-east corner of the field no Talchirs were seen in the Mand or any of its tributaries. At the south-east corner, Talchirs, resting on granitic gneiss, crop from underneath the Barakars; they are last seen in the Sukia stream, and consist chiefly of shales and sandstones with imperfectly developed boulder bed.

BARAKARS (COAL MEASURES): *Mand River section.*—Passing westwards down the river, from the Talchirs seen near Rabkob, the first Barakars met with occur in the reach east of Saipur. At the north end of it there is a small coal seam, of which the section is as follows :—

Dip 5°, to W. N. W.

Coaly shale, about	8″
Parting...	8″
Coaly shale and coal	1′ 4″
Base hidden.	

Beyond this, there are massive beds of sandstones and grits in some of the reaches; in others, for from 1 to 2 miles, no rocks whatever are exposed. Between this and Khargaon there are two or three outcrops of coal and coaly shale, but no coal. At Khargaon there are two seams, the upper containing carbonaceous shale, and the lower, which is seen under a massive sandstone, contains 1′4″ shaly coal. Half a mile from the mouth of the Saria stream there are several seams containing carbonaceous shale with coaly layers. From this, for 3 miles, there are only a few outcrops of sandstones, several of the reaches being filled with sand. A short distance from the Kopa river there is a seam containing a foot of coaly shale, base not seen. Between the mouths of the Kupa and Khanddhoa there are two seams of grey and carbonaceous shales with a dip of about 10°, to S.

A similar outcrop is seen in the reach west of Hathi. After this, up to a point 1 mile south of Dorki there are only a few outcrops of a peculiar yellowish and grey sandstone, not Talchir, but very unlike typical Barakar.

Under the east bank close by there is a seam of coal shale and poor coal, the latter 15 inches thick. The base of the seam is not exposed. Dip, 5° north-east. After this, there are numerous sandy reaches showing only rare exposures of sandstone.

Below Koraikela, hills consisting of the upper sandstones abut on the river.

From this to the boundary formed by Vindhyans at Daijari, the only rocks seen are sandstones occasionally associated with shales, which latter are in two cases somewhat carbonaceous.

The Vindhyan and gneiss boundary runs with the last reach, and in one place gneiss is exposed in the bed of the river. This boundary did not seem to be faulted. The high ridge of quartzites probably formed the boundary of the Barakars at the time of deposition exactly as it does now.

Tributaries of the Mand.—Above Rabkob fragments of coal were found in the bed of the Mand, which were apparently brought in by some of the small southern tributaries.

Kairja river.—In the Kairja, Barakar rocks extend for about three-fourths of a mile from the mouth. Near the base there is a seam consisting of carbonaceous and coaly shale with thin layers of coal. The boundary appears to be natural: a boulder bed, possibly of Talchir age, rests on gneiss; but there is also some evidence of crushing up and disturbance at the junction.

Samasota river.—At the mouth of the Samasota (or Gopal) stream, north-west of Rabkob, there were abundant fragments of coal, which proved that there was an extension of the Barakars in that direction. The section in fact abounds with coal seams, which at first have a slight rolling dip, but evidence of disturbance soon becomes apparent, and the river gives a section of a fine anticlinal, in which, on the rise, the seams and associated sandstones dip at angles from 40° to 55°, to east. From underneath these, a Talchir boulder bed with associated shales and sandstones crops out, but after one-fourth of a mile or so the Barakars re-appear; but the fall of the anticlinal is less steep than the rise, and the dip is not too great for the working of some of the seams. The following is a list of the seams seen in this river:—

		Ft.	In.
1st.—Fair coal under massive sandstone, dip, 8° north-west . .		1	3
2nd.—Shaly coal—seen		3	
	Ft.		
3rd.—Shaly coal much weathered	9		
Banked with sand, not exposed	4		
Good bright coal	3		
	———	16	

Base not seen, dip variable, 5°—8° to West-30°-North and North-West.

4th.—In a North-East to South-West reach, not represented on the map.

	Ft.	In.		
Coal	3	4		
Grey shale	6			
Coal and carbonaceous shale	1	6		
Grey shale	1			
			11	10

Sandstone.
Dip North-East.

5th.—A fine large seam exposed on the southern bank, dip quaquaversal.

Sandstone			20	
Seam—				
1. Shaly coal, about	2			
2. Coal, inferior, but burnable	1	11		
3. Grey shale		10		
4. Flaky coal shales with irregular coaly layers	9			
5. Coal, good, varies	1	6		
6. Grey shale	2	2		
7. Same as 5	5			
			22	5

Base not seen.

Unless there be coal below, I do not think this seam could be worked with any good result. This seam may be the same as No. 3. I think it is, for No. 4 is repeated in the next reach; the thickness slightly altered, but the relative position of the component layers the same. After it, there is a long south to north reach, towards the end of which, before the entrance to an east to west one and then continued in it, there is the following remarkable section, showing an amount of disturbance unparalleled in those portions of the Sirguja coal-fields which have been as yet examined:—

	Ft.	In.	Ft.	In.
1. Sandstone q. p.			30	
(1) 2. *Seam*, dip 33° East-North-East.—				
a—Coal, good	1			
b—Shale	3			
c—Carbonaceous shale, with coaly layers	3	10		
d—Coal, about	2			
			9	10
(2) 3. Sandstone, about			50	
4. *Seam*—				
Stony and shaly coal			13	8
5. Sandstone			42	
(3) 6. *Seam*, dip 50°.—				
Coal withc arbonaceous shale parting	4	3		
Covered	9	9		
			14	

		Ft.	In.
7. Sandstone		29	5
(4) 8. *Seam*—			
Coal and coal shale, much hidden		9	9
9. Sandstone		44	5
(5) 10. *Seam*—			
Coal and carbonaceous shale frequent partings, but much of the coal good		34	4
Dip 50° falling to 45°.			
11. Sandstone		39	0
(6) 12. *Seam*—			
Concealed	23		
Flaky coal	7 7		
		30	7
13. Sandstone		51	0
(7) 14. *Seam*—			
Coal and carbonaceous shale portions good		20	7
15. Sandstone		75	0
(8) 16. *Seam*—			
Poor earthy coal and carbonaceous shale seen		4	
17. Sandstone with pebbles, say		50	
TOTAL		517	7

Talchirs, boulder bed, shales and sandstones, in a north-west reach. Barakars come in again after one-fourth of a mile or so. Close to the boundary there is a seam of coal and, in the next reach one with a dip of 35° to N. W., it is 15 to 16 feet thick, and is of very variable quality. In the next reach, E. W., there is an exact repetition of the section on the other side of the Talchirs, but with the dip in the opposite direction, 35°—40° W. and W.-N.-W. changing to north towards the end of the reach.

In the next long north to south reach there is a seam of 4′ 6″ of coaly shale and coal, dip 15° to N.-E. showing a complete change of direction. I am not sure whether this is a repetition of one of the above seams. Another seam is seen in the next reach after which the sandstones again resume their horizontal position, and the same bed may be traced for a considerable distance.

Strong nests of coal occur in some of these sandstones.

A few reaches further, there is a seam at least 10 feet thick, consisting of the same flaky-looking coal.

A short distance beyond the Boro and Jamungri road ghât there is a 5 feet 10 inches seam of stony and shaly coal; the upper half contains fair coal; the dip is low to south-east, but the bedding all about appears to be very irregular.

Another seam in the next reach is seen on the Boro side. It contains about 10 feet of shaly coal, a portion of which has been on fire, though it contains much impurity; a fresh fracture shows a fair proportion of bright layers. Beyond this, there was still evidence of seams occurring in the higher reaches.

Between Tuludha and the Samasota, *viâ* the Jamungri road, there are several outcrops of Talchirs and gneiss, which afford further evidence of the disturbance and disruption of the beds in this neighbourhood, and render it extremely doubtful what the extension of the seams in a western direction may be. Should it ever be required to search for coal here, I would recommend the vicinity of Boro, east round to south at a distance of about half a mile, as the most favourable for making trial borings. The evidence of extensive disturbance of the seams, and consequent difficulty of working them in the country between the Boro hill and the Mand, would render it less desirable to test that area in the first instance.

Meria Kota stream.—In the Meria Kota stream beyond the first tributary, there is a seam of poor coal, of which 6 feet is exposed, dip to north-east. The same seam is again seen further on, where it shows a thickness of about 8 feet.

Some distance beyond two small waterfalls, there is a seam with a dip of 30° north. It is faulted against a bed of sandstone. Close beyond is a seam (possibly the same) with a dip of 8° north-east. It does not contain any continued thickness of good coal, being much parted by shaly layers. This is followed by another seam of about 6 feet with a dip of 10° to east. The coal is for the most part flaky and inferior. At the east to west boundary, west-south-west of Jamungri I saw no traces of coal from the higher parts of the stream, though it is probable that some of the Boro seams may extend thus far eastward. At the same time, it may be that the Barakars are covered up within a short distance of this by the higher sandstones and grits.

In the stream which rises near Jamungri I commenced to examine south-west of the village. Sandstones and grits, apparently Barakars, continue for more than a mile. Then Talchirs from the eastern boundary occupy the bed of the river for a few reaches, after which it runs in a deep gorge, which it has cut for itself in massive sandstones. As represented on the map, this river has the unusual feature, for one in a rocky country, of having two mouths whereby its waters join the Samasota. The explanation is that the narrow gorge being unable to carry off at times the whole of the water, the surplus finds a passage for itself by a northern outlet. I did not see any seam in this stream, but fragments of coal occur. Rolled fragments of gneiss abound, being brought in by the eastern tributary.

Ududha river.—The river south of Ududha (Hudhuda of the map) traverses deep gorges cut in massive sandstones. South-west of the village there is a seam of which the top only is exposed. At the highest point examined, a little north of west of the village there were still fragments of coal brought from higher reaches.

Saria river.—In the Saria river a little beyond the road-crossing, there are two seams of carbonaceous shale with coaly layers.

For several miles sandstones only are seen; they show more tendency to roll than is common in other parts of the area; the prevailing dips are 5°—10° to west and south-west.

North of the village of Konda there is a seam containing a few inches of coal in the exposed part. In an east and west reach higher up the stream there is a seam which, in addition to carbonaceous shale, contains about 3′ 6″ of flaky coal.

A short distance beyond this, there is another badly seen seam containing, apparently, several feet of coal mixed with shale.

At the Baisi and Ambgaon ghât and for some distance up and down stream a nearly horizontal seam paves the bed of the stream; it contains some good coal, but the whole thickness of the seam does not apparently exceed 5 feet. Between this and the Doridih and Ambgaon ghât there are no outcrops visible; but fragments of coal occur brought down from above. South of Potia there are sandstones which are probably Barakars.

Simi river.—About ½ a mile from the junction there are two seams of coaly shale with much carbonaceous shale, neither of any use. A little further on there is a seam with a dip at first to the west, afterwards changing to 12° south. It contains about 15′ of grey and black shales, and, in one place, a band of rather less than a foot of fair coal. The same seam shows at intervals for a considerable distance. I did not examine beyond the Chithra and Simipali ghât.

Kopa river.—From the mouth up to Chithra the rocks are for the most part covered. Near the mouth of a small stream, which joins the Kopa south-west of Chithra, there are three seams of from 2′—3′ each; they contain coal of fair quality mixed with carbonaceous shale. The dip of the first is 17° to west, but the third rests on a sandstone which is locally tilted to 35° to west.

A short distance beyond the southern tributary, there is a seam of rather more than 3 feet of carbonaceous and grey shales, with some coaly layers towards the base. In the reach entered by the next northern tributary, there is a considerable seam of carbonaceous shales, but no coal. Beyond the Kodardih stream there is a seam of carbonaceous shale 3′ 8″, dipping at 5° to south-south-west, but no coal.

Beyond this up to the Bartapali crossing I saw no seams, the river for the greater portion of the way being in a deep gorge of massive horizontal sandstones.

The last seam but one, mentioned above, is apparently one alluded to by Mr. W. T. Blanford;[1] it rolls a good deal and is of uncertain dip, but I saw no sign of coal in it

Khanddhoa river.—North of Hathi is a seam close to the road; it consists of 18′ of slightly coaly shale with a dip to south of about 8°.

About 2½ miles beyond this there is a seam with about 10″ of coal towards the base, the upper part consisting of grey carbonaceous shales, dip 5° to west. In the interval between these there are massive sandstones and two or three outcrops of carbonaceous shale, but no coal.

Beyond this there are several repetitions of the same seam and several outcrops of carbonaceous shales. At the road crossing between Nouapara and Jogra there is a seam containing less than a foot of inferior coal with a slight rolling dip to south.

Kurja river.—In the stream north of Pori there is a seam containing 1 foot of inferior coal much mixed with shale, dip 3° east. Before it was reached a number of transported slabs of coal with shale, generally 12″ thick, were found

[1] Records, Vol. III, pt. 3, p. 71.

lying in the stream. I can scarcely believe that they were derived from this seam, as they appear to be of much better material than what is seen *in situ*, but I did not see any traces of coal of similar character in two reaches further west, which were the limit of my examination in that direction.

Baghoud river.—From the mouth to the village of Galimar the Baghoud only shows sandstones and shales; some flakes of carbonaceous shale occur, but none *in situ.* The upper part of this river as also of most of the foregoing one traverses the upper or Hingir sandstones.

Bendo river.—In this river there are several outcrops of carbonaceous shale but no coal.

Jhampi river.—In this river the rocks exposed by the section are red, yellow, and white sandstones; no trace of coal or carbonaceous shale. I am inclined to believe that all these belong to the upper group.

Kurket river.—For half a mile from the mouth no rocks are seen; afterwards, towards the top of the first reach, there are coarse sandstones and grits similar to those in the Mand. Beyond this the river exposes Talchirs. The masses of coal seen in the bed are derived from seams in the Raigarh and Hengir field, which are traversed by the higher reaches of the river.

In reference to the economic prospects of this valley, I am distinctly inclined to regard them favourably. While it must be admitted that the majority of the seams which have been examined, as they happened to be exposed, do not disclose coal useful in quantity and quality, it should be remembered that the sections are much covered and the disturbance of the beds (excepting in the few noted instances) has not proved sufficient to give anywhere a complete section of the succession actually existing.

In some cases it is possible to trace the same bed of horizontal sandstone for several miles. The area being in the centre of the basin there is a good prospect of boring proving the existence of valuable seams.

Upper or Hingir Sandstones.

On the northern and for a considerable portion of the eastern boundary, the Barakar rocks are covered up by the upper sandstones. The peculiarities of the Matringa ghât section, alluded to below, afford evidence of great disturbance of level between different portions of the coal-fields. But I must confess myself not prepared at present, with the imperfect data which I possess, to attempt an explanation of the action which has taken place. The difference between the level of the Talchirs of the Arand and of the Samasota, whether produced by flexion, faulting or aboriginal deposition, amounts to from 900—1,000 feet. In all probability, this is really a measure of the subsidence which has taken place.

North-east of Porea there are sandstones with pebbles. These appear to be more common at and near the base of the hills than high up in the sections. The Boro hill and its neighbours are composed of ferruginous sandstones and grits. The scarped range to the east of this is formed of similar rocks, but less ferruginous and more compact. They are split up into angular blocks, in such a manner that at a short distance I supposed them to be metamorphics.

The spur south of Balpeda is composed of sandstones and grits. In the streams near Jamungri there are some sandstones and white argillaceous rocks which may be Barakars; but I rather incline to the belief that they must be included with the upper rocks. The range east of Jamungri is formed of sandstones and grits, south and east of which metamorphic rocks come in and bound the field up to the Sisringa[1] plateau. It is possible that there are sandstones on this plateau; but the first place in which I again met with them was in the Ghoradah hill; from thence the boundary, from various reasons, is very indistinct, but I believe it approximates closely to what is represented on the map, *i.e.*, it runs round the Enderkona hill.

The hill Ghoradah, 2,595 feet or some 1,500 feet from its base, is formed of sandstones and grits capped by laterite. All the hills south from this appear to be of the same sandstone, so that the gneiss boundary must be thrown considerably east of its position near Rabkob.

Whether gneiss or Barakars occupy the valleys, which occur further east of this range of hills, remains to be seen. It is probable that all the hills and ranges marked with distinct scarps are formed of the upper sandstones.

The Enderkona hill is formed principally of a pinkish sandstone, which is scarped similar to those in the hills further north. At Kida the base of the hill is formed of compact purple sandstone. Round the base of Enderkona hill the boundary runs to Aghori, and from thence to the hills below Gumar, which touch the Mand, and are continued again on the western bank.

The river south of Taraikela exposes red and yellow sandstones with occasionally white grits; some of the former contain red jasper pebbles.

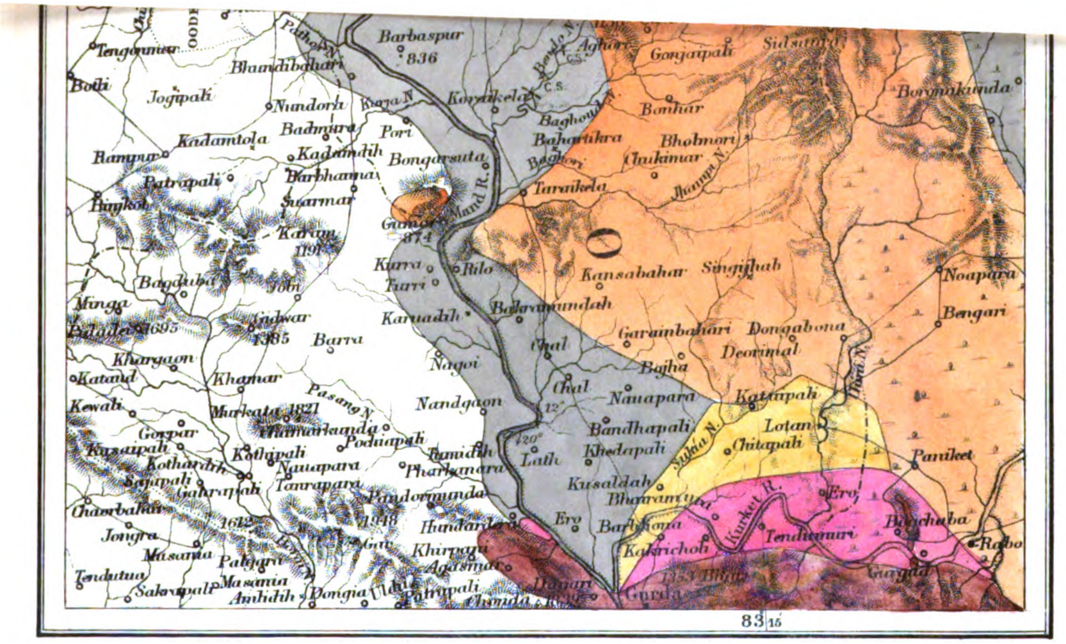
The high ground south of Taraikela is formed of ferruginous sandstones, grits and shales, with bands of iron-stone. From thence to Kataipali the boundary of these upper rocks has been roughly traced in that neighbourhood; they lap over on to the Talchirs. Their further eastern extension from this was not traced.

Sufficient has been said above to show how complete the unconformity of these rocks is with respect to the older formations, and yet the difficulty of separating them from the underlying Barakars in some sections is excessive. Taken as a whole, their lithological characters and the absence of coal are such as to justify their abstraction from any close connection; but individual beds often present the very strongest resemblance to certain grits and sandstones of the Barakars. In all these particulars, as well as in their physical characters, they present much similarity to the grits of the Rajmahal hills.

I have often been struck with sections especially round the Mainpât and neighbouring *pâts* as being exact repetitions of some I examined in the Rajmahal hills. Here as there, there are massive distinctly scarped sandstones, which rest indifferently on Talchirs, Barakars or gneiss, and are covered by trap and massive laterite.

Since the above was first written, these upper (Hingir) sandstones have in part been identified by their fossil contents with the Kamthi group, but representatives of higher Gondwana groups are also very possibly present too.

[1] A village close to east-by-north of Chuimati summit.



MAND COAL FIELD.

Scale 1 Inch = 4 Miles.

0 1 2 3 4 5 10 Miles

Kamthi Group and Upper Gondwanas ? — Barakar Group — Talchir Group — Vindhyan Series — Metamorphic Series

Coal Seams —— Carbonaceous Shale ------ C S. Dips ↙ Gold Washings ⊙

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Vindhyans.

It has been mentioned above that the coal-bearing rocks are cut off on the south by a ridge of rocks of Vindhyan age. These consist of quartzites and quartzitic sandstones.

At intervals granitic gneisses intervene along the boundary.

The quartzites are first met with on the west bank of the Mand, opposite Ero; there they form a succession of high ranges, often with steeply scarped sides. The strike of these hills corresponds with that of the boundary, and indeed of the river itself, for 2 miles. Below Daijari the boundary is suddenly deflected to the east, which direction it maintains for several miles, and then it strikes in the direction of Sambalpur.

The observations hitherto made on the metamorphic rocks are too scattered and detached for special record. It will be an interesting task to trace the origin of the gold which is found in the old alluvial deposits of the tract which extends between the Mand and Ebe rivers. As these deposits lap round a central group of metamorphic rocks, the existence of auriferous quartz reefs in them may very possibly be hereafter proved.

Report on the Pench River coalfield *in Chhindwára District, Central Provinces, by* W. T. BLANFORD, F.R.S., *Senior Deputy Superintendent, Geological Survey of India.*[1] (*With a map.*)

The coal seams described in the following pages occur at a distance of from 12 to 20 miles north-north-west and north-west of the station of Chhindwára, in the Central Provinces, and in the neighbourhood of the river Pench, a tributary of the Kanhán river and ultimately of the Godávari. The occurrence of coal at one of the localities, Barkoi, has been known for some years. It was first discovered about 1852, and was mentioned by the late Mr. Hislop in a paper published, in 1855, in the Quarterly Journal of the Geological Society of London The country was roughly mapped, both geologically and topographically, by Mr. J. G. Medlicott, of the Geological Survey of India, in 1856, and the tract in which coal seams have now been discovered is shown, in the map,[2] to be formed of the rocks of the Indian coal measures, or Damuda series of the Survey classification. Mr. Medlicott's survey was necessarily merely general, and could not comprise the search for outcrops of coal, a task involving the examination of every stream and nala, of every hill side and every field. The utmost that could be done was to define the area in which such a search could be carried on with a chance of success.

[1] The trial borings in the Shahpur coalfield having proved very unpromising, the prospect of a coal supply in this region turns to the Pench river field, some 35 miles to the east on the same (southern) border of the Sátpura basin of Gondwána rocks. As a good indication of what is to be expected there, Mr. Blanford's report (written 16 years ago) is published in anticipation of the detailed survey to be shortly undertaken. The line of localities marked on the annexed map sufficiently indicates the position of the coal measures.

[2] Memoirs of the Geological Survey of India, Vol. II, part 2.

In the present instance there seems to have been unusual unwillingness or apathy on the part of the natives of the district, who alone could effectually search for outcrops of coal seams, in furnishing information of their existence. Officer after officer has been compelled to report his inability to ascertain the existence of any other coal in the district than the Barkoi seam, and it was ultimately by accident that Major Ashburner, the present[1] Deputy Commissioner of Chhindwára, became acquainted with the occurrence of the mineral at Sirgori, and following up the discovery most energetically, succeeded, in the short space of three months, in ascertaining its presence in the several places mentioned below.

I am happy to report that I have been able to form a highly favourable opinion of the coal and of the facilities for working it which are presented by its mode of occurrence.

Before proceeding to describe the several outcrops in detail, it may be useful to mention briefly the peculiar topographical and geological characteristics of the tract in which they occur. Upon the former depends the facility or difficulty of communication with adjoining districts, and upon the latter the existence and area of the coal field.

Physical geography of Chhindwára District.

To the north of the Chhindwára district lies the flat open valley of the Narbada, to the south are the broad plains of Nágpur, watered by the tributaries of the Godávari; these areas are approximately at the same level, about 1,000 feet above the sea. They are separated by a tract of much higher country averaging at least 2,500 feet and being part of a belt which may be considered to stretch nearly across India dividing, in the west, the watershed of the Narbada from that of the Tapti; in Central India, intervening between the Narbada and the feeders of the Godávari; and to the east, separating the valleys of the Son and other affluents of the Ganges, from the tributaries of the Mahánadi and other rivers of Orissa. In the country between the Narbada and the Wainganga, this belt is about 80 miles broad, the northern portion consisting of massive flat-topped hills, intersected by deep ravines, all covered by dense jungle traversed by very few roads, and very thinly populated. The southern portion, which is the true dividing ridge, is far less irregular, and in most parts consists of a broad undulating table-land, generally fertile, and, in many places, well populated and cultivated. Upon this southern portion are the Civil Stations of Betúl and Chhindwára.

Distribution of coal-bearing rocks.

Although a very considerable proportion of this belt of country in the Betúl, Chhindwára, and Narsinghpur Districts consists of coal measure rocks (Damuda), these are chiefly found in the deep valleys and on the sides of the hills of the wilder northern portion. Such is the case at Mopáni, on the Sitariva, near Narsinghpur, and in the several known coal localities of the Táwa valley. So far as the country has been hitherto mapped, the only coal measure rocks known to occur upon the table-land forming the southern portion of the belt are those in the neighbourhood of the Pench river, in which the seams now discovered occur. This

[1] That is, in 1866.

circumstance is of great importance, because communication with the country, either north or south, involves only the descent of one scarp, while from all the other known coal-fields of the neighbourhood of the Narbada, communication with the south involves an ascent of from 1,000 to 1,500 feet, in addition to the descent of the southern scarp. The distance of the various coal localities from Chhindwára is from 12 to 20 miles; from Chhindwára to the foot of the ghât at Rámakona is 28 miles, and from Rámakona to Nágpur 50, total 90 to 98 miles.

General geological structure of Pench river coal-field and neighbourhood.

The general geological features of the neighbourhood of the Pench river coal-field may be mostly gathered from Mr. Medlicott's map. The following brief description is derived chiefly from the map, partly from my own observations. The country north of the station of Chhindwára consists of metamorphic rocks, which extend to the west far beyond the town of Umrait, and continue for about 10 miles due north of Chhindwára, when the sandstones and shales of the Damuda series are brought in by a fault of unknown dimensions, but undoubtedly of considerable magnitude; probably, north of Chhindwára, of some thousands of feet. Upon both formations indifferently is a great spread of horizontally or nearly horizontally bedded trap, which covers the whole country further east, but, to the west, has generally been cut through by river valleys, and denuded, so as to expose the subjacent formations; caps and patches of the trap remaining here and there. To the north of Umrait, between that town and the villages of Barkoi, Butaria, &c., a patch of trap covers a considerable tract, concealing the boundary between the metamorphic rocks and the Damudas, and trap again overlaps the boundary north-east of Chhindwára. From a few miles north of the Pench again all is trap. The country in that direction rises into a great table-land, in parts as much as 3,500 feet high.

The base of the trap is extremely irregular: the beds have been poured out upon an irregularly denuded and uneven surface of metamorphic and sedimentary rocks, and masses of the igneous rocks, filling up previously existing hollows in the older formations, occur even at the lowest portions of the country now exposed. Thus trap occurs in the bed of the Pench river in two places, one north, the other south of the villages of Chenda and Digawáni. Trap dykes intersect the sedimentary and metamorphic rocks in places, but they do not appear to be very numerous, nor to affect the quality of the coal.

Besides the Damuda or coal measure sandstones and shales, I found a considerable portion of the Pench valley to be occupied by rocks of a very different mineralogical character, thick beds of deep red clay with interstratifications of coarse sand and sandstone, and bands of nodular limestone. These do not appear to contain coal, and their appearance strongly recalls that of some beds, which I described in 1860 as the Panchet series,[1] and which overlie the coal-bearing rocks

[1] It should not be forgotten that this paper was written 16 years ago before Mr. H. B. Medlicott had classified the Gondwána beds of the Sátpura region and before anything definite was known of the Godávari Gondwánas. The only areas of these rocks that had been properly surveyed were those of the Damuda valley. The supposed Panchets doubtless belong to a much lower horizon and are in all probability Motur.

of the Raniganj field. But my time was too limited to allow me to investigate this intricate question, and my attention was necessarily chiefly confined to the coal beds.

Villages referred to, marked on map.

On the accompanying map (an extract from sheet No. 4 of the Revenue Survey of the Chhindwára District) will be found the various villages referred to below as in the neighbourhood of the coal outcrops. The majority of them are also marked upon the map, already referred to, as published to accompany Mr. Medlicott's report on the central portion of the Narbada district. These villages extend in a line running nearly due east and west for a distance of about 16 miles.

In describing the localities in detail, I shall commence with those farthest to the east, and proceed regularly westwards.

I. Sirgori seam.—The most eastwardly locality in which coal has as yet been discovered is close to the village of Sirgori, and nearly a mile north of the Pench river. The coal was found in a well sunk, twelve years ago, by the malguzar or patel of the village; and this circumstance coming accidentally to the knowledge of Major Ashburner, led to the discovery not only of this seam, but of all the others between Sirgori and Barkoi. Major Ashburner sank a shaft by the side of the well, and at the depth of 28 feet came upon the coal. All the beds cut through were of sandstone, coarse or fine; and the roof of the coal consists of coarse sandstone, obliquely laminated. After cutting into the coal more than 3 feet, water came in rather rapidly, and the shaft was stopped. With some little difficulty from the influx of water, I succeeded in digging into the coal further, until I had reached 4 feet 9 inches from the top of the seam. How much thicker it may be, I cannot say. The whole is of good quality, perfectly uniform, without shale partings.

Thickness of seam.

Quality of the coal.

The coal burns excellently, and leaves a considerable quantity of perfectly white ash. The most remarkable point about this coal is its freedom from iron pyrites. I have never seen any Indian coal which appeared so little impregnated. This is a most valuable property—the absence of pyrites tends to ensure the coal from decomposition on exposure to the weather, and from liability to spontaneous combustion; and if sulphur be not present in some other form, it especially qualifies the coal for the manufacture of iron and for forge purposes.

Geological character of neighbourhood and probable extent of seam.

The well in which the coal was found is just south of the larger of the two collections of houses composing the village of Sirgori. These two portions of the village are about a quarter of a mile apart, the larger being north-east of the other. In a nala between them fine sandstones are exposed, dipping north about 5°; these may be traced beneath the north-east portion of the village, and re-appear on the low hills about 200 yards east of the well; dipping at that spot north-north-west, at the same angle as before. The beds thus appear to be continuous along their outcrop for a distance of nearly half a mile, and unless some break of the rocks occur in the ground between their outcrop and the well, (of which I could trace no indication,) the coal should be continuous beneath them throughout that distance at least; how much further it is difficult to say. This is along the strike of the beds east and west. Coming up the dip of the beds towards the south, sandstones and shaly beds are seen with the same north dip in two or three places, the ground being however covered thickly with surface soil, so that very little can be seen. No trace of any outcrop can be found, and in a well 22 feet deep, just south-east of the smaller or south-west portion of the village, no coal was found, nor yet in another well, about 200 yards further west. Yet, if the coal continued at the same dip, its outcrop should be either at these wells or a little south of them, and in either case some indication of the coal should be seen in them. Its absence induces me to believe that the coal is, in all probability, cut off by a fault; and there is an indication of such a fault in a small nulla, 200 or 250 yards south-east of the shaft in which the coal is seen. This fault brings coarse grits against shaly sandstone, and it appears to have an east and west direction (perhaps east-north-east to west-south-west, a common direction of the faults in this country). The amount and the direction of its throw are quite uncertain, scarcely any rocks, except the overlying trap, being seen in the neighbourhood to the south. Boring is very desirable about this to test the extent of the coal, which, if the fault be a downthrow to the south of no great amount, would be found on the south side of the fault within a depth not too great to prevent its being worked. If the fault be an upthrow to the south, the coal will of course be cut out in that direction.

A small stream runs in a valley north of Sirgori village (the larger portion), and then passes east of the village, and runs southward, passing a little east of the shaft. In this stream, east of the village, and about 200 yards north-north-east of the shaft, sandstone is seen overlying shale,—the latter very carbonaceous in parts, dipping about 3° to north-north-west, and containing fossil plants. The sandstone differs greatly from the much coarser beds immediately overlying the coal. It is necessary to mention this, as the dark shales may be easily mistaken for an outcrop of coal, and it might be thought that the seam is here brought to the surface and repeated by a fault. I can see no indication of such an occurrence, but every reason, on the contrary, for believing that the coal underlies all these rocks.

Going further north, the beds appear to dip regularly until about 200 yards north of the village, and a quarter of a mile from the shaft where there may possibly be a fault. It is not very clearly seen, nor can even a guess be hazarded as to its amount or the direction of its throw; indeed, it is not certain that anything more than a sharp bend in the rocks exists, and of course it is quite possible, and even probable, that the coal recurs beyond.

It will thus be seen that for at least half a mile along the strike, and for nearly as great a distance along the dip, there is every probability that this seam is continuous; and it is in the highest degree probable that the coal will be traced far beyond these limits if proper boring operations are carried out. Before attempting to work the coal, a few preliminary borings should be made, especially in the direction of

Necessity for boring, and spots where it is desirable.

the dip, that is, north and south of the well in which coal has been found. These borings are needed both to ascertain, more definitely than can be done by surface exploration, the extent of the coal seam, and also to prove whether its thickness be constant,—seams of which the roof consists of coarse sandstone, as in the present case, being sometimes variable in thickness. I would point out as one place for a boring the spot immediately south of the large banyan tree, which is itself south of the north-east portion of the village, in order to ascertain if the coal approaches the surface there. Another boring should be made 150 or 200 yards north of the well in the low ground east of the village.

It is also extremely desirable that the coal should be at once sunk through in the shaft, and its thickness ascertained. This might be done at small expense.

Summary of prospects of the locality for coal-mining.

It has, I think, been clearly ascertained that the coal at this place is sufficiently thick to be profitably worked, that its quality is good—in some respects exceptionally so—that the dip is low and highly favourable, and that there is every probability that the seam is continuous over a sufficiently large tract of ground to repay considerable outlay in starting a colliery.

II. Sirgori seam No. 2.—Up the little stream, already mentioned as running north of the village of Sirgori, beyond the spot where indications of a fault are seen, nothing except coarse sandstone is met with, the dip of which is doubtful. About half a mile west-north-west of the village, the outcrop of a second seam of coal is seen in the nala, dipping north. On the north bank of the nala, Major Ashburner sank a shaft to a depth of 18 feet, passing through the seam, which was 3 feet in thickness. The shaft passed entirely through shale and shaly sandstone. The coal was mostly extracted in large slabs, and these, after being exposed on the surface for three months in the dry season, have split up into papery layers, to so great an extent as to prove that the coal is ill suited for carriage to any distance, and very liable to decompose. It is also rather shaly and impure; and, considering that the thickness of the seam is only 3 feet, I do not think it could be profitably mined. The coal burns well, leaving a grey ash, and appears tolerably free from pyrites.

There is not, so far as I can see, the smallest reason for supposing this seam to be a repetition of that seen to the south; the beds do not roll up again, and the two coals differ essentially in thickness, mineral character, and in the nature of the overlying rocks.

Some shales seen in the nala, just above this spot, are so ferruginous that they might be used as an iron ore. The ferruginous portion does not, however, appear to be of any great thickness; all that was seen was a band a few inches thick and somewhat variable in the proportion of iron contained.

III. Chenda seam.—The next locality to the westward is in the bed of the Pench river, 4 miles west of Singori, and half way between the villages of Chenda and Digawáni. The river here runs from north to south. So large a quantity of the mineral is here exposed in the bed of the river, that it is rather remarkable that its occurrence should not have been before noticed; and it shows clearly the utter indifference of the natives of the country to the subject, since they must have known that coal was worked at Burkoi, only 10 miles away, and sufficient power of inductive reasoning may be supposed to exist, even in the minds of Gonds, to enable them to see that the two minerals are identical. The spot was shown by a *gwála* to Major Ashburner, after that officer had offered a reward for the discovery of coal elsewhere than at Barkoi or Sirgori.

The spot is just north of the ford in the Pench, on the road between the villages of Chenda and Digawáni. About half a mile to the south, trap comes in, both in the river bed and on its banks: to the south of the trap, near the village of Dala, metamorphic rocks occur. North of the trap, for a considerable distance, no rocks are seen; at the ford the deep red clays and white sands, to which I have already referred, and which I believe to belong to a higher series of beds than those associated with the coal, are seen dipping about 20°, to south 10° west. They are faulted against the Damudas, or coal measure beds close by, and, about 100 yards north of the fault, coal appears on the east or left bank of the river.

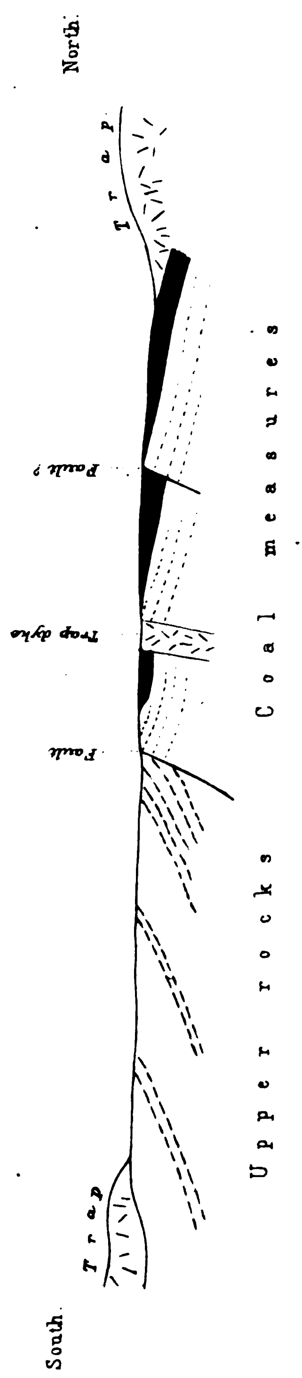
At this spot, Major Ashburner has made a small cut into the coal to ascertain its thickness; this cut exposes the following section:—

Section of seam and thickness of coal.

	Ft.	In.	Ft.	In.
Shale, decomposed, about			3	0
Coal ditto	1	0		
Shale	1	3		
Coal, rather shaly in places, but generally of fair quality	7	0		
Shale, in parts very carbonaceous and containing layers of good coal	2	0		
Coal of good quality	4	3		
			15	6

of which 12 feet 3 inches consists of coal.

Immediately to the north, a trap dyke, running east and west, and about 30 yards broad, crosses the seam. This great mass of igneous rock has tilted up the seam slightly to the north, but does not appear to have much affected the coal. The seam re-appears just north of the dyke, dipping north, at first at an angle of about 10°, but, immediately beyond, at a much lower dip, varying from about 3° to 5°. For about 150 yards from the dyke, the outcrop of the coal seam occupies the bed of the river; then massive sandstone comes in, apparently brought up by a small fault, striking nearly east and west, with an upthrow of about 20 feet to the north. The sandstones dip to north-10°-east at about 5°, and, upon them, about 30 yards further the coal seam re-appears; that is to say, coal of great thickness comes in, and it has every appearance of being the same seam. If not, two very thick seams must here occur, one above the other, and separated by only a few feet. The coal seam continues to crop out in the bed of the river for a short distance, when it is covered by the overlying trap, which forms both the bed of the stream and the hills on its banks. This trap continues for a considerable distance up the river.



Sketch section to illustrate mode of occurrence of the Chenda coal seam.

The accompanying sketch section will serve to show the manner in which this coal seam is exposed in the Pench.

On the east bank of the river is a rich alluvial and highly cultivated plain, in which no rocks are seen, until hills of trap rise close to the village of Chenda, half a mile away. To the west, the coal is seen in a small nala, about 150 yards from the bank of the river. The spot I believe to be north of the small fault mentioned, as repeating the seam in the river. I could not trace the seam further west, nearly all the rocks being concealed by surface deposits.

Quality of coal.

The quality of the coal is fair throughout; the lower 4 feet 3 inches seam, especially, being of very good coal, brighter and purer even than that of Sirgori, but containing much more pyrites. It burns with rather less flame than the Sirgori coal, and leaves a grey ash, reddish in parts. The smaller quantity of flame is, doubtless due to the Chenda coal being taken from nearer the surface, and partly perhaps to the vicinity of the large trap dyke to the place from which the coal was taken.

Mining prospects of the locality.

Whether this coal can be mined profitably or not, depends upon its continuance to the north under the overlying trap, and this continuance can only be ascertained by mining or boring. Very possibly the trap is of small thickness, and in that case the coal should be found beneath, but the base of the trap is too irregular for any opinion to be formed of its thickness from surface examination.

In any case, however, an enormous quantity of fuel could be quarried from this spot, for quarries could be made along three lines, as far as the outcrop of the coal extends—

1st.—South of the trap dyke.

2nd.—North of the trap dyke, and south of the fault.

3rd.—North of the fault.

No quarries, however, should be made along the third line, especially in the neighbourhood of the river, if deep mining to the north be found practicable. A large proportion of the coal would, of course, be inferior and chiefly suited for local purposes, but the lower portion of the seam would probably be sufficiently good for railway locomotives, and would bear carriage to a distance.

Taking the whole circumstances into consideration, it does not appear to me that this locality is so promising as Sirgori. At the Pench there is probably a thicker seam of coal—indeed the thickest as yet known to exist in Central India; the quality is good, and the dips are highly favourable, but the rocks appear to be much cut up by faults and trap dykes. If the coal is to be mined, it will be beneath very hard trap, entailing some expense in boring and shaft sinking, and the quantity of water met with is likely to be large. But if the coal does continue beneath the trap, its quality will assuredly be far better than in the section now exposed, (provided only that some sandstones or shales intervene between it and the trap, which is probable,) and it will be well worth the expense of a few borings to ascertain this. The spots for boring would be in the bed of the river, 150 or 200 yards north of the place where the coal disappear beneath the trap, and at the base of the hills to the east and west of the same spot.

Locality for borings to prove continuation of coal.

IV. Harrai seam.—At the village of Harrai, 2 miles south-west of Digawáni, coal was found in a well sunk for irrigation. After draining the well of water, however, we found that mud had accumulated to so great an extent in the bottom as to conceal the coal. There would have been considerable delay in clearing this. I cannot, therefore, state the prospects of this seam. The spot is close to the continuation of the large fault already noticed in the Pench, which brings down the red clays and their associated sands and limestones in the same manner at Harrai as further east.

V. Ráwanwára seam.—About a mile north of the last, and half mile south-west of the village of Ráwanwára, the following section is exposed in a nala:—

	Ft.	In.	Ft.	In.
Shaly sandstone			4	0
Fine compact sandstone			2	6
Coal	1	0		
Sandstone, shaly in parts	1	3		
Carbonaceous shale and coal	0	4		
Sandstone, with streaks of coal	0	7		
Carbonaceous shale and coal	0	6		
Dark grey carbonaceous sandstone	0	4		
Carbonaceous shale	0	8		
Coal	2	4		
			7	0
Carbonaceous shale			0	6
Grey shale (bottom not seen)			2	0
TOTAL			16	0

Here there are only 3 feet 4 inches of workable coal, divided into two parts by 3 feet 8 inches of sandstone and carbonaceous shale with threads of coal in places.

The dip at the outcrop is about 7° to the north. To the south there appears to be faulting, and the underlying rocks are not seen. On the west, coarse sandstone dips at 15° to north-10°-east, while to the north-east sandstones, overlying the coal, are seen nearly horizontal.

The coal appears to be of fair quality, but has not been cut into. A small quantity, dug from the outcrop, burned well, almost without flame, and left a grey ash. The seam, however, appears too thin to be worth working, especially in the neighbourhood of other and much thicker beds.

VI. Ráwanwára seam, No. 2.—About a mile west of Ráwanwára, coal again crops out in a nala; the precise thickness is not seen. At one spot there is only 1 foot of coal with shale above and below; dip 10°, to north-20°-west; 30 or 40 yards further west, 3 feet of coal is exposed, divided into two parts by about 2 feet of shale; and a few yards further, 2 feet of coal are seen, all dipping in the same manner as in the first instance mentioned. The two latter may belong to the same seam, the top not being seen in the latter case, and neither top nor bottom in the former. The whole section is very ill seen in a narrow nala, and a small shaft on its north bank would be necessary to prove the thickness of the coal seam, its quality, &c. So far as I could judge, the seam did not appear to be of any great thickness.

VII. Parassia seam.—The next place examined was about three-fourths of a mile west-south-west of the village of Parassia. Outcrops, apparently of the same seam, are seen in three places within a few yards of each other. No clear section is exposed. The coal dips to the north, and appears to be about 5 feet thick, but it is so crushed and decomposed that nothing can be clearly made out. The top of the seam is not seen, and the thickness may exceed that above mentioned; there is much appearance of faulting. On the whole the conditions are not promising, but without a small shaft or boring on the north side of the nala, nothing can be determined with certainty.

VIII. Bhandaria seam.—Rather more than a mile south-west of Parassia, and on the boundary of the village lands of Parassia and Bhandaria, several small seams of coal are seen in the Gogra nala, dipping about 10° to north-10°-west; the dip becoming more westwardly down the nala, which runs towards the east. The section is rather difficult to measure exactly, being somewhat broken. It appeared to be the following:—

	Ft.	In.	Ft.	In.
1. Coarse shaly sandstone			many feet.	
2. Shale, top not seen			2	0
3. *Coal*	1	0		
4. Sandstone of various colours, yellow, red, and black	1	8		
5. *Coal*, very good (the base is concealed by gravel, and the thickness may be a few inches more, but only a few inches).	2	6		
6. Sandstone	3	6		
7. Carbonaceous shale	0	8		
8. Sandstone	0	9		

	Ft.	In.	Ft.	In.
9. Carbonaceous shale	0	7		
10. *Coal*, very good	3	3		
11. Shale	0	6		
12. Sandstone	0	3		
13. *Coal*	0	6	15	2
14. Shale	...		0	2
TOTAL			17	4

Or the coal seam, from the top of No. 3 to the bottom of No. 13, measures 15 feet 2 inches, of which 7 feet 3 inches is coal, in general of excellent quality. Just below this a turn in the nala brings in the thickest seam, No. 10, again, and its thickness is correctly seen in a vertical bank; it then consists of—

		Ft.	In.
No. 9	Shale		
10	*Coal*	1	0
	Shale	0	2
	Coal	3	6
	TOTAL	4	8

The difference (1 foot 5 inches) in the two measurements may be due to error in measuring a broken, ill-exposed seam in a nala in the first instance, or to the seam having thickened in the interval, about 30 yards; the latter, I think, the more probable, as seams like this, much interstratified with beds of sandstone, are generally somewhat irregular in thickness, and often excessively so. Indeed the whole section recalls the irregular beds of the western portion of the Raniganj coal-field in several respects.

Thirty or forty yards down the stream, the outcrops of two other small seams are seen, but neither exceeds 18 inches in thickness. They are beneath the above section, 15 to 20 feet of sandstone and shales intervening. Ascending the nala, also, to the east, and 20 to 30 feet above the section measured, a thin, very shaly seam is met with.

Mining prospects of the locality.

Whether this locality is workable or not, depends mainly upon the constancy or otherwise of the seams in thickness, which must be determined by boring or by driving galleries on the seam. The coal appears excellent; the dips, though higher than in some other localities, are not unfavourable; but there is the important drawback, that with the good coal a considerable mass, equal to the coal in bulk, of useless rock intervening between the seams must be dug out, which would much increase the cost of working the coal.

IX. Bhutaria seam.—Close to the boundary between the village lands of Bhutaria and Bhandaria, about a mile west of the former, and barely half a mile east of the latter, is the next locality where coal has been found. The seam dips to the southward or to south-east at about 5°. The outcrop is obscure. I dug out the top of the seam, but under 1 feet 4 inches of splendid coal I found a thick bed of shale, very hard and difficult to cut. After sinking into this for 1 foot 10 inches, I tried another spot, a few yards further east, where the coal re-appeared in the nala, though the top was not seen. Here I sank a small hole to a depth of 4 feet 6 inches, without reaching the bottom of the coal. Including, therefore, the abovementioned seam of 1 foot 4 inches, there is, at this spot, a minimum thickness of nearly 6 feet of coal. It is of fair quality, and burns well; but the lower portion contains a great quantity of iron pyrites, and even the upper 1 foot 4 inches, when burnt, leaves a reddish ash. This, however, appears to be the only drawback. Very little can be made out in the adjoining ground, but the dip is low and favourable.

About a quarter of a mile to the east in the same nala, the top of an outcrop perhaps of the same seam can be traced for at least 100 yards.

X. Barkoi seam.—The next spot to the west is Barkoi. Here alone have any workings taken place, and even here they have not been extensive, consisting of one small quarry. The opening made, however, is sufficient to enable a better judgment of the characters of the seam to be formed than in most of the other places mentioned.

The coal was first observed on the banks of a nala which runs from north-east to south-west, just south of the northern portion of Barkoi village. The quarry is north of the nala, and exposes the following section:—

	Ft.	In.	Ft.	In.
Earth			0	6
Sandstone			3	3
Shale (generally decomposed)			6	9
Coal, decomposed in the quarry, shaly towards the top	2	4		
Shale, variable, about	0	2		
Coal	6	0	8	6
Shale becoming sandy below.				
			19	0

The total thickness of coal is thus 8 feet 4 inches, but the uppermost 1 foot or 18 inches and the bottom 1 foot are very shaly, and there appeared to be about 6 feet of good coal. In the quarry as at present worked, there is less than this, for the upper portion is too much decomposed to be of much value, and not more than from 4 to 5 feet of marketable coal is obtained. None of the coal quarried can, of course, be equal in quality to that which would be obtained if it were mined from a greater depth below the surface. The dip is to the south-south-west, and does not appear to average more than 3°, though amounting to as much as 5° in places.

Associated rocks and geological characters of neighbourhood. Probable extent of seam.

On the south side of the nala, massive felspathic sandstones overlie the coal. They can be traced to a considerable distance, and are well seen in another small nala to the south, which cuts deeply into them. To the north, the coal doubtless crops out close by and is lost. There is no indication of its recurrence in this direction, though the beds roll and are unsteady in their dip.

To the west, or rather south-west, down the little nala, the coal can be traced for a short distance, and about 150 yards below the quarry, north-west, Mr. Adams, the agent in charge, sank a small pit at my suggestion, and came upon coal at the depth of 7 feet; this gives a fall of about 20 feet in 150 yards; but as the direction of the nala is not quite the same as the dip of the coal, the latter being more to the south, the inclination is in reality rather greater. To the east and north-east, the coal can be traced for some distance. About 150 yards from the quarry, there is a small fault with a throw of, apparently, not more than 15 or 20 feet, striking north-west—south-east, which brings down the coal to the north-east. At least such appears to be the case, though the seam beyond is immediately covered by sandstone instead of by shale. This may be due to the decomposition of the shales in the nala bank, and to the sandstone sinking on the coal, or to local unconformity at the period of formation of the coal—a very frequent occurrence in coal measures. At the same time the seam may be different. The section thence to the east is ill seen; the nala is small and choked with blocks of sandstone; but about 200 yards beyond the fault the coal re-appears, perhaps brought up by another little break.

In a nala which passes by the southern portion of the village of Barkoi, south-east of the coal outcrop, a poor section of the beds is seen, the greater portion consisting of coarse felspathic sandstone, similar to that overlying the coal. One small outcrop of a coal seam, 6 inches thick, is met with. The beds have no distinct dip; they are, apparently, slightly inclined to the south. There is no reason for supposing the small outcrop to be in any way connected with the Burkoi seam. In all probability it is much higher in the series, and the Barkoi seam, if constant, which there appears no reason to doubt, should underlie all these beds. In fact, there seems every probability of its existing under a considerable tract of country.

Quality of coal.

The quality of the Barkoi coal is much the same as that of the others described. It is less bright than the Chenda coal, but it is undoubtedly fair fuel. It, however, contains a large proportion of iron-pyrites, more than any of the other seams, except perhaps that of Bhutaria (and this has not been sufficiently cut into to determine). The lower portion of the seam appears, however, to contain less pyrites than the upper. In the coal now extracted from near the surface, the pyrites has, in great measure, decomposed, leaving the joints of the coal lined with peroxide of iron, and a white efflorescence (? sulphate of alumina) frequently forms on the surface. Both of these tend much to injure its appearance. The coal ignites with great readiness, and burns very freely with much flame. The ash is in parts deep red, in others only reddish, and in some cases nearly white.

Despite the considerable proportion of pyrites contained, this coal does not appear to decompose rapidly when exposed. In some heaps, which have been lying on the surface exposed to the weather for two years, the coal has not split up or broken to any extent.

Mining prospects.

The workings hitherto, as I have stated, have been but small. The circumstances under which the seam occurs are, I am inclined to believe, very favourable for mining; the dip is low, and although faults occur, they appear to be of small amount. The shale and overlying massive sandstone would form a good roof in all probability. There is nearly a mile of gently rising ground between the outcrop of the coal and the hills to the south, so that, if the seam be continuous, a colliery may be worked for many years before it is likely to be necessary to sink shafts to any great depth. In this, as in all collieries, however, some preliminary exploration by boring is desirable before any large outlay in shaft sinking and erection of steam engines is undertaken.

Any coal that may exist to the north of the nala may as well be quarried as the quarries there would not affect deeper workings. South of the nala quarries would be objectionable, as if deeper workings are commenced, the quarries will tend to increase the quantity of water met with.

IX. Gogri or Hingladevi seam.—The last place that I visited to the westward was about 2 miles west of Barkoi, in the lands of the village of Gogri, and close to a small jungle shrine known as Hingladevi. Mr. Adams showed me the spot, and, at my request, set workmen to dig into it. They had reached the depth of 4 feet 10 inches from the top of the coal seam, when I saw the spot a second time, all the thickness being through coal. The excavation was continued, and beneath 9 inches of shale was found 6 inches more of coal, beneath which shale recurred, and below that again sandstone. I was informed of this in a letter from Mr. Adams, accompanied by specimens, which reached me after I had left the coal-field. I do not quite understand whether the upper portion of the seam exceeded 4 feet 10 inches or not; but there must be a seam of above 5 feet of coal. It apparently dips at a low angle to the south.

The coal appears of fair quality, though shaly in parts. The outcrop is in the bed of a small nala running between low hills, but with ranges of greater height to the south and south-east. In consequence of the unevenness of the ground, the spot is not so well suited for mining as Burkoi.

Coal at Paláchaori.

Besides all the above localities, coal is said to have been found in a well at the village of Paláchaori, north of the last described locality.[1]

Importance of the discoveries of coal seams.

The above details will, I think, serve to show that these discoveries of coal seams are the most important that have been made in India for many years, amongst all the previously known coal localities in Central India; to the west of the meridian of Jabalpur, there are but two seams, both at Mopáni, in Narsinghpur district, which exceed 4 feet in thickness. Near the Pench, within an area of 16 miles in length from east to west, no less than six (or, including Bhandaria, seven) localities have now been discovered in which seams exceeding that thickness occur; and when it is borne in mind that, with two exceptions only (Barkoi and Hingladevi), the whole of these localities have been discovered since the month of October last, and solely through the researches of Major Ashburner, I think it is only reasonable to believe that many other workable seams may still remain undiscovered in this

[1] Since my departure, Major Ashburner informs me that he has discovered two other places where coal occurs.

neighbourhood, and that there is every probability that this portion of the great Sátpura coal-field equals, in mineral wealth, the coal-fields of the Damuda valley in Bengal.

Favorable conditions for mining.

The circumstances under which the coal occurs, appear, in most instances, to be favorable to mining enterprise. The dips are very low, and, so far as a judgment can be formed from the very imperfect sections exposed at the surface, there appears good reason to anticipate that both the quality and thickness of most of the seams will be found constant, at all events over a considerable area. Faults are numerous, but the majority do not appear to be of sufficient amount to affect mining operations injuriously. It is probable that these faults will be found to decrease in number, the greater the distance from the fault bounding the coal measures to the south.

Quality of coal.

The quality of the coal, so far as a judgment can be formed by inspection, and by burning it in heaps, is similar to that of the coals of Raniganj, and other mines in that neighbourhood. It is a free-burning, non-caking coal. It is decidedly inferior to the better qualities of English coal, both on account of the larger proportion of ash and of the lower percentage of fixed carbon. At the same time, I see no reason for doubting that, for railway purposes, the Pench river coal is perfectly adequate; it is just as well suited as the Raniganj coal, with which the East Indian Railway was worked for some hundreds of miles, and I believe that for all local purposes, or for fuel for stationary steam engines, it is excellently adapted; while for the manufacture of iron, the freedom from pyrites possessed by the Sirgori seam, if found to be constant, should give that coal advantages over most other Indian coals with which I am acquainted.

Seams discovered probably distinct.

The question may possibly arise, whether some or all of the seams discovered may not be identical. Without a much closer examination of the country than it has been possible to make hitherto, it would be impossible to answer this question precisely in every instance; and, even were an exact survey made, the large area of ground covered and concealed by trap, and other formations more recent than the coal-bearing rocks, would render the tracing of each seam a hopeless task, until mining operations had advanced considerably. But there can, I think be no question that the majority of the seams are quite distinct from each other, and I have not been able, in a single instance, satisfactorily to ascertain that any seam examined was identical with one seen elsewhere.

Localities best suited for mining.

Amongst the localities I have described above, I am disposed to believe that those best suited for mining purposes are Sirgori, Bhutaria, and Barkoi; but further explorations by boring, as I have shown above, are desirable in every instance. The availability of the splendid seam on the Pench, at Chenda, depends, as I have above stated, on its continuance to the north, beneath the trap in the river. Further exploration is required at Parassia, and it is extremely desirable that the thickness of the seams there and at Bhutaria, and, above all, at Sirgori, should be ascertained at once.

Specimens sent for analysis.

With this report I send for analysis fair specimens of the four principal seams named, *viz.*, Sirgori, Chenda, Bhutaria, and Barkoi[1]; those from Chenda being taken from the lower 4 feet 3 inches coal, which is the best part of the seam, and which in the cutting made was least injured by surface decomposition. The specimens from Barkoi are also from the lower part of the seam, for the same reason. In comparing the results it should be borne in mind that the coal from Chenda, Bhutaria, and Barkoi, is outcrop coal, and that fuel of a superior description will, doubtless, be obtained, by mining—fuel, however, which may probably contain more sulphur and gaseous ingredients, while the coal from Sirgori is mined from 30 feet below the surface. It should also be remembered that the present specimens are small fragments, broken from various parts of the seam, for the purpose of obtaining a *fair sample* of the whole.

Climate of district.

Apart from geological conditions, the circumstances of the country are, I think, favorable for the establishment of collieries,—the country being high, the climate is cool, and well suited for Europeans, except for two or three months, during which, owing to the prevalence of jungle, it is feverish.

Supply of labour.

The population of the district is chiefly Gond. These people are indisposed to work regularly, and labour for hire may have to be imported. But *quasi*-aboriginal tribes like the Gonds, if kindly treated, are excellent labourers, and are likely to become good miners, being superior in physique to the average labourers of Central India. The miners at Raniganj belong exclusively to races allied to the Gonds, Bhonris, Santals, &c.

The immediate neighbourhood of the Pench river is fertile, and the villages are numerous; away from its banks, the population is sparse, and the greater portion of the country covered with jungle.

Camp, Betul district,
March 10th, 1866.

	Fixed Carbon.	Volatile matter.	Ash.
[1] Chenda	61	16	23
Barkoi	50·3	26	23·7
Bhutaria	49·3	26·5	24·2
Sirgori	61·6	28	10·4

List of coal seams hitherto discovered in the Pench river coal-field.

Number.	NAME OF VILLAGE.	Thickness of seam.	Thickness of good coal in seam.	Average angle of dip.	Direction of dip.	REMARKS.
		Ft. In.	Ft. In.			
I	Singori	Above 4 9	Above 4 9	5°	N.	Not yet sunk through.
II	Ditto	3 0	3 0	5°	N.	Not workable.
III	Chenda and Digawáni (Pench R.)	15 6	12 3	3°	N.	
IV	Harrai	?	?	?	?	Particulars not ascertained.
V	Rawanwára	7 0	3 4	4°	N.	Probably not workable.
VI	Ditto	?	Above 3 0	10°	N. 20° W.	Thickness not ascertained.
VII	Parassia	?	Above 5 0	?	N.	Exact dip and thickness not ascertained.
VIII	Bhandaria	15 2	7 3	10°	N. 10° W.	
IX	Bhutaria	Above 7 8	Above 5 10	5°	S.	Total thickness not sunk through.
X	Barkoi	8 6	About 6 0	3°	SSW.	
XI	Gogri (Hingladevi)	? 6 0	? 5 3	About 5°	S.	This seam may be a few inches thicker.

Note on borings *for* coal *at* Engsein, *British Burma:*[1]

By R. ROMANIS, D.SC., F.G.S.E.

A company being engaged in exploring the post-tertiary strata at Engsein, about 6 miles from Rangoon, for coal, I took the opportunity to examine the specimens brought up.

The surface consists of sand loosely cemented together by peroxide of iron. Throughout this bed there are found nodules and bands of a hydrated peroxide of iron containing manganese. This bed of yellow-sand passes into a bed of grey sand, evidently the same before the iron in it has become peroxidized.

Below the sand is a considerable depth of a fine clay, like pipe-clay. From this one or two fragments of stone were brought up, which, I am informed, are called "boulders" by the borers.

I was puzzled to account for their presence. They are composed of a crystalline rock of comparatively small density; with a glass I observed small reddish-brown crystals like garnet. There are no traces of volcanic action in the neighbourhood so far as I know, and it is not easy to see how they could have been brought into their position. They may have been shot from some former sub-marine volcano now concealed beneath the alluvium of the delta, or they may be fragments of a meteorite. I have not yet analysed them.[2] In this bed, too, were found casts of the roots of some plant, apparently a water-lily. A thin seam of lignite, about an inch in thickness, was passed through. I shall take an early opportunity of re-visiting the borings.

I understand that a friable sandstone underlies the clay, and that this crops up to the surface at a short distance to the north, and that a new boring is about to be commenced to explore the strata below.

On Sapphires *recently discovered in the* North-West Himalaya:

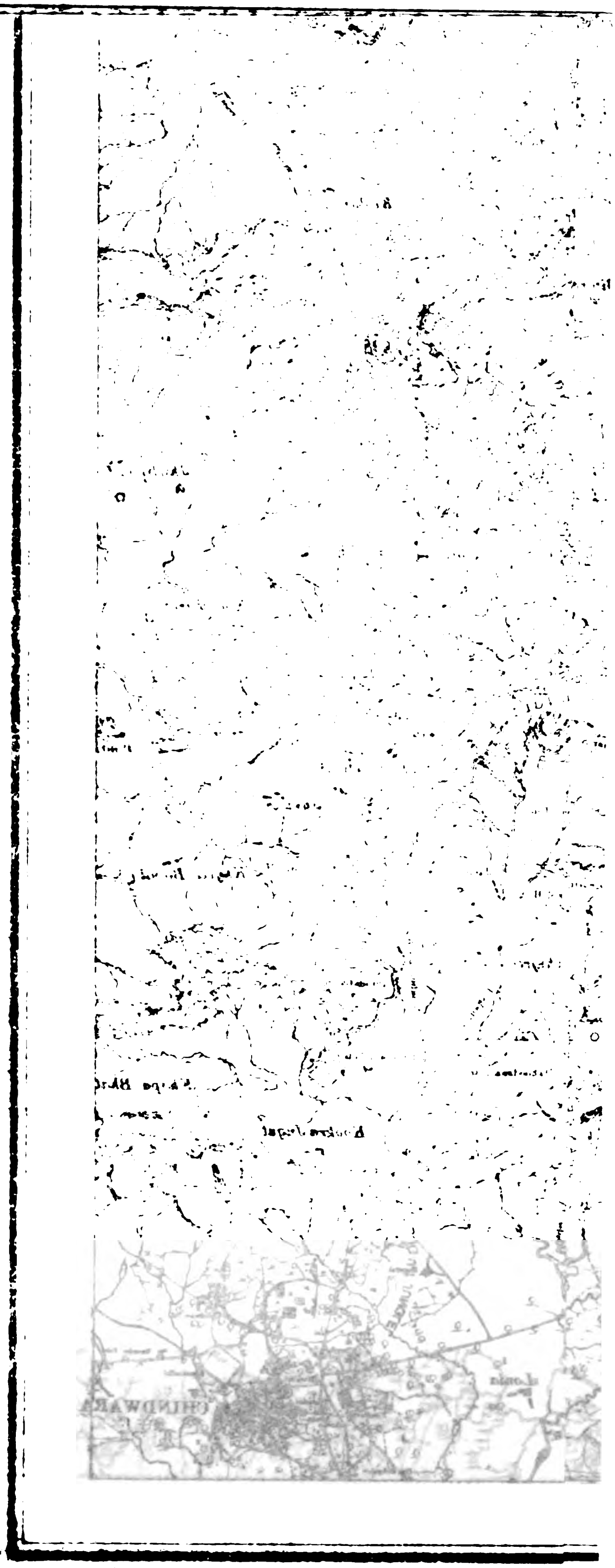
by F. R. MALLET, F.G.S., *Geological Survey of India.*

Some excitement has been caused of late in Upper India by the discovery, in the region beyond the snows, of stones concerning which the most conflicting accounts have appeared from time to time. At first they were described as amethyst, or as blue quartz, subsequently as sapphire, and later on as amethyst and as sapphire again.

An equal amount of uncertainty has prevailed as to the locality from which the stones have been obtained. The discoverers, naturally enough, have not

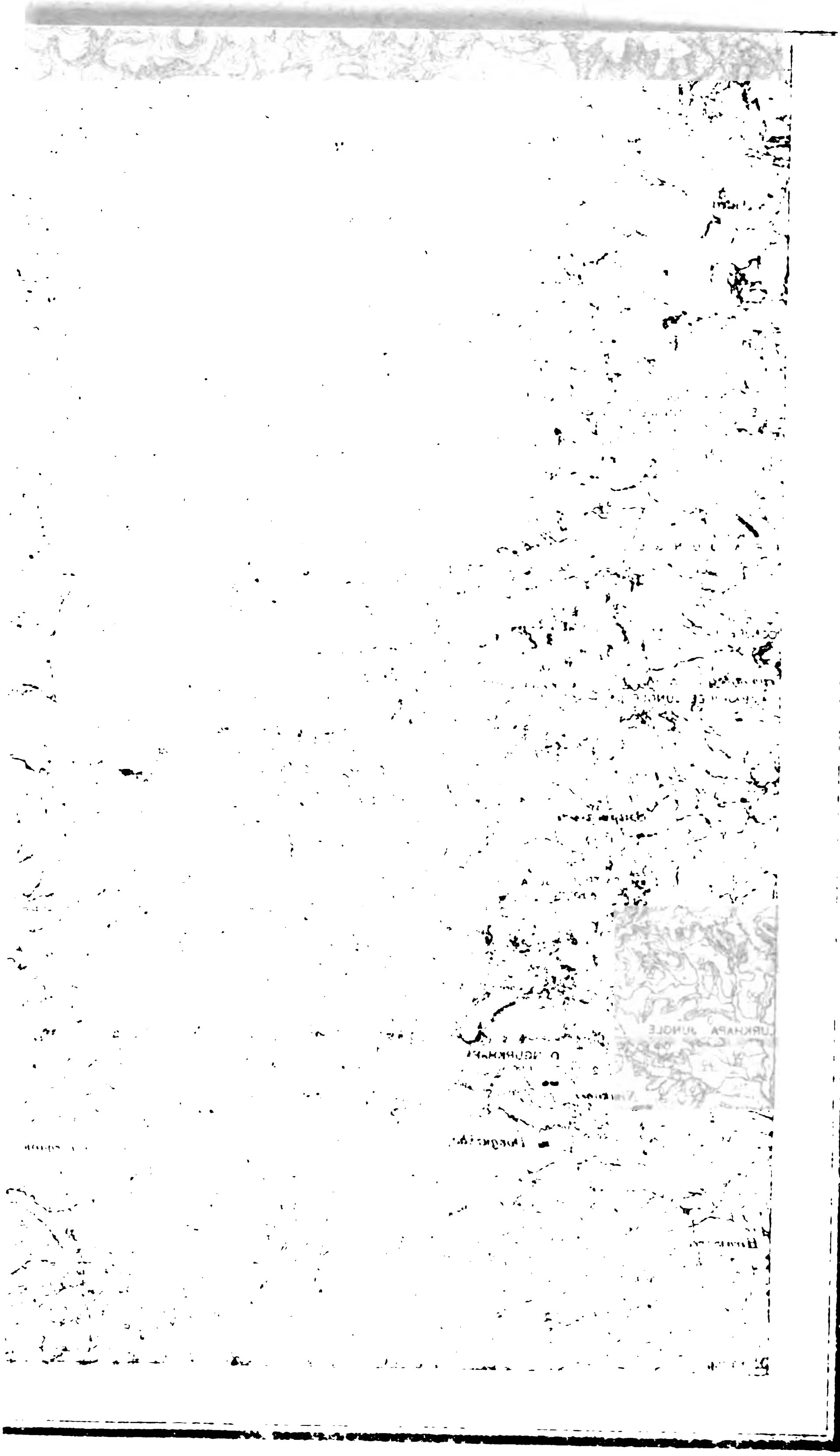
[1] Frequent mention having lately appeared in the newspapers of a discovery of coal near Rangoon, some information on the subject would naturally be expected from the Geological Survey I had endeavoured, officially and otherwise, to ascertain the locality of the exploration and the facts upon which it was based, but without success; so the notice (communicated unsolicited) by Dr. Romanis is very welcome. I need hardly add that it only increases our curiosity as to what can have led to the search for coal in such ground.—H. B. MEDLICOTT.

[2] In a later note Dr. Romanis adds—"I have analysed the so-called boulder and satisfied myself that it is not of igneous origin, but there must be some mistake in the account I received of the way it was found."



H VALLEY.

derlined.



felt particularly eager to impart their secret to the rest of the world, and have perhaps not displayed any remarkable energy in correcting such false reports as may have arisen. There appears, however, to be little doubt, now, that they are found in the neighbourhood of Padam in the Zánskár District, within the territory of Káshmir. The discovery seems to have been due to a landslip, which laid bare a new face of rock in which some of the blue stones were visible. On working into the rock large quantities were subsequently extracted. The first lots of the mineral that were brought across the snow are said to have been sold at extremely low rates, owing to the ignorance of the carriers as to their value. Now, however, the gems are fetching high prices, Rs. 85 a tolah, having, it is said, been offered at Simla, while for individual specimens considerably higher rates have been declined. It was stated some time ago that the Delhi jewellers had bought up more than two lakhs (20,000£) worth of the stones.

As it was desirable that the real nature of the mineral should be ascertained beyond doubt, two specimens, obtained at Simla, were recently forwarded to this office by direction of the Punjab Government: one of these weighs about 250 grains, the other about 110. The larger is in part transparent, and of a rich blue tint, partly bluish-white and translucent. The smaller is almost wholly of the transparent blue variety, but shades into brown in one or two spots. The physical and chemical characters of the specimens show conclusively that they are true sapphire. The specific gravity of the larger piece was found to be 3·959 and of the smaller 3·961.[1] The mineral scratches topaz; is infusible before the blow-pipe; and when fused in powder with acid potassium sulphate, and dissolved in water, yields a bulky precipitate of alumina with ammonia.

Of two other specimens, subsequently sent, which were obtained by the Assistant Commissioner of Kulu, one is a double hexagonal pyramid (probably 4P2, but with irregular angles) terminated by the basal planes. There are four or five smaller crystals of sapphire attached to, or embedded in, it. The crystal is $2\frac{3}{4}$ inches long and weighs rather more than 800 grains. It is bluish-white and translucent, with transparent blue portions irregularly mixed. The other specimen is about an inch and a quarter long and seven-eighths of an inch diameter at one end. It constitutes one-half of a double hexagonal pyramid (2P2), which has been broken across near the centre. The fracture displays a cavity of considerable size in the interior, containing two crystals of tourmaline. One of these is of comparatively large size, but showing no well-defined faces; dark-brown in colour, and semi-transparent. The other is very much smaller, but well-crystallised (∞P2. ∞R. R.), and transparent, the body of the crystal being light brown, and the termination indigo-blue.

I have also had an opportunity of examining a consignment of the gems

[1] The specimens are thinly coated in places by a white mineral (with minute botryoidal surface), which may be gibbsite, but there is too little of it for satisfactory determination; and on the surface of the larger one there are two or three minute crystals of greenish tourmaline. The presence of these minerals introduces a slight error into the above-given specific gravities, for the sapphire alone. This error, however, probably does not exceed 1 in the second place of decimals, and reduces the apparent below the true value. Although the amount of foreign matter on the smaller specimen is much less than on the other, the observed specific gravity is higher by only ·002.

aggregating some pounds in weight. They included, besides irregular fragments, a considerable number of crystals, one of the largest and best formed of which was a double hexagonal pyramid terminated by the basal planes (4P2. 0P.). It measured 3″ × 1¾″ × 1¼″, and, like all the others, was bluish-white and translucent, with transparent blue portions irregularly mixed. The blue parts of course constitute the valuable portion of the crystals, and are carefully cut out by the lapidaries, while the bluish-white are scarcely entitled to the name of sapphire, and would be more appropriately designated as corundum. A considerable proportion of the specimens contained small crystals of dark-brown tourmaline, which seem to be most common in the interior and near the centre of the sapphire crystals.[1]

[1] Since the above was in print, the following letter has been received from the Revd. A. W. Heyde, the Moravian Missionary for many years resident in Lahul, than whom no one is more likely to receive correct information on the subject :—

Letter from the REVD. A. W. HEYDE, *Moravian Missionary, dated Kyélang* (viâ *Kangra and Kulu*), *Punjáb, the 18th April 1882.*

Owing to the fact of my being shut up by snow during the winter months, a letter from Mr. Lydekker, of the 21st of February, reached me only four days back. He writes for information regarding the blue stones which have lately been found in the neighbourhood of Lahul and sold in large quantities, chiefly by Lahulies, at Delhi and elsewhere. I have gathered what information I could.

The place from which all the blue stones which have come into the market *till now* have been taken, is, according to one informant in Padar [Padam], about half a day's journey from the top of the *Umasi Pass*, 2 or 3 kos *to the east* of the village of Machél (which I cannot find on my maps). According to another informant, the place is reached best from the top of the Pentse La, between Zánskár and Rangdum. From the Pentse La you have to cross the same range which is crossed by the Umasi, when you find the spot on the *southern* slope, after having descended for a short distance. This way is only known to the Zánskár people living near the Pentse La. The exact spot is situated as high as the line of perpetual snow where vegetation has ceased. Its surface is a dark-brown earth, followed by a stratum of a white stuff, resembling, as my informant said, *bul* (soda), which is found in the Nubra valléy.

In this white stratum regular crystals or shapeless bits, large and small, of the blue stone are found singly and can be taken out "like potatoes" without any instrument. But when this white layer, which does not appear to be thick, is worked through, more or less solid rock is met, which is *also blue*, and from which bits can be taken only with instruments. This information I received from different people, two of whom professed to have seen the place. How far all this may be true, I cannot tell, though I have no reason to doubt the information as a whole.

Very interesting is the statement made to me, that this place is not the only one where these stones are found under similar conditions. In the immediate neighbourhood of the spot described, the people know of two others, in one of which the blue stone is found not below the ground but in horizontal seams of a large rock, but also, as it appears, surrounded or embedded in that white stuff. Another spot where this stone is said to exist is from 50 to 100 miles or more to the east, or rather south-east, in the *same range*, above the monastery of Bardan in Zánskár (a village near by is called Pipcha). And only yesterday I heard that a shepherd of Lahul *thinks* he has seen the same stone here in Lahul high up in the hills on the right side of the Chandra Bhaga, about two marches upwards from Tri Lok Náth; in this case, also, it seems, at the height of the snow line. This, if true, would not be in the main range, but in a branch of it. In Padar these stones were first found, as is said, by a *shikári* about two years ago. Only last year he and other people of Padar found out that they had some value, beginning to sell them to traders and several people of Lahul, at one rupee a seer. As yet the Maharája's people know only of that one place where the stones are found; the others are kept secret by the people for fear of hardships which might follow a disclosure. As the stones are found at so great a height, partly in well nigh inaccessible spots, the Maharája's guards who have been stationed to watch that one place from a distance are unable to prevent the inhabitants from taking out and selling stones still. In Zánskár large quantities of them are still in the hands of the people, amongst which there are said to be some very perfect and large crystals—one of them is said to be a foot in length.

I myself have not made an object of buying such stones, but have seen different bits of them. The upper end of what seemed to have been a regular crystal, having been broken, had *two* broad sides and *four* small sides. Several shapeless bits were covered with a whitish crust consisting as it were of minute quartz or lime crystals, the crust adhering very firmly. Others were irregularly covered with well-formed small crystals.

The thick end of another broken larger crystal looked for about an inch like topaz, the colour being that of a deep-coloured sherry wine, quite transparent, the two colours (blue and yellow) running gradually into each other.

I forgot to mention that in the localities in Padar where the stone is found, the common pebble in large and small crystals abounds.

Jewel merchants from the plains pay here at present as much as Rs. 30 for one tola of the blue stone if the colour is pure. I further forgot to mention a report, according to which also stones of a *red* colour have been found in the same localities.

Notice of a recent Eruption *from one of the* Mud Volcanoes *in* Cheduba.

The following letter from the Commissioner of Arakán to the Government of Burma, relating to a fiery eruption from one of the mud volcanoes in Cheduba, is published in continuation of similar records[1] :—

From COLONEL E. B. SLADEN, *Commissioner of Arakán, to the Secretary to the Chief Commissioner, British Burma, Rangoon. Dated Akyab, 4th January 1882.*

I have the honour to report a rather interesting phenomenon in connection with the shock of earthquake which was felt at this station on Saturday morning last, the 31st December.

2. The vibrations commenced at about 7-55 A.M., and were continued at intervals from ten to fifteen minutes.

They were not severe, but doors and windows of houses rattled; furniture was made to undergo a see-saw movement, and pendulum clocks in some instances stopped.

3. I was myself at the time on board the S. S. *Mahratta*, off the mouth of the Sandoway river, and the point of interest in relation to the earthquake is, that, simultaneous as regards time with its occurrence at Akyab, we were eye-witnesses of one of those violent volcanic eruptions which have already been observed to take place on some of the islands lying off this coast during the great earthquakes of 1833 and 1839.[2]

4. In the present instance, the eruption occurred in one of the extinct volcanoes near the southern extremity of Cheduba Island.

As we were lying at anchor at the time off the mouth of the Sandoway river, we must have been about 30 miles from the scene of the volcano; but even at this distance a dense column of smoke and broad massive flames of fire were seen to rise, as it were, from the horizon, and stretched far up into the distant sky.

Viewed even by daylight, the sight was a magnificent and impressive one, owing to the great volume of flame and the immense height to which it rose. Dr. McClelland, writing of

[1] Vols. XI, p. 188; XII, 70; XIII, 206; XIV, 196.
[2] Vol. XI, pp. 197, 206.

the eruption in 1833, says that the flames issued to the height of *several hundred feet*; and the description given in Silliman's Journal of a similar eruption in 1839 is to the effect that "fire mingled with smoke and ashes rose to a *fearful height*."

5. In these two instances the observers were within 3 or 4 miles of the eruptions. In the present instance, we were 33 miles in a straight line from the scene of the eruption, and at that distance, the flames, as seen by us, appeared at times to reach half-way up from the horizon to the sky, and to have a lateral (apparent) breadth of from 30 to 40 feet.

They continued to issue forth with greater or less effect for about 15 minutes, and then suddenly disappeared; but the smoke, which had risen in a long straight column, formed itself into a vast black canopy, which hung like a cloud in the sky, and was visible for hours after the eruption was at an end.

6. I may mention that the high land of Cheduba was quite visible from where we were, and that bearings, taken at the time, indicated the scene of the eruption to be the extinct volcano known locally as the "Naga Dwen."

ADDITIONS TO THE MUSEUM.

Donors.

A collection of vertebrate fossils from Perim Island (see above, p. 104).
CAPTAIN SEARLE,
Supdt. of Marine, Calcutta.

Mammalian bones from pleistocene beds of the Jamna valley, in the Bánda district.
MR. JOHN COCKBURN.

A slab of shale with plant-impressions from the Karharbari coal-field.
W. G. OLPHERTS, C.E.

Two blocks of English patent fuel.
THE MADRAS RAILWAY CO.

A block of cupriferous gneissose schist from the Báraganda copper mine, Hazáribágh.
MR. N. KENNY.

Specimens of crude asphalt, 'boiled pitch,' and 'glance pitch', from Trinadad.
DR. O. F. BRICHMANN.

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BRONN'S.—Klassen und Ordnungen des Thier-Reichs. Band VI Abth. III, Reptilien, Lief. 25-26 (1881), 8vo., Leipzig.

Encyclopædia Britannica, 9th Ed., Vol. XIII. (1881) 4to., Edinburgh.

KARRER, FELIX.—Der Boden der Hauptstädte Europa's (1881), 8vo., pht., Wien.

MOURLON, MICHEL.—Géologie de la Belgique. Vols. I—II (1880-81), 8vo, Berlin.

RENAULT, M. B.—Cours de Botanique Fossile, Année II (1882), 8vo., Paris.

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Annales des Mines, 7th Series, Vol. XX, livr. 4 (1881), 8vo., Paris.

Annales des Sciences Géologiques, Vol. XII, No. 1, and XIII (1881), 8vo., Paris.

Annales des Sciences Naturelles, 6th Series, Zoologie et Paléontologie. Vol. XI, Nos. 5-6, and XII, Nos. 1-2; and Botanique, Vol. XII, No. 1 (1881), 8vo., Paris.

Annals and Magazine of Natural History, 5th Series, Vol. IX, Nos. 49-51 (1882), 8vo., London.

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Athenæum, Nos. 2825—2836 (1881-82), 4to., London.

Beiblätter zu den Annalen der Physik und Chemie, Band V No. 12, and VI, Nos. 1—2, (1881-82), 8vo., Leipzig.

Bibliothèque Universelle. Archives des Sciences Physiques et Naturelles, 3me. Période. Tome VI, Nos. 10—12 (1881), 8vo., Genève.

Bibliothèque Universelle et Revue Suisse, 3me. Période, Tome XII, Nos. 34—36 (1881), 8vo., Lausanne.

Botanisches Centralblatt, Band VIII, Nos. 8 and 10—12, and IX, Nos. 1—8 (1881-82), 8vo. Cassel.

Chemical News. Vol. XLIV, Nos. 1151—1153, and XLV, Nos. 1154—1162 (1881-82), 4to., London.

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Das Ausland, Jahrg. LIV, Nos. 50—52, and LV, Nos. 1—9, (1881-82), 4to., Stuttgart.

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Iron. Vol. XVIII, Nos. 466—468, and XIX, Nos. 469—477 (1881-82), fol., London.

Journal de Conchyliologie, 3rd Series, Vol. XXI, No. 3 (1881), 8vo., Paris.

Journal of Science, 3rd Series, Vol. IV, Nos. 97—99 (1882), 8vo., London.

London, Edinburgh, and Dublin Philosophical Magazine, and Journal of Science, 5th Series, Vol. XIII, Nos. 78—80 (1882), 8vo., London.

Mining Journal, with Supplement, Vol. LI, Nos. 2416—2419, and LII, Nos. 2420—2427 (1881-82), fol., London.

Naturæ Novitates, Nos. 24—25 (1881), and Nos. 1—4 (1882), (1881-82), 8vo., Berlin.

Nature Vol. XXV, Nos. 633—644 (1881-82), 4to., London.

Neues Jahrbuch für Mineralogie, Geologie, und Palæontologie, Jahrg. 1882, Band I, heft 1 and 2 (1882), 8vo., Stuttgart.

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„ Zeitschrift der Deutschen Geologischen Gesellschaft, Band XXXIII. heft 3 (1881), 8vo., Berlin.

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THE AUTHOR.

April 6th, 1882.

RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1882. [August.

Note on the coal *of* Mach (Much) *in the Bolan pass, and of* Sharág *or* Sharigh *on the Harnai route between* Sibi *and* Quetta, *by* W. T. BLANFORD, F.R.S., *Senior Deputy Superintendent, Geological Survey of India.*

When on the way, in October 1881, to examine the hill tracts north of Sind and west of the Punjab, I received instructions to examine two localities at which coal had been found, one on each of the routes between Sibi[1] and Quetta. One of these localities, that at Mach on the Bolan route, had already been visited and described[2] by Mr. Griesbach, but after his examination fresh discoveries were made. As will be seen however, my conclusions as to the value of the coal seams are practically the same as Mr. Griesbach's. The other locality, Sharág or Sharigh on the Harnai route, along which it was at one time proposed to lay a railway to Quetta, and which lies to the eastward of the Bolan pass, had not previously, so far as I am aware, been geologically examined.

My visit to both localities was necessarily very brief, but still I think sufficient to enable me to judge of the probability of their affording fuel on a large scale. My opinion, I regret to say, is unfavourable.

It is unnecessary here to enter at any length into the geology of the beds[3]. Mr. Griesbach has already shown, quite correctly I believe, that the coal of Mach belongs to the lower part of the eocene system. The position of the Sharág beds is not so clear[4], but that they belong to the same system is unquestionable. The similarity in mineral character of the beds associated with the coal[5] in both localities is so great that there is probably very little, if any, difference in age;

[1] The terminus at present of the railway.

[2] Report on the geology of the section between the Bolan pass in Biluchistan and Girishk in Southern Afghanistan, Mem. Geol. Surv. India, Vol. XVIII, Pt. 1, p. 22.

[3] I hope to be able to give a fuller account of the geology of the country in a future report.

[4] I had not time to examine fully the surrounding country.

[5] It may be possibly questioned whether the mineral found at Mach and Sharág should be called lignite or coal, but as the latter term has been generally used, I shall retain it. The substance is certainly not a typical lignite.

but the occurrence of coal or lignite beds in the eocene deposits of Western India appears to be local and occasional, and it is not as yet ascertained that all such deposits are on the same horizon.

It will be well briefly to describe each locality separately, and to commence with Mach.

Mach (*Much*).—The camp known as Mach, between Sir-i-Bolán and Ab-i-gúm, is four marches (about 45 miles) from Quetta, and six marches (about 65 miles) from Sibi. The elevation above the sea-level is nearly 4,000 feet. Hills occur to the eastward and westward, but for about 2 miles east of the camp, and for a much longer distance to the northward, the surface is nearly a plain, much covered by deposits of gravel, and intersected by deep ravines, in some of which sections of the rocks associated with the coal are seen. A particularly good section is exposed in a stream bed running from the north to join the main Bolan river just opposite the Mach camp. This stream is the Maki Nadi of the map, and is, I think, that called the Mach river by Mr. Griesbach, on the bank of which he measured the sections given in detail in his report[1]. Here several beds of coal occur, but very few, if any, of them exceed a foot in thickness at the outcrop[2].

The beds associated with the coal consist of grey and olive shales, weathering into clay at the surface, sandstones mostly very soft, and a few harder calcareous beds, containing marine (or perhaps estuarine) fossils, chiefly bivalve shells (*Lamellibranchiata*) in great abundance, but not of many species. The sections already mentioned in Mr. Griesbach's report afford a general idea of the rocks.

All the beds are greatly disturbed, and in places irregularly contorted, and the dips are, as a rule, very high, and frequently nearly or quite vertical.

Precisely opposite to the camp at Mach, in the bank of the main or Bolan stream-bed, a thicker seam was found[3] after Mr. Griesbach's visit. Into the outcrop of this seam, at the base of the bank, some holes had been made, from two of which, only a very few feet apart, coal was being dug at the time of my visit. The thickness of the seam exposed was 2 feet 8 inches in one hole, 2 feet 4 inches in the other, as nearly as could be ascertained under the circumstances, the holes being small and irregular, no good face of the coal exposed, and a considerable quantity of water running in from the gravel in the stream bed. But of the thickness named, the uppermost, 6 to 8 inches, was very shaly and impure[4];

[1] *Op. cit.*, pp. 23, 24.

[2] Many of the seams are excessively decomposed at the outcrop, and would perhaps prove rather thicker if cut into.

[3] By Captain Johnson, Commissary of Ordnance. This officer had unfortunately left Mach before I arrived, and I found no officer stationed at the post.

[4] The following is an analysis by Mr. Mallet :—

Moisture	7·0
Volatile matter (exclusive of moisture)	38·8
Fixed carbon	17·6
Ash	36·6
	100·0

whilst the lower, 2 feet or rather less, were of better quality. An analysis of a fair sample by Mr. F. R. Mallet gives—

	Per cent.
Moisture[1]	10·9
Volatile matter (exclusive of moisture)	33·1
Fixed carbon	41·0
Ash	15·0
	100·0

The ash is red, indicating the presence of iron pyrites in the coal.

The seam, where cut into, dips about 50° to the north. Ten or 12 feet above it is another much thinner bed, and 12 feet higher another, consisting of several bands of coal, measuring in the aggregate perhaps 20 inches, distributed through 4 to 5 feet of shale. None of the separate bands of coal exceeds 6 inches in thickness. Several other thin seams occur higher in the section.

There is much reason to suspect that the thickness of the principal seam is not uniform. It appears to vary in the few feet exposed, and so far as could be learned from the native workmen, who had been engaged in digging coal from it, it thins out to the westward. The associated clays can be traced for some distance, but no distinct outcrop of the thick seam is exposed. In the opposite direction to the east and north-east, all outcrops are concealed by the gravel in the bed of the stream.

Sharág or *Sharigh.*—The camp and military post marked as Sharág on the map, but commonly known as Sharigh, lies at a distance of four long marches (about 70 miles) from Quetta, and of five marches (about 80 miles) from Sibi, at approximately the same elevation (4,000 feet) above the sea as Mach, in the middle of a plain extending to a great distance to the north-west and south-east, and broader than usual, being probably 7 or 8 miles from north to south, at the spot selected for the camp.

The principal place where coal occurs[2] is about 3 miles south of the post and close to the hills forming the southern boundary of the plain. A small stream, the Siah Dad, running from the plain, cuts its way through the hills to the southward, and close to the spot where it enters the hills a much smaller stream runs in from the west, and exposes in its bed an excellent section of the rocks, which are imperfectly seen in the Siah Dad itself. As already mentioned, these rocks are similar in character to those of Mach,—soft grey or olive shales, more or less sandy, and weathering into sandy clays at the surface, soft sandstones and hard calcareous bands containing fossils. All are vertical or nearly so. In a measured section of about 370 feet of these strata, there are about thirty beds of coal, the great majority less than 6 inches thick, and many only 1 or 2 inches. Only four beds equal or exceed a foot in thickness, and of these, two are chiefly composed of shales. The thickest seam measures 1 foot 9 inches. Fair samples

[1] Water that is driven off at a temperature of 230° Fahr.

[2] I was more fortunate at Sharág than at Mach, for at the former Major Newport, of the 24th Bombay Native Infantry, the discoverer of the coal, still commanded the post when I visited it. He took me over the ground and gave me all the information in his power.

of this seam (No. 1), the quality of which is superior to that of most of the others, and of a thinner band 8 inches thick (No. 2), have been analysed by Mr. F. R. Mallet with the following result:—

	No. 1.	No. 2.
Moisture	6·8	3·0
Volatile matter (exclusive of moisture) .	40·8	42·8
Fixed carbon	47·6	46·1
Ash	4·8	8·1
	100·	100·0

No. 1 does not cake, and yields a red ash; No. 2 cakes to a light porous coke, and yields a red ash.

In another spot, three quarters of a mile further north, and consequently nearer to the camp at Sharág, the outcrops of several thin coal seams are seen in the banks of a stream bed. The coal-bearing rocks are probably the same as those to the south, repeated by a roll of the strata. Again, the dip is nearly vertical. One bed of coal was seen a foot thick, and of good quality. It was possible to trace the outcrop of this seam on the surface of the ground for about 350 yards by the aid of a conspicuous band of highly fossiliferous sandstone abounding in bivalve shells, and occurring just above the coal. Within the distance named, the thickness of the coal seam diminished, until it was only represented by a layer or two, scarcely an inch thick, in carbonaceous shale. This was the only instance in which the outcrop of a coal-bed could be traced more than a few yards, and it affords strong presumption of the inconstancy in thickness of these seams,—an inconstancy which has been observed in similar deposits amongst the eocene rocks of other parts of India and Burma.

The country around Sharág has been searched in all directions by Major Newport without any other outcrops having been found. But about 7 miles east-south-east of Sharág, on the road to Harnai, three little seams are exposed 200 or 300 yards north of the road in a small stream running from the north. One of the seams is 7 inches thick, the others 1 to 2 inches. A little further on the Harnai road, a thin coaly layer is seen by the road side. Again, on the same road, about 3 miles east-south-east of a small village called Nasuk, and 12 miles from Sharág, in a section cut by a small stream close to the road, and on the north side of it, four little seams are seen,—the two upper mere layers, the third 8 inches thick, and the fourth, separated by 5 inches of clay from the third, 3 inches in thickness. In all these cases the beds are nearly horizontal. These outcrops, all observed in the course of a single march along the road, render it highly probable that many more would be discovered if a thorough exploration of the country were undertaken; but at the same time they do not add to the probability of thicker beds of coal being found.

The details given above lead to the following conclusions:—

1. Not a single seam has been discovered, either at Mach or Sharág, thick enough to pay for mining on a large scale, even if the thickness of the seam were known to be constant, and if other circumstances were favourable to mining,—neither being the case.

2. The evidence is very imperfect, but so far as it extends, it appears probable that the seams are inconstant in thickness, and thin out within short distances.

3. The conditions under which the seams occur at Mach and Sharág are unfavourable to mining, though not such as to render it impracticable. In the first place, the beds dip at high angles and are often vertical. There is, however, much probability that by search other localities might be found where the dips are moderate, as in the case of the little seams noticed between Harnai and Sharág. Secondly, the associated rocks are so soft that mining would involve the necessity of heavy timbering or of masonry to protect the means of access to the mine.

4. The analyses given above, and especially those of the Sharág coals, show that the mineral found would be of considerable value, if it could be procured in sufficient quantity. It should be remembered that the specimens analysed are taken from the outcrop, and that at a little depth below the surface the quality of the coal would in all probability be better.

A railway could be worked with such fuel, although the work done would be less than that yielded by coal containing a larger proportion of fixed carbon. The quantity of iron pyrites in the different seams is probably variable, but in those especially examined, it does not seem sufficient to prevent the coal being used for a railway.

It is evident that a considerable quantity of useful fuel for local purposes can be procured from the outcrops of the seams. So far, however, as can be judged from the facts hitherto known, the supply obtainable is insufficient for a large work such as a railway.

New faces *observed on* Crystals *of* Stilbite *from the* Western Ghâts, Bombay; *by* F. R. MALLET, F.G.S., *Geological Survey of India.*

During the construction of the Great Indian Peninsular Railway, when very heavy cuttings and tunnels were being driven through the trappean rocks of the Bhor and Thul Ghâts, magnificent specimens of zeolites were brought to light in great profusion. The species occurring most abundantly were stilbite, apophyllite, heulandite, and scolecite, all of which were represented by splendid crystallizations[1]. Large collections were made at the time by Mr. W. T. Blanford for the Geological Museum, where the finest specimens are now included in the systematic collection of minerals.

Most, if not all, of the stilbite specimens fall under one or other of four types[2]:—

1*st.*—Salmon-coloured crystals, generally of considerable size—very commonly, for instance, an inch, and sometimes two inches across (in the direction $\infty \breve{P} \infty$). They have the faces $\infty \breve{P} \infty$. $\infty \bar{P} \infty$. P., and are not uncommonly somewhat (but not highly) sheaf-like, from the aggregation of simple crystals into compound ones. They are generally (but not always) implanted by one end, and hence usually present only one pyramidal termination. Crystals of this type are frequently thickly grouped, occurring either alone, or with apophyl-

[1] Manual of the Geology of India, p. 304.

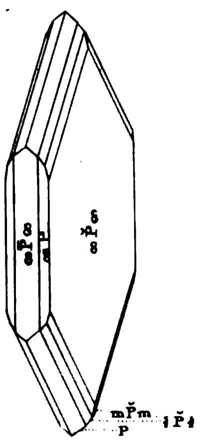
[2] Excluding lamellar specimens, in which the crystallization is obscure.

lite, which not uncommonly takes the form of minute crystals implanted on the surface of the stilbite. Quartz, &c., is also found in the same association, but not so frequently. In other cases the stilbite occurs in isolated crystals of the type in question, being then very usually associated with large, thickly grouped, crystals of apophyllite.

2nd.—Highly sheaf-like forms, sometimes so much so that viewed on the face ∞ P̄ ∞ they have the appearance of a fan, or in the comparatively rare cases where both ends of the crystal are free, of two fans with the points together: the crystals are commonly of considerable size, averaging say one-half to one inch across. They are generally thickly grouped, but sometimes occur singly. They occur either alone, or associated with heulandite, apophyllite, scolecite, or with crystals of the third type.

3rd.—Thin tabular crystals of comparatively small size (more commonly a quarter to an eighth of an inch across, sometimes much less); non-sheaf-like, or very slightly sheaf-like in form, and exhibiting the combinations ∞ P̆ ∞. ∞ P̄ ∞. P. and ∞ P̆ ∞. ∞ P̄ ∞. ∞ P. P. They occur alone, and with apophyllite, heulandite, scolecite, and perhaps other minerals. In one case small crystals of this kind were observed implanted on large ones of the first type, showing that the former were of later formation. The crystals of the second and third types are white.

The crystals of the fourth kind, which are by far the least common, occur on the surfaces of cavities which are lined by minute crystals of quartz. No other zeolites are associated with them (except in one specimen which includes apophyllite). They are salmon-coloured; of considerable size, averaging say half an inch across; generally tabular and non-sheaf-like, or very slightly sheaf-like in form. Generally they present the faces ∞ P̆ ∞. ∞ P̄ ∞. ∞ P. P., but in some there is also a face replacing the edge between ∞ P̆ ∞ and P. The parallelism of the edges between this face and ∞ P̆ ∞. & P., respectively, shows that the formula for the face in question is m P̆ m. Striæ and irregularities on ∞ P̆ ∞. and P. prevent more than roughly approximate angular measurements. For m P̆ m ∧ P. the value 152°¼ was obtained. A more reliable result, however, can be deduced from the observation that the plane angles formed by the edge between m P̆ m. & ∞ P. with the edges between m P̆ m. & ∞ P̆ ∞. and m P̆ m. & P. (all of which edges are straight and sharply defined) are either right angles or extremely close approximations thereto. Assuming them to be actually right angles the calculated value of m P̆ m ∧ P. is 154° 35′, giving a value for m of 2·5098, or a close approximation to $\frac{5}{2}$. Taking m at $\frac{5}{2}$, the value of the angle m P̆ m. ∧ P. is 154° 41, the plane angles formed by the edge between m P̆ m. & ∞ P. with the edges between m P̆ m. & ∞ P̆ ∞. and m P̆ m. & P., respectively, being 90° 8′ and 89° 52′.



The value of the following angles therefore are—

$$\tfrac{5}{2}\breve{P}\tfrac{5}{2}. \wedge P. = 154° 41'.$$
$$\tfrac{5}{2}\breve{P}\tfrac{5}{2}. \wedge \infty\breve{P}\infty. = 145° 41'.$$

On one crystal there is also a face m $\breve{P}$ m replacing the edge between $\frac{5}{2}\breve{P}\frac{5}{2}$ and $\infty\breve{P}\infty$. The value of m is much greater than $\frac{5}{2}$, but owing to the position of the crystal in a cavity, it is impossible to get even a rough measurement of the angles between m $\breve{P}$ m and the adjacent faces, without destroying the specimen.

Professor Heddle has noticed the occurrence of a face replacing the edge between $\infty\breve{P}\infty$. and P. on crystals of stilbite from Dumbartonshire, and from near Mount Nombi in Australia. He obtained the value 149° 45′ to 150° for the angle m $\breve{P}$ m. $\wedge$ $\infty\breve{P}\infty$. in the Scotch specimens, and 152° 32′ to 153° in the Australian. These results, however, he considered little better approximations, and he felt little doubt that the face was the same in the specimens from both localities[1]. The angles 149° 45′ and 153° respectively give a value for m of 2·9266 and 3·3497, the angle when m equals 3 being 150° 22′. The probability therefore would seem to be that the face noticed by Professor Heddle is different from that on the Indian specimens.

The total number of faces, which, as far as I have been able to ascertain, have hitherto been noticed on stilbite, are, $\infty\breve{P}\infty$. $\infty\bar{P}\infty$. ∞P. P. 0 P., which are given in all mineralogical works; $\frac{3}{2}\breve{P}\infty$. noticed by Des Cloizeaux on crystals from Bergen Hill (New Jersey)[2]; m $\breve{P}$ m (3 $\breve{P}$ 3 ?) recorded by Heddle; $\frac{5}{2}\breve{P}\frac{5}{2}$ and m $\breve{P}$ m (m having a high value) on crystals from the Western Ghâts.

On the traps *of* Darang *and* Mandi *in the North-West Himalayas,—By Colonel* C. A. McMAHON, F.G.S. (*with two plates*).

The occurrence of intrusive traps in the lower Himalayas is mentioned at pages 21 and 70, Vol. III, Memoirs, Geological Survey, and at pages lvii and 606, Manual of the Geology of India, whilst notices of the trappean rocks of Darang (Drang) and Mandi will be found at pages 58, 59, and 61 of Vol. III Pt. 2 of the Memoirs.

Doubts have at different times been expressed regarding the origin and nature of the traps described in this paper. At one time there was a tendency to regard them as metamorphic rocks; and although in the passages referred to they are spoken of as 'traps,' and are described as occurring along a definite horizon, they do not appear to have hitherto been recognised as true lavas. The microscope, I think, enables us to set any doubts upon this point at rest.

I have examined 26 slices[3] of the trap, of which the ridge to the east of Darang is composed, and 9 slices of the trap, in the same line of strike, exposed in the bed of the Suketi at Mandi.

[1] Mineralogical Magazine, Vol. IV, p. 44.
[2] Manuel de Minéralogie, Tome I, p. 416.
[3] Prepared for me by Mr. F. G. Cuttell, 52, New Compton Street, Soho, whose workmanship leaves nothing to be desired.

It would be wearisome to the reader were I to describe each of these slices, but I think it desirable to describe several typical specimens in some detail, and this I now proceed to do.

No. I.—A greenish-grey rock: specific gravity 2·89. It has rather a mottled appearance under the pocket lens, owing to the alteration of a portion of its mineral contents into delessite, or a mineral approximating to delessite. A portion of the rock is soluble in hydrochloric acid, and the dissolved portion contains both ferric and ferrous oxide. A few crystals of iron pyrites are to be seen.

Appearances under the microscope.—This slice may be described as a net-work of felspar and augite crystals set in viridite, which in part appears to represent the original glassy base[1].

There are numerous crystals of augite scattered through the slice. Portions of each of these crystals have been altered into brownish-green granular matter. The portions which have escaped alteration are clear and colourless in transmitted light and polarise fairly well. They are not dichroic; several of the crystals are twinned, and many of them exhibit the orthodiagonal cleavage lines very distinctly.

Most of the felspar crystals exhibit the characteristic twinning of triclinic felspar in polarised light, and their optical properties agree with those of labradorite. Alteration has been set up in the felspar, and has declared itself by the presence of granular matter in the body of the crystals.

The grouping of the felspar crystals, and the general effect of the slice when seen by transmitted light, is illustrated in fig. 1, plate I. It is very characteristic of an eruptive rock.

The viridite, in this slice, is of pale green colour. It is feebly dichroic in patches, and, for the most part, remains dark between crossed nicols. It exhibits little or no fibrous or radiating structure.

Scattered through the mass is some white mineral matter that is perfectly opaque in transmitted light, and which, from its appearance and mode of occurrence, is I think, leucoxene, a product of the alteration of ilmenite.

No. 2.—A greenish-grey rock. Specific gravity 2·90. It has a slightly mottled look under the pocket lens, but minute prisms and irregular crystals of felspar are visible in it here and there.

Microscopic aspect.—The most prominent objects in the slice are the crystals of felspar, of various sizes and shapes, starred about in the field of the microscope. The great majority are distinctly seen to be crystals of triclinic felspar, and the others appear to belong to that system also. They are in fairly fresh condition. Fig. 2, plate I, is a representation of a portion of this rock, as seen under the microscope by transmitted light.

Those who are not familiar with the subject of microscopic petrology, may be surprised to find that the prisms of felspar, represented in these illustrations, do not present more regular forms. It must be remembered, however, that the principal axis of crystals in an igneous rock usually point indifferently in all directions,

[1] This supposition is confirmed by an examination of the basalts of Bombay, to be described in my next paper. In the Bombay lavas the conversion of the *base* into viridite can be distinctly traced.

and a slice made at random cuts the crystals contained in the matrix in every conceivable direction. For instance, in fig. 10, plate II, supposing a slice of the crystal therein represented were made in the direction from *a* to *b*, the outline of the section, as seen in the field of the microscope, would present a considerable modification of the true shape of the crystal.

Other causes also operate to produce irregularities of shape. Crystals forming in the proximity of other crystals appear to be sometimes stunted in their growth owing to crowding; whilst the different degrees of crystallographic energy with which the constituents of different minerals come together appear to exercise more or less influence on crystals forming in their vicinity. The want of perfect molecular freedom, when an eruptive rock is rapidly cooled at the surface of the earth's crust, must also affect the results. This freedom of molecular action becomes less and less as the cooling proceeds; hence crystallisation is often arrested before the outward form of a crystal is finished; portions of the magma are cooled before the chemical elements contained therein have had time to combine to form crystals—leaving here and there what is termed a "glassy base." The molecules of other crystals, again, coming together with energy, and being, so to speak, pressed for time, catch up portions of the glassy base and small crystals of other, previously formed, minerals, and enclose them in their own substance.

Another cause to which irregularities of outward shape are due, is the alteration which minerals undergo, after the consolidation of the rock, by the passage through it of acid and heated water. Cracks are formed both in the body of the rock, and in individual crystals, by the contraction due to cooling and to crystallisation, and along these fissures heated and acid water, or steam, penetrates; chemical action is set up, and, amongst the results, the outward form of crystals is often much altered.

The slice under consideration contains a good specimen of those radiating and cruciform groups of felspar crystals which are so characteristic of eruptive rocks. Some of the radiating prisms exhibit the twinning characteristic of triclinic felspars. The twins appear to be arranged in groups, in each prism, and the whole combined as penetration twins. A sketch of one of these groups is given at fig. 1, plate II.

No. 3.—A greenish-grey compact rock. Specific gravity 2·93.

Microscopic aspect.—This slice contains numerous felspar prisms pointing in all directions. Most of them are distinctly seen to belong to the triclinic system. Numerous instances of stellate grouping of felspar prisms occur in this slice. One of them is depicted at fig. 2, plate II. Alteration has been set up in the felspar, and shows itself by the formation of granular matter and patches of viridite in the interior of the crystals.

Fields of pale amorphous viridite are abundant in the slice, and in them are located multitudes of epidote crystals, many of them presenting good characteristic crystallographic forms. They are principally located round the margins of the viridite fields.

The remains of augite crystals are to be distinctly made out, but they have all been, more or less, converted into a greenish-brown non-dichroic substance.

Portions of the slice here and there are obscured by an alteration product, white in reflected and purplish black in transmitted light.

Nos. 4 and 5.—A dull greenish, or greenish-grey, compact rock, weathering light brown. Specific gravity 2·83. Under the pocket lens it has a somewhat mottled appearance.

Microscopic aspect.—The slice consists of crystals of felspar and augite starred about in what represents the original base or magma. This probably, as seen in many basaltic rocks—in the Bombay basalts and some Vesuvian lavas for instance—was originally full of minute grains of magnetite or ilmenite and imperfectly crystallised matter, and this has been changed into an alteration product which exhibits no crystallographic form. It is white in reflected and opaque in transmitted light.

Augite in this slice is very abundant; twinning is common in it; sometimes the orthodiagonal cleavage lines are very distinct, whilst in other crystals the characteristic intersection of the prismatic cleavage lines is well seen.

The unaltered portions of the augite are fresh and polarise well, but much of it has been transformed into a brownish-green substance.

Fig. 4, plate II, is an illustration, taken from slice No. 4, of the way in which the augite crystals have been eaten up and converted into this substance. The fragments shown in the illustration appear to represent the remains of a group of augite crystals originally in close juxta-position to each other, but which have now been split up into a little archipelago of augite fragments. The alteration which has taken place in these cases can be distinctly traced to the passage of water along cracks, and the alteration can be seen in all its stages in the slices under consideration.

Fig. 7, plate II, represents a twinned augite in slice No. 4, in which great irregularity of outward form has to some extent, at any rate, been produced by the corrosive agency of acid water, but in which internal alteration through cracks has not proceeded as far as in fig. 4. Under the microscope the dark lines which traverse the crystal are distinctly seen to be little canals filled with the products of aqueous alteration.

In many cases the alteration of the augite has resulted in the formation of mica. Fig. 5, plate II, is an illustration of a case, taken from the slices under consideration, in which part of an augite crystal (*a*), the external outline of which has been rendered irregular by its change into a greenish substance, has been converted into mica, as at *b*; whilst another portion (*c*) appears to be in process of conversion into this mineral. Another illustration is given at fig. 6, plate II, also taken from one of these slices, in which small fragments of augite are seen to be encased in mica. Doubtless the latter is an alteration product, resulting from the change of a large augite crystal, small fragments of which escaped conversion. The little canal-like cracks through which the corroding liquid originally gained access to the heart of the augite, are still visible, and an attempt to represent them has been made in the sketch.

Mica is scattered about rather plentifully in these slices, and in transmitted light, it varies in colour from red to green.

Bischof[1] alludes to the conversion of augite into a brownish, or leek green, mica. Some augites contain as much as 11·05 per cent. of alumina (J. D. Danas' "System of Mineralogy"); whilst, according to the same authority, some micas contain as little as 9·27 per cent. of that constituent. All that seems essential for the conversion of the one mineral into the other, is a removal of a large proportion of the lime from the augite and the introduction of the alkaline element—a process which one can readily understand taking place in the "wet-way."

The felspar crystals have been so kaolinised and altered that all trace of twinning has been obliterated.

I have detected one small prism of hornblende. It is probably an alteration product.

No. 6.—A compact grey rock faintly tinged with green. Specific gravity 2·92.

Microscopic aspect.—The base has been converted partly into an amorphous substance, bluish-white in reflected and olive green in transmitted light, and partly into granular viridite. In this base felspar crystals are scattered about in immense profusion, some in minute needle-shaped prisms, and others in prisms of some size. A large proportion of them exhibit the characteristic twinning of triclinic felspar. Some of the medium-sized crystals have caught up portions of the base in the act of crystallisation, and the portions so included conform to the shape of the felspar prisms.

The slice contains some good-sized crystals of epidote.

No. 7.—A grey, compact, amygdaloidal rock. Specific gravity 2·88. The centres of the amygdala consist of quartz, the inner lining being sometimes composed of epidote. Epidote is also seen to line cracks and to abound in the vicinity of the amygdala.

Microscopic aspect.—The slice consists of countless felspar prisms, starred about in a felspathic cryptocrystalline base. A large proportion of the felspar exhibits the twinning peculiar to triclinic felspar. A considerable amount of epidote is seen dotted about in small granules and in meandering lines. Here and there patches of viridite are seen throughout the base.

Amygdaloidal cavities occur here and there, filled with quartz, epidote, and delessite. The quartz is greatly crowded with a fine dust of opaque matter, which, on the application of high powers, is seen to consist of a multitude of extremely minute gas and liquid cavities.

A sketch of one of the stellate groups of felspar crystals before alluded to, contained in this slice, is given at fig. 9, plate II. The illustration shows the appearance of the group in polarised light with crossed nicols.

For the sake of comparison, I have given at fig. 8, plate II, a sketch of a triclinic felspar group taken from a slice of domite, in my possession, made from a specimen collected by me on the Puy de Dome, Auvergne. All the radiating prisms are seen in polarised light to be many times twinned, but they are arranged in groups which simulate the twinning of the Carlsbad type.

I have often observed this peculiarity in plagioclase, and it appears to be produced by one set of twins being thick at one side of the prism and thin at the other side; whilst the second set of twins are thick on the side in which the first set are thin, and thin on the side in which the first set are thick. The

[1] Chemical Geology, Vol. II, p. 326.

effect of this peculiar arrangement therefore is, that, when viewed in polarised light, one-half of the prism appears almost wholly dark, whilst the other half exhibits an almost unbroken sheet of colour; the twins which at that azimuth suffer extinction of light being very thin relatively to the twins which at that azimuth polarise in more or less brilliant colours.

This arrangement may be traced in fig. 8 sufficiently, perhaps, to make my meaning clear; but I have attempted in this sketch to reproduce the general effect, as far as that can be given in black and white, rather than these minute details of structure.

Throughout the base are scattered granules of black opaque matter that appears to be magnetite arrested in the act of crystallisation. A sketch of one of these granules, as seen with the aid of somewhat high power, is given at fig. 11, plate II. Forms of this kind appear to me to indicate that the rock cooled rapidly under conditions that interfered with the molecules of the ferriferous mineral coming together in the form of a regular crystal. As pointed out by Dr. Sorby, there is a strong tendency on the part of crystals formed in slags to assume skeleton forms, and I have noticed that salts crystallised rapidly on a glass slide very frequently assume the sort of skeleton form shown in fig. 11, instead of regular crystals; each salt, speaking broadly, having its own pattern. Skeleton crystals of magnetite, similar to those occurring in these rocks, appear to be very characteristic of volcanic rocks and furnace slags[1].

A few flakes of a reddish mica are to be seen in this slice.

No. 8.—A grey, compact, amygdaloidal rock. Specific gravity 2·84. A reddish mica is seen here and there in amygdaloidal cavities, associated with the other minerals therein.

Microscopic characters.—Prisms of felspar, much of which is distinctly seen to be triclinic, are scattered about in a felspathic base. Amongst the felspar a striking case of cruciform penetration twins is to be seen. The two arms of the cross intersect at an angle of 85°.

A considerable proportion of the base is represented by minute patches of viridite, partly fibrous and partly granular. Scattered through it, there is a considerable amount of opacite in granules, representing, I apprehend, imperfectly formed magnetite. It is similar in character and appearance to that described in slice No. 7.

The amygdaloidal spaces are plugged with quartz and viridite. In some, the viridite is seen by itself; in others an intergrowth of the two has taken place, granules of quartz being surrounded by the viridite in some cases, and in others, numerous patches of viridite of various sizes and shapes being included in the quartz.

The viridite is in some places amorphous, and in others, in radiating or sheaf-like bundles of fibres. I believe it is in part delessite and in part chlorite. Round the margins of the chloritic inclosures in the quartz it passes into the vermicular form of pro-chlorite.

The quartz, which occurs both in the amygdaloidal cavities and filling what were apparently fissures, contains many flakes of a reddish mica. The quartz is

[1] Rutley's Study of Rocks, p. 154.

remarkable for containing numerous very minute rounded liquid cavities with moveable bubbles.

From the fact that the quartz occurs in the amygdaloidal cavities and from its intimate intergrowth with the delessite, I see nothing to support the supposition that it is of fragmentary origin and has been brought up with the lava stream from below. On the other hand, though liquid cavities are very common in the quartz of granite and quartz-porphyries, I am not aware of their having been before observed in quartz plugging amygdaloidal cavities. Dr. Sorby mentions a solitary case of liquid cavities having been found in some trachyte of solid character at Ponza[1] which appears to have been formed under considerable pressure. They are, however, very common in quartz veins, and to their presence principally, Dr. Sorby attributes the usual whiteness of vein quartz. The quartz under consideration is of dull white colour and it probably owes its opacity and whiteness to the same cause. The presence of the liquid cavities in the quartz of slice No. 7, and in that under consideration, may, I think, be explained on the supposition that the lava stream after solidification was covered over for a considerable thickness by other lava streams, or by stratified deposits, and that the plugging of the cracks and the amygdaloidal cavities was accomplished with the aid of highly heated water or steam *under pressure.*

There is a great thickness of trap exposed at Darang.

Nos. 9 & 10.—A greenish-grey rock with numerous amygdaloidal cavities; Sp. G. 2·77[2].

Microscopic aspect.—The amygdaloidal cavities contain scolecite. The inner kernel of some is formed of calcite, whilst fissures in the scolecite are filled with this mineral. The study of these amygdala under the microscope affords an illustration of how one might often be misled by a chemical analysis. Viewed macroscopically the calcite would probably escape observation altogether.

The base is cryptocrystalline, and it contains multitudes of tufts of a fibrous chloritic mineral. Numerous small patches of viridite are also to be seen scattered through the mass. There are patches of a greenish mica both in the matrix and the amygdala.

Granular epidote is plentiful. A fine group of epidote crystals is imbedded in the scolecite.

The stellar arrangement of the felspar crystals may still be traced, but the felspar is a good deal altered, and no distinct indication of the twinning of the triclinic system remains.

No. 11.—A greenish-grey compact rock, Sp. G. 2·81. There are numerous round lumps of delessite plugging what were apparently amygdaloidal cavities. Other such cavities are seen to be lined with a dull reddish-brown mica. The centres of the cavities are filled with quartz.

Microscopic aspect.—The slice consists of numerous crystals of felspar of various sizes starred about in a fibrous translucent ground mass, olive green in

[1] Quart. Journ. Geol. Soc., London, Vol. XIV, p. 484.

[2] This is within the minimum for basalts, but it is probably somewhat under the mark owing to the presence of air in some of the unfilled or partially filled amygdaloidal cavities. The presence of scolecite and calcite in the latter must also affect the result.

transmitted light. More dense and opaque patches of the same material are dappled about in it in a spotty way, whilst, here and there, along what were apparently lines of infiltration connecting amygdaloidal cavities, it assumes a ropy appearance.

Most of the felspar crystals are distinctly triclinic and are in prismatic forms affording rather sharp outlines. In some instances they have caught up portions of the olive green base in the act of crystallization, the base being moulded to the form of the felspar prism.

Fig. 3, plate I, is a representation of a small portion of this slice, as seen in the field of the microscope. Annexed to a group of plagioclase felspar crystals one of the cruciform arrangements of felspar prisms, so often alluded to in the preceding pages, is seen to be attached. The arms of the cross intersect at an angle of 83½°, and they exhibit the twinning peculiar to the triclinic-system. The two long dark lines in the group above the cross are portions of the base caught up in the act of crystallization. The amount so caught up in the present instance is small, but occasionally, in some of the slices described in this paper, the amount is considerable relatively to the size of the prism.

Some of the amygdaloidal cavities are plugged with delessite in fan-shaped and radiating forms; others contain, intermingled with the delessite, a mica, red in transmitted light, and a little quartz.

Epidote is abundant, and occurs either in or connected with amygdaloidal cavities.

Mandi Traps.

The traps seen in the bed of the Suketi river at the town of Mandi occur in the line of strike of those at Darang. The outcrop is here much thinner than at the latter place.

I have examined seven sections of the Mandi trap made from chips and two from slices of the rock. There is no perceptible difference in the character of these specimens, and it will suffice to describe the two slices.

Nos. 12 and 13.—A dark-grey compact rock with a slight tinge of green in it; Sp. G. 2·88.

Augite is abundant. Some of the crystals are fairly regular in shape and twinning is common in them. A little mica is visible in these slices.

A cryptocrystalline or partially devitrified base, forming irregularly shaped spaces, is to be seen here and there. The felspar prisms do not present sharp outlines, and they are kaolinised and decomposed. No trace of triclinic twinning is to be seen in them.

The olive green ground mass has been partially converted into viridite, which is only seen, however, in minute patches disseminated through the mass.

The rock is evidently a lava that has rapidly cooled, the augite being the only mineral that has had time to crystallise regularly and perfectly.

Conclusion.

The specific gravity of basalt ranges from 2·76 to 3, its mean specific gravity being 2·90. The specific gravity of the traps described in this paper ranges from 2·77 to 2·93, their average being 2·86. The specific gravity test therefore points to these rocks being classed as basalts.

The microscopical examination of thin slices supports this view. Augite is generally abundant in them; plagioclase forms a prominent component in most of the slices; and, in those in which the twinning peculiar to triclinic felspars is not visible, its absence is satisfactorily accounted for by the kaolinisation and alteration of the felspar.

Olivine is usually one of the first minerals in a basalt to undergo decomposition, and it is often represented by a green product of alteration.[1] Olivine has not been detected. Its presence was not to be expected in a rock which has undergone considerable alteration, and, moreover, though its occurrence is very common, it is not present in all basalts. None of the Bombay basalts I have examined contain any.

Magnetite is plentifully represented in these slices by skeleton crystals arrested in the progress of crystallisation, and also by the secondary products of its decomposition.

Mica often occurs in basalts. Its presence in these slices appears to be due to the alteration of some of the original minerals.

The epidote, calcite, delessite, pro-chlorite, and scolecite, are also the secondary products of the decomposition of some of the original constituents of the rock.

Quartz only occurs in amygdaloidal cavities and cracks, and its presence in such situations is not unusual.

The mineralogical contents therefore of the thin slices examined under the microscope, agree with the specific gravity test, and show that those rocks are altered basalts.

Basalts are classed as volcanic rocks, and the fact that the traps under consideration are abundantly amygdaloidal, and that the microscope reveals the presence in them of a glassy or imperfectly crystallised base, shows that they were consolidated at the surface of the earth's crust. All the details of their structure corroborate this view, and I think they are without doubt altered basaltic lavas.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Portion of a slice of an altered basalt. Darang, in the Mandi State, North-West Himalayas.

Fig. 2. Ditto ditto.

Fig. 3. Ditto ditto.

PLATE II.

Figs. 1, 2, 3, and 9, illustrations of stellate grouping of felspar prisms, characteristic of eruptive rocks, and basalts in particular, taken from the Darang basalts.

[1] Rutley's Study of Rocks, p. 254.

Fig. 8. Another illustration of stellate grouping of triclinic felspar taken from a domite, Auvergne.

Figs. 4 and 7. Augite crystals in process of alteration into a green product by the passage of corroding liquids through the rock.

Figs. 5 and 6. Pseudomorphs of mica after augite, taken from the Darang basalts.

Fig. 10. Illustration showing the modified shape of sections of minerals, as seen in thin slices under the microscope.

Fig. 11. Skeleton form of magnetite taken from one of the Darang basalts.

Further note on the connexion between the Hazára *and the* Kashmir Series—*By* A. B. WYNNE, F.G.S., *Geological Survey of India.*

The recent appearance of Mr. Lydekker's latest paper on the geology of Kashmir (Rec. Vol. XV, p. 14) throws so much more light upon the question of the relations of the rocks in two adjoining regions that I am tempted to offer a few further remarks in continuation of my last papers on Hazára.

We are now enabled to extend the comparison which I applied to the then known Kashmir section (Rec. Vol. XII, p. 128, &c.), so as to embrace the actual continuation of the Hazára rocks as they pass thence into Kashmir and Kaghán as follows, the annexed list including all the main groups of the whole region on both sides of the Kunhar[1]-Jhelum valley which appears to have been the main drainage outlet of the area from an early period :—

HAZARA.	KASHMIR AND KAGHAN.
7. Murree Beds (probably partly miocene).	7. Murree Beds (miocene).
6. Nummulitic.	6. Nummulitic.
PRESUMABLE OVERLAP.	OVERLAP AMOUNTING TO UNCONFORMITY.
5. Cretaceous (feebly fossiliferous).	5. Absent or unknown.
4. { Jurassic.	UNDETECTED OR ABSENT.
UNCONFORMITY, ? VERY LOCAL.	
Triassic upper and lower. }	4. Trias and ? Jura.
3. Infra-Triassic and Tanól group.	3. Carboniferous.
UNCONFORMITY (STRONG).	UNOBSERVED.
2. { Attock Slate of Northern Punjab. Trap division absent. } Silurian.	2. { Aqueous. Traps. }
1. { Schists. Gneiss (primitive). }	1. { Newer gneiss including representatives of 2 and 3. Gneiss (primitive, Central). }

This comparison will be seen to present some advance beyond that of my former paper (Rec., Vol. XII, p. 128), in which, as Mr. Lydekker observes, the schists of North Hazára are not separately included, because his Kashmir sections quoted offered nothing with which to compare them, and they could not be introduced as

[1] This Kunhar river is also called the Nainsúk, by which name I first knew it.

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GEOLOGICAL SURVEY OF INDIA

Mc Mahon: Mandi trap. Plate 1 Records, Vol. XV.

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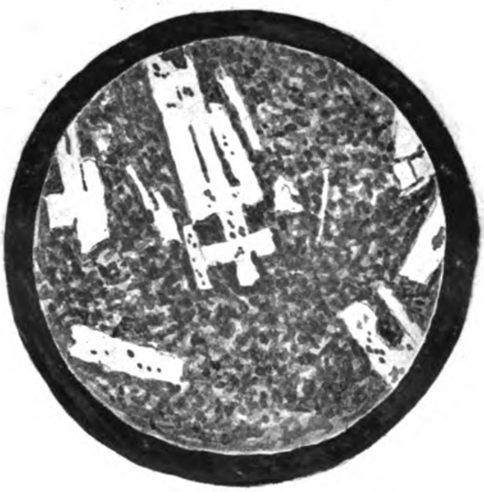
2 × 60



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Reproduced in heliogravure from the original drawings at the Surveyor General's Office, Calcutta.
April, 1882.

Fig 1

Fig 2

Fig 3

Fig 4

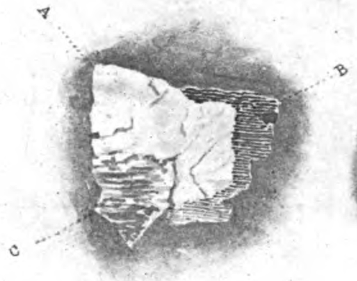


Fig 5

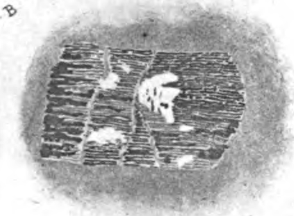


Fig 6

Fig 7

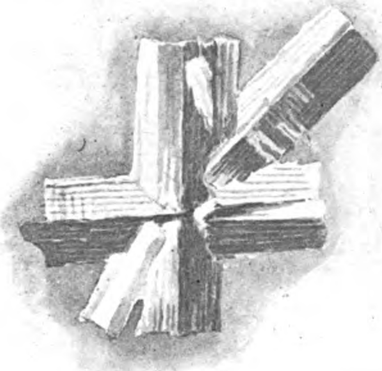


Fig 8

Fig 9

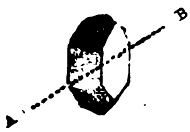


Fig 10

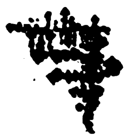


Fig 11

Reproduced in heliogravure from the original drawings at the Surveyor General's Office, Calcutta.
June, 1882.

absolutely unrepresented, when they were found to pass out of the Hazára district, into then unexamined ground.

They have a position in the list nevertheless, where they are placed together with the Infra-triassic and Tanól series as he partly suggests; the Tanól portion of this set of rocks passing, as stated, into crystalline, *i.e.* metamorphosed, rocks and gneiss.

The identity of the gniess in both areas is now established and that also of the next adjoining beds.

The Attock slates are shown to be those of Kashmir, and their Amygdaloid division is approximately placed.

The carboniferous horizon is not much [more clear, but the trias beds are identified, and the Murree beds are now known to be partly miocene, at all events.

The main points of difference appear to be as follows:—

HAZARA SIDE.	KASHMIR SIDE.
1. Presence of a cretaceous horizon.	Its absence.
2. Partial separability of the trias and jura, with a local discordance.	Usual blending of these without discordance.
3. Presence of an infra-triassic or lower division of the trias.	Occurrence at this horizon of a carboniferous group.
4. Presence of a thick group of Tanól beds identical or partly so with the foregoing.	Apparent absence of these beds.
5. Absence of an amygdaloid series in the silurian Attock slates.	Presence of an inferior silurian amygdaloid group.
6. Presence of a complete sub-trias discordance.	Absence of this feature or its imperceptibility.
7. Concealment or obscurity of a sub-tertiary overlap discordance.	Presence of a sub-tertiary break and overlap.

The main points of agreement are these:—

HAZARA SIDE and KASHMIR SIDE.

1.—Similarity of tertiary group in both.

2.—General similarity of the newer or perhaps upper half of the mesozoic rocks with small exceptions.

3.—Similarity of the lower palæozoic silurian-Attock-Kashmir slates.

4.—Similarity cf the schists and gneiss.

5.—Universal disturbance.

It seems from the lists that the points of difference are equal in number to the main rock-groups, and those of agreement are rather more than half as many as the differences.

1. The cretaceous horizon established in the Sirban sections in Hazára and at great distances to the eastward in the Himalayas may well be present in other places though unrecognizable, as appears frequently to be possible even in Hazára.

2. The triassic rocks in this region being yet known to present in one place only (at Sirban) all the conditions as to definite zones and sufficiently fossiliferous ones, to enable detailed separations to be carried out, it seems most probable that the mixed character or the unfossiliferous condition of the Kashmir and Kaghán rocks is the general rule in both areas. The definite horizon may

of course exist everywhere, but under impenetrable obscurities, and even the appearance of discordance fairly established between these and the Spiti shale jurassic of Sirban being quite unpronounced elsewhere in Hazára, it may well be lost to sight in Kashmir.

3. The fact that Mr. Lydekker finds the carboniferous group of Kashmir vanishing into obscurity northwards, where its fossils disappear, is strongly indicative of the same unfortunate occurrence in Hazára and the consequent impossibility of defining its position closely, while it may be fairly surmised that the Hazára infra-triassic Tanól rocks or some portion of these are equivalent to the carboniferous group of Kashmir.

At the same time the idea suggests itself that the Sirban trias may really exhibit only a higher portion of the whole great group which may be elsewhere represented by more obscure older developments more widely spread, and that the carboniferous representatives may be found or supposed to exist amongst the lowest layers of these and partly amongst the likewise unfossiliferous strata of the Tanól group.

4. This Tanól group presents one of the greatest difficulties in reconciling the structure of the two regions as at present interpreted. Its thickness renders the absence of its recognition in Kashmir, &c., strange; and its place is peculiar, lying exactly between the now well-identified Attock-Ladák slates and the metamorphic schists (including rocks of different horizons), into which the same Attock-Ladák slates are supposed by Mr. Lydekker to merge by reason of increasing metamorphism.

These Tanól rocks, or their congeners, the infra-triassic, one or both, extend towards and into the lower part of the Kunhar valley, but crossing this no place is found for the group in the series of Kashmir and Kaghán, and a short line, obliquely crossing the valley from the Lachi Kun nummulitics to the Hazára older gneiss near Bálakot, marks the approximate boundary between the Attock-Kashmir slates and their supposed more highly metamorphosed continuation into the "newer gneiss" northwards. South of this boundary, however, between Bálakot and Gharri Habibula on the flanks of the Lachi Kun mountain, the Kashmir-Attock slates are not typical Attock slates at all, but more allied to the metamorphic schists. This point would so far favour the supposition that a northerly transition was taking place from less to greater metamorphism; but not far south of Gharri Habibula the slates possess their normal character, and appear projecting unconformably from beneath infra-triassic or Tanól quartzites and dolomites. The supposition that the Attock slates are the same to any extent as the schists to the north which pass into or are scarcely separable from the Tanól beds would then demand the incredible conclusion that both an unconformity and a transition between the older and newer groups should occur in the immediate neighbourhood of Gharri Habibula,—a view in which I cannot coincide.

Although the Tanól or infra-triassic beds fall readily into none of the Kashmir sub-divisions or have not been admitted into any, I certainly found them on the right bank of the Kunhar at the place last indicated, and saw at least one small tongue of them crossing the river. It seems marvellous if some representative of these dolomites, quartzites, argillaceous and other rocks does not also occur to the east, because, although in discordant relation with the silurian slates on their southern side, they have been found to mingle gradually with the schists to the northwards, which in their eastern extension become the "newer gneiss" of various ages, and also because dolomites and quartzites are mentioned among the rocks of Northern Kashmir.

If the group has an extension to the eastward, there seems, however, not much more likelihood of its being closely identified among the "newer gneiss" series than either the metamorphosed silurian or carboniferous members of that division. Connected with one or both of these groups, rocks of Tanól aspect might occur, though without sufficiently distinct grouping or identity to have urged their separation.

5. Had they possessed this distinctive character, there would only have been the absence of the apparently fugitive volcanic amygdaloids from amongst the Hazára slates to have caused any very prominent disparity between the general series in these two areas. The horizon or horizons of this amygdaloidal silurian group or groups being rather uncertain, but still placed below the slates or in their lower portion, the idea is suggested whether some of these volcanic rocks may not represent the horizon of the Tanól group, but this question I have not sufficient evidence to follow out.

From what I know or can gather of the general aspect of the geology of the whole region, I should rather expect to find the principal portion of the Tanól beds occupying a carboniferous or other intermediate horizon between the uppermost slates and the lowest fossiliferous triassic rocks.

So far the obstacles, as it were, to extending either the full Kashmir colouring of the map into Hazára, or *vice versâ*, have been noticed; the question of the arrangement of the groups is another matter.

In the parts of Kashmir and Kaghán, most adjacent to Hazára conformity real or apparent would seem to be the rule throughout the whole sequence. From an inspection of Mr. Lydekker's map and from his remarks it would appear evident that this conformity of the tertiaries north of Mozufferabad upon the palæozoic rocks assumes the nature of an overlap, amounting to the total discordance which I had already indicated from limited observations (Rec. XII. p. 127).

The unconformity at Sirban, in Hazára, where the infra-trias is not only discordant to but contains derived fragments of the Attock-Ladák slates, is established. It appeared to me to occur again without the derivative feature near the road from Abbottabad to Mánsahra and also on the right bank of the Kunhar river south of Gharri-Habibula, and yet it does not appear to have been detected in Kashmir or Kaghán, where secondary rocks occur within 12 and 32 miles of the Gharri locality, roughly speaking.

This unconformity proves so complete a break between the infra-trias and the silurian that I held myself prepared to find those of the Tanol beds most nearly identical with the infra-trias of Sirban completely discordant to the Attock slates at any place where they might occur in junction with these.

This appeared to be the relation of the groups on the lower Sirun and Dor rivers near the Indus.

The disturbance in most places greatly concealed or quite obscured any identification of this relation in connexion with the silicious and dolomitic bands of the Tanól group, while in many instances they appeared to be simply intercalated with the other Tanól beds; besides, there was always the possibility in consequence of the break at Sirban that infra-trias rocks of other places might exhibit a larger thickness of themselves or of other subjacent conformable beds. I was therefore the less surprised to find great irregularities and sudden development or reduction of the unconformable infra-trias (presumed to be in some degree equivalent of Tanól rocks) in various localities, nor did it appear improbable that the unconformity so clear at Sirban should be obscured by being removed further elsewhere from the dolomites and quartzites, or altogether lost to view in the more metamorphosed area of the schists.

Whatever portion of the Tanól beds may be identical with the infra-trias will carry with it much of the associated and stratigraphically united Tanól rocks not largely developed, if at all, at Sirban. The place of these Tanol-infra-trias beds must lie at the upper side of the discordance there, and it is impossible in so limited an area to place on the same horizon any rocks supposed to form a part of the Attock-Ladák silurians on the lower side of this discordance.

To say that the dolomites and quartzites of the Tanól area are not infra-trias but metamorphosed trias-jura, will provide no escape from the dilemma, for the trias and infra-trias have always been found as part of the same conformable sequence.

In one way it seems still possible to reconcile some of the discrepancy between the Hazára area and that to the east. I offer the suggestion with much reservation on the supposition that the rocks of both regions pass northwards into a metamorphic *terra incognita*, where important divisions become undistinguishable and the clearest indication of stratigraphic arrangement at low or high angles are untrustworthy. This being granted (if possible) it may be that the schistose series (newer gneiss of Lydekker) represents among its other constituents a lower portion of the Attock-Ladák silurian, or even the same beds as are elsewhere unmetamorphosed; that over these the schists passing upwards and uniting with the Tanól group (on an extension of Mr. Lydekker's hypothesis) represent the carboniferous and triassic horizons. Some of the dolomites, &c., of the Tanóls belonging to the former, and others with their associated slates, &c., being the unconformably enfolded representatives of the trias and infra-trias or "trias-jura" division, all in a metamorphosed or sub-metamorphosed state.

At this distance, both as regards time and place from the region and its examination, one is apt to have a less lively faith in his own deductions, and yet after reconsidering the question with the aid of Mr. Lydekker's paper, unless the perplexities of mountain structure will endorse so large a draft upon speculative hypotheses as the above suggestions demand, I am unable to see in what way the interpretations of Hazára Kashmir and Kaghán can be brought into closer concordance.

Notwithstanding that I am ready to admit any reasonable amount of possible misinterpretation not of a glaring nature amongst the obscure stratigraphical features of a metamorphosed and disturbed mountain region, the greater difficulty presents itself that it is not so much obscurity of the stratigraphic relations in Hazára as the reverse which has led to my interpretation of the district, and that no amount of the inversion, which it is now the custom to call in aid so largely, can set aside local deductions from such physical facts as the Sirban infra-trias unconformity.

Notes on the Umaria Coal Field (*South Rewah Gondwána basin*)—*By* THEODORE W. H. HUGHES, A.R.S.M., F.G.S., *Geological Survey of India.*

Owing to the great interest that has been aroused regarding the occurrence of workable coal at Umaria and in the Johilla valley in the Rewah territory, I have no doubt that a short notice relating to it, preliminary to a fuller description in our Memoirs, will be generally acceptable. Under ordinary circumstances the publication of the facts in connection with the coal would not have taken place until next year, by which time the map of the larger area to which this ground belongs would have been completed. So many enquiries, however, have been set on foot, as to the extent of the coal, its thickness, the quality of the coal and the facilities for working it, that it has become a duty to respond to them without delay.

Previous notice.

In a previous volume[1] of the Records of the Survey, I have described the geological position of the Umaria and Johilla coal. Its proper place is amongst the true or older coal-measures of India, and it is not to be confounded with the younger coal of the Mahanadi, Lameta Ghat and Jabalpur. This is a favourable point, and it implies that the coal will be moderately steady both in quality and quantity, features which are not characteristic of the newer coals.

Captain Osborne, 1860.

Many years have elapsed since the original discovery of the coal that I am writing about. The first who drew attention to it was Captain Osborne, the Political Agent of Rewah in 1860. Afterwards some Royal and Civil Engineers reported on it, but their recommendations were not strong enough to induce any active steps being taken to explore the field. Subsequently, and quite recently (1881), it was my good fortune to meet with a gentleman in charge of the Rewah administration[2] who responded cordially to my suggestions that the coal-measures should be tested near Umaria and in the Johilla valley; and within a few weeks of my broaching the plan of operations, boring tools were got ready, and Mr. Stewart, who had previously been in charge of the Narbada trial borings, was appointed, on a salary of Rs. 420 a month, to test the various sites indicated by myself. It is a great satisfaction to be able to say that the word *success* may be freely used. An abundance of coal has been proved; a large area has been determined; the con-

[1] Records G. S. I., Vol. XIV, pages 313—315.
[2] Captain Barr, Political Agent, Baghelkhand, and Superintendent, Rewah State.

ditions for working are favourable; the quality of the coal is fair in the laboratory, and the practical results are satisfactory.

The accident of position has caused much more attention to be devoted to the Umaria than to the Johilla area, the former locality being 14 or 15 miles nearer to the station of Kutni, on the East Indian Railway. The Johilla valley was merely looked at in case the Umaria borings should fail to realise the expectations formed of them. The extra distance would have been a very small drawback, if the only alternative left of procuring coal had been the opening-up of that part of the district; and it was deemed advisable, while means were at hand for under-ground exploration, to make as effective use of them as possible.

As matters have turned out, there was no necessity to have taken the precaution of examining the Johilla coal lands, but the information that has been gained respecting them is a valuable item added to our positive knowledge.

First boring at Umaria, 22nd January 1882.

The first boring at Umaria was commenced on the 22nd January 1882 on the site selected by myself. It was to the north of the outcrop of the coal seam, and was intended to prove the true thickness of the coal. According to Mr. Stewart's reading of the samples it is 7 feet. This may be accepted as the average thickness of the coal seam, the outcrop of which is seen in the Umrar river, running between the two villages of Khalesar and Umaria.

It would be needless multiplication of details to allude to each bore-hole section. The object with which the various positions were chosen was to test the extension of the coal both laterally and to the deep.

Had more time been at our disposal more ample results could have been achieved, but as the case stands even now enough data have been gathered to show that the seam exposed in the river extends over a *proved* area of $1\frac{1}{2}$ square miles, and that it is fair to assume 3 square miles as probable and easily worked coal lands.

Second seam.

In boring No. 7*a*, immediately on the right bank of the Umrar, a second seam was met with, which is, I fancy, higher in the series than that proved in No. 1. It was again passed through in Nos. 8 and 9, and it was just touched in No. 11. It appears to be a permanent bed, so that we may calculate upon two seams of coal, which at a very low average may be taken as 14 feet thick.

Most of the borings were put down within the limits of the Umaria holding; but in order to learn something of the lie of the land between Khalesar and Lálpur on the other side of the river, I directed Mr. Stewart to start No. 6. A series of misfortunes rendered this hole and two subsequent ones useless as indicators, none of them having been completed. The question therefore as to what becomes of the coal in that direction is an open one, but I incline to think that the coal is there, and that had the borings been carried deeper they would have proved this to be the case. It is unfortunate that there should be uncertainty on the point, as, owing to this circumstance, I have for the sake of being within the mark omitted it from the calculable coal lands.

Available coal at 300 feet is about 28,000,000 tons.

I presume that I am expected to give a few figures showing the amount of coal that I consider to exist in the Umaria field. It is an unsatisfactory task to undertake, as those know who make calculations of this sort. With an average thickness of 14 feet, I think that within the area of 3 square miles there is an available amount of 28 millions of tons at a depth of 300 feet from the surface.

Dip slight.

The dip of the measures is slight, and the coal keeps well up for a long way to the deep, so that it presents great facilities for being readily worked.

With respect to the quality of the coal the only seam that could be tested in the laboratory and tried practically on the railway was the lower one.

About one hundred tons were excavated from the outcrop, and consignments were made to the East Indian and Great Indian Peninsula railways. From Mr. Pont, of the East Indian line, I heard that the working power of the coal was 41 lbs. the train mile.

From Mr. Brock, of the Great Indian Peninsula line, the most favourable result was 33 lbs. the train mile.

The Great Indian Peninsula trials show the coal in a very favourable light, and nearly equivalent to the best and freshest samples of the Karharbari field.

Considering that the coal on trial was merely surface stuff, the result is quite surprising. It is possible also that when the drivers and firemen are better acquainted with it they will be able to get still more work out of it.

Analyses made in the Survey laboratory by Mr. Hira Lal, who has been associated with me in the survey of the South Rewah coal areas, gave the following result:—

Analyses of different bands in the Umaria seam.

	a. °/₀	*c.* °/₀	*d.* °/₀	*e.* °/₀	*f.* °/₀	*h1.* °/₀	*h2.* °/₀	*h3.* °/₀	*h4.* °/₀
Moisture (at 230° F.)	5·8	3·6	2·6	3·4	2·2	2·4	2·4	2·6	2·8
Volatile, exclusive of moisture	23 6	30·0	19·6	34·4	24·4	25·8	26·0	29·2	27·6
Fixed carbon	52·4	53·6	57·2	55·0	35·6	59·4	57 8	52·2	59·0
Ash	18·2	12·8	20·6	7·2	37·8	12·4	13·8	16·0	10·6
Caking	...	+	...	+	+	...	...	+	+
Not caking	+	...	+	...	...	+	+	...	...
Colour of ash	white.	pink white.	white.	grey white.	white.	white.	white.	white.	white.

N. B.—The band *f.* yielded about 15 °/₀ of oil and tarry matter.

The samples were taken by myself from the quarry at the outcrop. The index letters refer to the section which is—

Descending.	Inches.
a—Coal hard	6
b—Stony band	1
c—Coal bright	6
d— „ hard	7
e— „ bright	6
f— „ hard	4
g—Stone band	2
h—Coal hard	2 ft. 0
	4 ft. 8

The seam is not so thick at the outcrop as it is farther to the deep. The best coal is the lowest band, lettered *h*. It contains a high percentage of fixed carbon, which accounts for the excellence of the trials on the Great Indian Peninsula railway.

Of the bore-hole sections, I give Nos. 1 and 7*a* to show what rocks were passed through, and the thickness of the two seams.

No. 1.—*Commenced 22nd January 1882, ended 10th February 1882.*

	Feet.	Inches.
Black surface soil	1	6
Brown coarse sandstone	4	0
Grey soft „	1	6
Red coarse hard „	1	0
Yellow coarse hard sandstone	1	0
Grey earthy „	2	0
Yellow hard coarse „	1	0
Red coarse hard „ with clay	2	6
Grey hard coarse „ „	2	6
Mottled coarse earthy „	2	0
Grey hard fine „	2	0
Light brown fine hard „	2	0
Dark brown fine hard „	1	6
Brown hard „	7	6
Grey soft shaly „	1	0
Red coarse soft „	2	0
Brown fine soft „	1	0
Yellow fine soft „	1	0
Brown and yellow mottled clay	1	0
Brown shaly soft sandstone	1	0
Gray and brown shaly sandstone	1	0
Brown shaly soft sandstone	1	0
Grey fine soft sandstone	1	0
Brown clay, hard „	1	0
Grey and soft shaly sandstone	1	0
Carbonaceous shale „	5	0
Coal	3	0
Carbonaceous shale	1	0
Grey shaly sandstone	1	0

	Feet.	Inches.
Coal	7	0
Carbonaceous shaly sandstone	9	0
„ shale	2	0
Coal	2	0
Carbonaceous shaly sandstone	3	0
White hard sandstone	16	0

No. 7a.—*Commenced 17th March 1882, ended 30th April 1882.*

	Feet.	Inches.
Dark brown sandy surface soil	16	0
„ „ clay and pebbles	5	0
Brown clay and sand	2	0
Light brown mottled shaly sandstone	1	0
„ and red sandstone	1	0
Brown shaly sandstone	1	0
Red „ „	1	0
Yellow „ „	1	0
White „ „	2	0
Brown and white shaly sandstone	1	0
White „ „	1	0
Brown and white „ „	2	0
Red and brown „ „	1	0
White and brown „ „	1	0
Yellow „ „	1	0
Red and white „ „	1	0
Brown and yellow „ „	1	0
„ „ „	1	0
„ and white „ „	2	0
„ „ „	1	0
White and red „ „	1	0
„ and yellow „ „	2	0
Brown and white „ „	3	0
White „ „	8	0
„ sandstone	1	0
Brown „	5	0
Grey „	2	0
Brown „	6	0
Grey „	23	0
Carbonaceous shaly sandstone	5	0
Grey sandstone	1	0
Carbonaceous „	5	0
Grey „	2	0
Carbonaceous „	8	0
Grey „	20	0
Coal	13	0
Carbonaceous shale	25	0
Coal	11	0

Of the Johilla borings I have little to say; one was put down near the junction of the Marjada and Umarha streams and the other on the left bank of the Johila. The sections speak for themselves, and the coal appears to be better even than that of Umaria.

No. 2.—*Commenced 6th March 1882, ended 23rd April 1882.*

	Feet.	Inches.
Yellow clay (surface soil)	1	0
Brown shaly sandstone	10	0
Dark brown shaly sandstone	5	0
Carbonaceous clay	2	0
" shale	9	0
Grey shaly sandstone	2	0
Brown shaly sandstone	5	0
Coal	17	0
Carbonaceous shaly sandstone	1	0
Grey " "	1	0
Coal	3	0
Carbonaceous shaly sandstone	1	0
Grey " "	1	0
Carbonaceous " "	3	0
Coal	8	0
Carbonaceous shaly sandstone	4	0
Grey " "	2	0
Carbonaceous shale	2	0
Grey shaly sandstone	1	0
Carbonaceous shaly sandstone	1	0
Grey " "	4	0
Coarse sandstone	1	0
Grey "	6	0

No. 3.—*Commenced 13th March 1882, ended 23rd April 1882.*

Dark brown surface sandy soil	1	0
Dark shaly sandstone	1	0
Grey " "	1	0
Brown " "	3	0
Coal	17	0
Grey shaly sandstone	1	0
Carbonaceous shale	6	0
Grey shaly sandstone	1	0
Carbonaceous shaly sandstone	9	0
" shale	2	0
Coal	6	0
Carbonaceous shaly sandstone	6	0
Grey " "	4	0

The proving of the Umaria coal-field shows how valuable an adjunct to the labours of the Geological Survey are the facts that can only be discovered by a series of borings. A large area of coal has thus been proved, and our doubts dissipated; and we have now ample knowledge to direct us in our projects and plans for the future. The coal is good, and there is plenty of it. It is within *one hour's* railway journey of Kutni, and from its commanding geographical position, as may be seen by looking at a map, it is one of the most important areas of supply for Central and Upper India. It will be of immense utility to the Great Indian Peninsula railway, and to the feeders of that line; and I have no doubt that a large up-country consumption will be established.

What is now wanted is a line of rail to Umaria, and I trust it will be my fortune to see one started and completed within the next two years. There is a large grain traffic passing through Umaria, but I have no statistics to give. I have no hesitation, however, in saying that a railway would probably pay its way, though perhaps 2 to 3 per cent. of interest would be all that the capital would realise until the road was extended more to the east and served a larger area of country.

The Daranggiri Coal field, *Garo Hills, Assam—By* TOM D. LA TOUCHE, B.A., *Geological Survey of India.*

Immediately to the north of the gneissic range running westward from the Khasia plateau and forming the culminating ridge of the Garo hills, the cretaceous rocks in which the coal of this district occurs occupy a series of detached basins in the gneiss, and rest directly upon it. Of these basins the two largest,—marked as coal-fields on the Ordnance map, and known as the Rongrenggiri and Daranggiri fields respectively,—are situated in the valley of the Sumesary or Semsang river. In the Rongrenggiri field, which extends from about 2 miles to the west of the thanna at that place eastward to a short distance to the east of Shemshanggiri, there are, as far as I could discover, no coal seams of any practical value. A seam of good coal, 1 foot thick, occurs in a hill due east of Shemshanggiri, and at the west end of the field are several outcrops of a bed of carbonaceous shale, about 3 feet thick, which, I believe, represents the principal seam of the Daranggiri field described below. A fairly continuous section is exposed in the bed of the river and its tributaries between these beds and the gneiss on the one hand and the nummulitic rocks which occupy the centre of the basin on the other, and in these rocks only a few insignificant strings of coal and thin beds of carbonaceous shale occur.

The Daranggiri field, its position and area.—The Daranggiri field is situated on both sides of the Sumesary river, where it turns south in a long reach before cutting through the main range at Jankaray village. It is about 10 miles in length from west to east, extending from a little to the west of Daranggiri to Rengdim in the Khasia hill district, and about 6 miles in breadth from north to south, from a short distance above the junction of the Rongoli stream with the Sumesary to the Rongkhai stream on the south. On the south side of the latter river are a few outliers, but these are separated from the gorge of the Sumesary, through which the projected railway will probably pass, by some miles of exceedingly rugged ground so that they are not of much importance.

Within these limits the coal-measures occupy an area of about 50 square miles, but, as will be seen from the analyses given below, the seams which occur in the portion of the field lying between the Rengchi, Rongkhai and Lengta streams is almost, if not quite, worthless; besides which the small thickness of the seams in this portion of the field, not more than 2 feet 6 inches, would probably prevent their being worked with profit, even if the coal were of better quality. There remains, then, the western half of the field extending from Daranggiri to the Rengchi, an area of about 20 square miles, in which there is at least one seam of coal of good quality of a thickness sufficient to be worked profitably.

1. Daranggiri outcrops.—The outcrops of the principal seam in the neighbourhood of Daranggiri have already been described by Mr. Medlicott. (*Records*.

G. S. I., Vol. VII, pt. 2, p. 58). Besides this seam three are five others exposed in the cliffs about Daranggiri, but of greatly inferior thickness. The following section is exposed in a cliff on the east side of the Rongwi (Nongal) stream, a short distance below its junction with the Rongmadu, and may be taken as a type section of the coal-measures throughout the field :—

		Ft.	Ins.
1. Coarse yellow and brown sandstones	about	240	
2. White sandstones with bands of shaly clay rock	"	70	
3. *Coal*	"	1	
4. Shaly clay rock	"	3	
5. *Coal*	"	0	10
6. Shaly clay rock	"	4	
7. *Coal*	"	0	6
8. White sandstone with bands of shale	"	20	
9. *Coal*	"	7	6
10. Sandy shale with strings of coal in lower part	"	5	
11. *Coal*	"	1	
12. Carbonaceous sandy shale	"	5	
13. *Coal*	"	1	
14. Carbonaceous shale, base hidden under water	"	?	
	TOTAL	358	10

The section is given in natural order; dip about 5° to south-east.

In this section the beds immediately below the coal are not exposed, but on following down the stream the rise of the strata gradually brings them up until, at a short distance above the junction of the Rongwi with the Sumesary, they are seen resting directly upon the gneiss, and consist of about 200 feet of coarse purple and yellow grits and conglomerates. Similarly to the west of Daranggiri the seam may be traced rising steadily along the cliffs bordering the Rongmadu, the lower grits and conglomerates appearing beneath it, until it is overlapped by the higher strata which rest against the gneiss of Naramkhol and Tobeng hills. To the south of Daranggiri the principal seam disappears beneath the bed of the Rongwi, a short distance above its junction with the Rongmadu, but it appears again in the same stream, about 1½ miles further to the south, being bent up sharply against the gneiss of the main range, with a dip to north-east increasing in this section from 35° to 65° within a distance of 100 feet. On the same strike the seam appears to the west in the Nongalbicha stream and to the east in the Rongju below the village of Baduri, where it is nearly vertical.

2. Sumesary outcrops.—Descending the Sumesary from its junction with the Rongwi, the south-east dip of the strata brings the coal seams down to the river level about quarter mile above its confluence with the Garigithem stream. The same series is seen here as in the section at Daranggiri, except that the lowest one foot seam is absent. The dip of the beds is 2° to 3° to south-east, but slightly undulating, and becoming horizontal a little further down the river. The outcrop of the principal seam here, and in the Garigithem stream, about a quarter mile to the east, has been described by Mr. Medlicott (*loc. cit.*); it is about 6 feet thick. Further to the east the coal is overlapped towards the north by higher beds, which rest directly upon the gneiss, and occur in patches on the tops of the hills as far north as Sudugiri.

3. *Goreng hill outcrop.*—In the north-south reach of the Sumesary gneiss is exposed for a considerable distance above the junction of the Rengchi. This rock extends beneath Goreng hill to the Renchi, forming an almost horizontal but uneven floor, upon which the coal-measures rest horizontally. The lower part of these, about 200 feet, consists of coarse grits and conglomerates, which form a perpendicular cliff extending almost continuously round the south end of the hill. At the top of this precipice the coal occurs, but generally its outcrop is much obscured by talus. Large fragments of it, however, occur in all the streams which flow from the hill to the Sumesary and Rengchi. A good section is exposed in the Nengja stream, a small tributary of the Rengchi, about 1 mile from the latter, as follows:—

	Feet.	In.
1. Coarse sandstone, about	12	0
2. Coal, about	3	6
3. Clay rock with carbonaceous markings, about	4	0
4. Fine yellowish brown sandstone, about	4	0
Total	23	6

The beds are horizontal.

A short distance down the stream a band of carbonaceous shale, about 18 inches thick, is exposed, but in this part of the field I could not find any of the smaller seams which occur at Daranggiri.

Total amount of coal.—In this area of 20 square miles the average thickness of the seam is 5 feet 6 inches (7 feet 6 inches at Daranggiri and 3 feet 6 inches on the Rengchi); the total amount of coal calculated from these data is about 76,000,000 tons.

Quality of the coal.—The coal of the principal seam is bright black in colour, becoming brown when crushed; it contains numerous specks and nests of a brown resinous substance; it lights readily and burns freely. The seam is very free from shaly partings. The coal from the seams to the east of the Rengchi is brownish-black in colour, and much more shaly. Specimens taken from four localities have been assayed by Mr. Hira Lal, Sub-assistant Geological Survey, with the following results. To these I have added an assay of the coal from the outcrop at Daranggiri, taken from Mr. Medlicott's report, *loc. cit.*:—

Assays of Daranggiri coal.

	% 1	% 2	% 3	% 4	% 5
Moisture (at 230° F.)	11·5	6·2	2·6	3·0	2·8
Volatile, excluding moisture	33·1	39·4	21·6	31·2	40·2
Fixed carbon	47·7	51·8	4·0	14·0	27·4
Ash	7·7	2·6	71·8	51·8	29·6

No. 1.—Daranggiri, 7′-6″ seam (assay made in 1874).

No. 2.—Nengja stream, 3′-6″ seam: caking; ash, white.

No. 3.—Hill side above Rongtok stream: non-caking; ash, white.

No. 4.—Fragment from talus at outcrop in bank of Lengta stream: non-caking; ash, pinkish.

No. 5.—One foot seam in Rongwi stream above Daranggiri: non-caking; ash, greyish white.

Position of the principal seam as regards working.—Except in the south-west corner of the field, where the strata are bent up sharply against the gneiss of the main range, they are either horizontal or dip at very low angles, and there seems to be an absolute freedom from faults over the whole area. The greater part of the seam is above the level of the principal streams so that the coal might be economically extracted, and the mines drained by adits. Moreover, as the rock immediately above the coal is generally a fine clay rock, tolerably impervious to water, the mines would to a certain extent be kept dry by it.

That part of the seam which dips below the surface of the rivers would have to be got at by shafts, but the strata above the coal, consisting of about 300 feet of sandstone and shales would present no difficulty to the sinking of these. Finally, the line of the proposed railway, up the gorge of the Sumesary, passes through the centre of the field so that if this scheme is ever carried out there appears to be no reason why the coal of this field should not be worked with facility and profit.

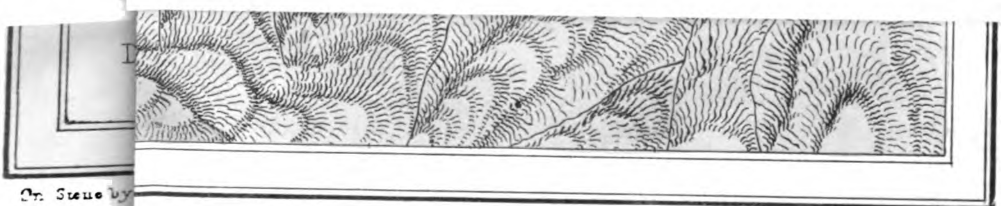
Nummulitic limestone.—On the high ground to the east of Daranggiri, there are two patches of nummulitic limestone, indicated by surface fragments, but as they are entirely covered by jungle I was unable to determine their thickness and extent. However it is quite possible that quarries opened in them would supply lime sufficient for small buildings and other works in the field itself. At Siju on the Sumesary, to the south of the main range, is a large deposit of limestone of good quality.

In concluding I must express my thanks to Captain Maxwell, the Deputy Commissioner of the district, for the great interest he took in my work, and for the assistance he gave me, so that although I was totally unacquainted with the country when I arrived in it, I had no difficulty in obtaining either carriage or supplies.

On the outcrops of coal *in the* Myanoung *division of the* Henzada *district.—By R. Romanis, D. Sc., Chemical Examiner, British Burma (with a plan).*

Having ascertained from Major Spearman that the coal reported in the Henzada district was found at Mokhoung, near Hleemouk, on the Nangathoo river, I proceeded thither, leaving Henzada on the morning of April 27th and arriving at Hleemouk on the following morning. The way lies along the Henzada embankment for 25 miles as far as Kyoukywa, where the Bassein river is crossed; thence by cart-roads through rice-fields to Kwingouk, where the Nangathoo river is passed. From this place to Hleemouk is about 8 or 9 miles. The road several times enters the bed of the Nangathoo stream. The last 2 or 3 miles of the road pass through forest, but it is almost level the whole 15 miles from Kyoukywa.

I found the outcrop at Mokhoung, the site of a deserted village about 4 miles from Hleemouk. It is at the foot of a steep bank composed of clay and loose stones lying upon shales which dip to the north at an angle of 45°. The river flows along the foot of the slope, crossing the strata at right angles to the strike. At a point where there is a fold or bend in the strata, and the dip changes to the south, the coal appears as a bed 22 inches thick below 24 inches of carbon-



On Stone by

aceous shales. I was not able to follow the strike of the beds across the river, as there is a wide alluvial tract on the other side beneath which it is concealed, if it exists at all, nor could it be found to the south of the fault, where the beds dip to the south. As it appears at a fault, the coal is much broken by the bending of the rocks, and patches of shale occur throughout the bed, which induced me to think it a mere pocket in the shale. A watercourse, which seems to mark the line of dislocation, enters the stream at the place where the coal appears. About 100 yards further up the stream some coal was found amongst the debris at the foot of the bank; and in a watercourse which enters the stream to the north is a thin bed of carbonaceous shale under a bed of quartz.

While at Hleemouk a piece of coal was brought in, said to be from Kywaising in the Okepo district. On examining it I found that it melted and formed a coke, which the Mokhoung coal does not do. I at once proceeded to the place, which is about 12 or 14 miles from Hleemouk, near the junction of the stream, called in Fitzroy's map the Shwayneing with the Okepo river. It is not marked in that map, which appears to be incorrect in the representation it gives of this district.

On arriving at Kywaising we were conducted to the coal. It is found at a place about 1½ hour's walk from Kywaising over low hills covered with bamboo forest.

The coal appears at a sharp bend of a watercourse which flows from north to south into the Shwayneing river. At the point where the coal is exposed the stream makes a sharp turn and flows from west to east for about 120 yards. The south bank is about 50 feet high and steep. The coal is exposed along the whole of the bank in a bed about 12 feet thick. A cutting was made into the coal when the following section was found:—

	Feet.	Inches.
Soil and decomposed yellow shale	5 or 6	0
Carbonaceous shale	0	4
Coal	1	6
Carbonaceous shale	0	2
Coal	1	6
Carbonaceous shale	0	4
Coal	1	6
Carbonaceous shale	0	2
Coal	1	6
Carbonaceous shale	1	6
Coal, good quality	2	0
Coal, inferior	2	0
Total	11	6

The lower portion was concealed by debris, and the exact thickness could not be estimated. Since my return I have been informed by Mr. Lewis, who continued the work after I left, that the layers of shale become mere partings in the coal, and that there are 6 feet of coal, then 2 feet of shale, and then 4 feet of coal, the upper 2 feet of good quality.

The dip of the bed of coal is 30°, to E.

I examined the rocks in the neighbourhood and found that they dipped like the coal at 30°, to E. The strike is north and south. I observed layers of carbonaceous shale at three places in the watercourse, and found that they crossed it and passed under the opposite bank, showing that there is no fault but the strata dip under the hill to the east. Over one of these beds there lies a thick bed of quartz-breccia. From the dip of the strata and the position of the quartz-breccia and shale I conclude that they lie under the coal.

Having finished my observations at this place I visited the outcrop at Poosoogyee, in the Myanoung district. On my way through Hleemouk I revisited the outcrop there. It was too dark to see what had been done, but I was told that the coal had come to an end after four bags had been got out, and that the rest was all shale. Mr. Lewis, who saw the place by daylight, says this is not the case; there is a layer of coal 18 inches thick.

Poosoogyee is about 30 miles from Myanoung, on the Padaw river. On my way I halted at a Chin village, Yaynantoung, so named from a petroleum spring about 4 miles away in the hills. I did not visit it as the quantity of petroleum is very small, but it is evidence of the presence of bituminous strata. The spring is marked on the map as east of the village.

The outcrop of coal is about 4 miles from Poosoogyee on the left bank of the Padaw stream. It is a band varying from 18 to 6 inches in a bed of carbonaceous shale dipping 60°, to E. It is very friable, crumbling into powder between the fingers. The stratum in which it occurs is much contorted, and in one or two places the coal thins out altogether. On examining the neighbourhood I found a bed of quartz conglomerate overlying a bed of bituminous shale in two places, one further up the stream than the coal, the other lower down, dip 60° to N.E. at the latter, 60° to E. at the former, evidently passing below the coal, and thus bearing the same relation to the coal that similar beds do at Kywaising and Mokhoung, from which I infer that the same strata of coal, shale and conglomerate appear at each place. The coal is at its maximum thickness at Kywaising and thins out to 22 inches at Mokhoung, 12 miles south, and to less than 12 inches at Poosoogyee, 18 miles north. The following diagram shows the order of the strata, as it appears to me :—

Yellow shales and sandstone several hundred feet.
Coal 10 feet.
Carbonaceous shale (?)
Yellow shale and sandstone, 300 feet.
Quartz breccia, 5 feet.
Carbonaceous shale, 2 feet. (?)

I do not think that it is worth while at present to bore at either Poosoogyee or Mokhoung. At Poosoogyee the rocks are much contorted; they have been indurated by infiltration of silica; the dip is great and the seam irregular. It is possible that the irregularity is due to the twisting of the strata at the point where they crop out, and that a boring put down to the eastward may find the coal more regular and less friable, but it seems to me that the Kywaising outcrop is the one most likely to repay exploration.

On stone by

I should recommend that two borings be made, one to trace the coal under the opposite bank of the stream, that is, to the eastward, the other to the southward to follow the coal towards the river. The shale and soil covering the coal on the west side of the watercourse cannot be many feet thick, and several borings may be made without trouble.

As to the question of transport, the Okepo river is navigable during the rains for boats of 10 tons as far as Kywaising. The coal is about 5 or 6 miles distant from the village. Four miles of the road are level, but the bed of the Shwayneing river is crossed several times. For the last 2 miles the road is the bed of a watercourse covered with loose stones, but if the coal is in quantity there will be no difficulty in making a path by clearing the bamboo forest and cutting a road in the hillside. Good timber may be obtained from the pyinkado trees *(Xylia dolabriformis)*, which grow plentifully on the spot. In the dry weather there is only enough water in the Okepo to float bamboo rafts, but it is only 16 miles by cart-roads to the Bassein river, and I suppose a light tramway might be laid down at small cost, if the coal is in sufficient quantity.

Analyses of coal:	*Kywaising.*	*Poosoogyee.*
Moisture	1·48	6·36
Volatile matter	26·58	18·21
Fixed carbon	65·12	69·65
Ash	6·82	5·78
	100·00	100·00

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 4.] **1882.** **[November.**

Notes on a traverse across some gold-field *of* Mysore, *by* R. BRUCE FOOTE, F. G. S., *Deputy Superintendent, Geological Survey of India.* (*With a map.*)

In August 1881, I made a rapid traverse north-westward from Bangalore to the neighbourhood of Honali (Honhully) on the Tungabhadra and very nearly up to the southern boundary of Dharwar District. As my route lay in most parts across a very bare and open country and I travelled by day only, map in hand, I was able to form a very fair general idea of the leading features of the country, which proved to be of much interest for comparison with the results of various traverses I had made in the South Mahratta Country, the southern part of which is formed of the northerly continuation of the great gneissic series which forms the Mysore plateau. Later in the year I connected the Bangalore end of the traverse with older work in Salem District by another traverse along the Madras railway down to Jalarpett Junction. The results of the combined traverses show that the Mysore table-land is traversed by great bands of granitoid and schistose gneiss, the southerly extensions of some of the great bands recognized in the South Mahratta Country. When the whole of this region shall have been geologically examined it is more than probable that all the bands known to the north of the Tungabhadra (see map) will be traced far to the south. The traverse now to be described shows that three great bands of schistose rock occur on the Mysore plateau, and that two of these are actual continuations of two of the great schistose bands in Dharwar districts which, in my Memoir of the Geology of the South Mahratta Country (Memoirs, Geological Survey of India, Vol. XII, p. 43) I described as the Nargund and Bail Hongal (Dharwar) bands. For convenience of description these bands will in the sequel be referred to as the "Dharwar—Shimoga" and "Dambal—Chiknayakanhalli" bands. Both these bands have been traced across the Tungabhadra, the latter in a chain of hills running down southward to Chitteldrug and Chiknayakanhalli, while the former forms another chain of hills passing Harihar (Hurryur) and Shimoga and stretching further south towards Hassan. These bands are of considerable width, the Dambal—Chiknayakanhalli band, which is considerably the narrower of the two, measuring 18 miles across where crossed by the line of section. In addition to their geological interest, these two bands are of importance, as within their limits occur several of the auriferous tracts which have of late attracted so much attention. The Dharwar—Shimoga band is slightly auriferous at its northern extremity, and streams rising on it near Bail Hongal and Belowaddi in the Sampgaon Taluq of Belgaum district used formerly to be washed for gold. The auriferous tract of Honali lies within the same schistose band a little to the north of Shimoga. The Dambal—Chiknayakanhalli band contains the auriferous tract of the Kapputgode hills, near Dambal to the north of the Tungabhadra; while south of that river on the Mysore plateau, near the town of Chiknayakanhalli, are quartz reefs reported to be auriferous, and which have attracted the notice of several speculators, who have taken up land for mining purposes.

This schistose band is seen to stretch away far to the south-south-east in a line of low hills, and is said to extend to Seringapatam, passing that place and the town of Mysore to the eastward, and then trending round to the south-west and continuing into south-eastern Wynáad, where it forms the gold-field around Devala. This tallies with Mr King's observations in the Wynáad,[1] a strong band of schistose gneiss having been shown by him to occur at and around Devala, in which chloritic schists occupy an important position. My informant as to this extension of the Dambal—Chiknayakanhalli band was Mr. Lavelle, the pioneer gold prospector of the present time, who has traced the band from the Wynáad north to beyond Chitteldrug. I have no doubt but that Mr. Lavelle's observations will be fully confirmed when the whole of Mysore shall have been surveyed geologically. If the parallelism of strike continues between the southward extension of the Dharwar—Shimoga band and that of the Dambal—Chiknayakanhalli band, it is highly probable that the former will be found to constitute the auriferous tract said to exist in the North Wynáad. The stratigraphical relations of the several great bands, both granitoid and schistose, have yet to be worked out, for in the northern part of the great gneissic area they were found too obscure to be satisfactorily explained, and it remains to be seen whether they represent two or more great systems. Their position and relation are shown in the accompanying map and section.

Rocks seen along the line of section.

Eastern granite-gneiss band.

If the line of section be followed from S.-E. to N.-W. it will be seen to traverse a region of very typical granite gneiss, extending from Jallarpett Junction (Madras Railway, South-West Line and Bangalore Branch) for a distance of some 30 miles. This granite-gneiss tract forms the eastern edge of the great Mysore plateau which is here a wild, rugged, picturesque jungle region.

Kolar gold-field schistose band.

To the west the section crosses at its narrowest part the band of schistose rocks in which lies a little to the north of the railway the now well-known Kolar gold-field, at present a scene of energetic mining work on the lands taken up by a number of large mining companies. This schistose band, which will be most

[1] See Preliminary note on the gold-fields of South-east Wynáad, &c., by William King, B.A., Deputy Superintendent, Geological Survey of India. Records, Geol. Surv. of India, Vol. VII, p. 26.

appropriately called the Kolar schistose band, forms an important synclinal trough resting on the adjacent granite-gneiss rocks. It is the only one of the great schistose bands whose relations to the associated bands of granitoid rocks have (as yet) been distinctly traced. A fuller account of this band with especial reference to its auriferous character will be given further on.

Bangalore granite-gneiss band.

On crossing this Kolar gold-field band, the section trends northerly as far as the Kolar road railway station when it bends sharp round to the west and continues in that direction as far as Bangalore. The very broad band of granitoid gneiss, which extends between the Kolar gold-field schistose band to the second great schistose band (the Dambal—Chiknayakanhalli band), forms in its eastern part an open undulating plain from which rise a few important rocky hills, as the Tyakal (Tiacull of sheet 78), Balery and Vakelair hills north of the railway. A number of small low table-topped hills are also to be seen at small distances from the railway, as the Bettarayan Betta (Baterine hill of sheet 78), 3½ miles north-east of Kolar Road railway station, the Patendur hill, 2 miles south-west-by-south of the Kargudi (Curgoory) railway station, and the low hillock crowned by a mantapam about a mile north of the Maharajah's new palace at Bangalore. These three hillocks are capped with beds of true sedimentary laterite underlaid by lithomargic clays. Of precisely the same aspect, both in form and colour, are the Shiva Samudra, Jinnagra and Chicka Tagaly hills which lie a few miles north of the railway near the Kargudi and Mallur stations. Identical in form and appearance also is a much more extensive development of table-topped plateaus which are well seen from Bettarayan hill lying several miles to the north and covering a considerable area. The laterite at the north-eastern end of the Patendur hill is distinctly conglomeratic and contains a tolerable number of well-rolled quartz pebbles. The red colour of the sides of these hills and plateaus added to their sharp cut tabular shape, makes them conspicuous from considerable distances. No organic remains were found in connection with these lateritic beds, and the number of sections examined was not sufficient to enable me to form any positive opinion as to their origin, and still less so as to their geological age,—but there can be no doubt that they are the scattered outlying remains of a formerly far more extensive formation.

To the north-west of Bangalore the undulation of the country increases considerably and the streams run in much deeper channels affording more numerous sections both of the surface soil and sub-rock. The surface of the country is generally covered with a thick layer of red soil which often contains a large percentage of pisolitic iron (hæmatite) in segregational form.

Thirty-two miles north-west of Bangalore the section cuts across the line of hills running north and south from the Cauvery river, a little east of the great falls, up to Nidugal on the frontier of the Bellary district. This line of hills culminates close to the section in the fine peak of Sivaganga which attains the

[1] The expression line of hills is used in preference to the term chain as there is little continuity of high ground, the hills being mostly quite detached and separated in some parts by considerable spaces.

height of 4,559 feet above sea-level. Like many other groups of granitoid gneiss hills in the south, these hills are very rocky and bare and look as if they had never been covered with a real forest growth.

Dambal—Chiknayakanhalli schistose band.

The section maintains its north-westerly course up to Tumkur, beyond which town it turns suddenly westward and, after a course of 16 miles in which remarkably few outcrops of rock are seen, meets the second great band of schistose rocks in the line of hills rising between Hagalvadi and Chiknayakanhalli. This second great band of schists is, as will be seen by a glance at the accompanying map, the southerly continuation of the Dambal—Chiknayakanhalli schist band as defined above (page 191). The width of this extremely well marked schistose band which the section crosses at right angles is 18 miles. The character of the scenery is markedly different; smooth grass grown hills, generally well rounded, with very few conspicuous exposures of rock, take the place of the bold rocky bare hill masses seen east of Tumkur. The rocks consist of hornblendic, chloritic and hæmatitic schists cropping out at very high angles or in vertical beds. Several large quartz reefs occur traversing these schists, and one large one crosses the road some distance west of Dodygan halli. Time did not allow of my doing any prospecting here, but several prospectors have stated that their researches were rewarded by the discovery of gold in appreciable quantity both in the quartz and by washing the local soils. The extension southward of this schist band may be traced by the eye for many miles owing to the very characteristic features of the low line of heights which extends south in the direction of Seringapatam. That they extend still further south and then trend south-westward into the south-eastern part of the Wynáad may be assumed as a fact on the strength of the information kindly furnished by Mr. Lavelle, the pioneer gold prospector—(See *ante*, page 192). The contact of the schists and granitoid gneiss is unfortunately concealed by superficial deposits at the places where the section cuts across their respective boundaries, but the impression left in my mind by the general appearance of the localities was that the schists were overlying the granitoid beds, and the same relation appeared to me to exist in the Dambal gold-field, as far as its western boundary is concerned. The eastern boundary of the schist band was not traced near Dambal and Gadag (Gudduck), but further north it is completely hidden by the tremendous spread of cotton soil there prevailing. Passing on a little to the south of west from the schistose band the section runs across a granitoid gneiss region, and after passing Tripatur crosses the watershed between the Cauvery and Krishna hydrological basins, the section trending more and more north-westerly along a rapid descent. It leaves the high, picturesque, granitoid hill masses of Hirekal Gudda and Gardangiri to the right and beyond Banavar skirts the eastern boundary of the third or Dharwar—Shimoga schist band for several miles, but does not actually leave the granitoid rocks till it has passed Kadur by some six miles. The rocks of this granitoid band, which may for convenience be called the Mulgund-Kadur band, offer no speciality calling for remark. Like the hilly region running east of Tumkur, the hills may preferably be described as forming a line rather than a chain for they occur in numerous detached masses.

Dharwar—Shimoga schist band.

As just mentioned, the section gets on to the third schistose band six miles to the north-west of Kadur, and here the schists are mostly chloritic, of pale colour with intercalated more highly siliceous bands, ranging from chloritic gneiss to quartzite. To the south of the road the quartzites increase much in development and rise into a high ridge with a great cliffy scarp on the eastern face of Coancancul peak. Further west, to the south of the high road, rises a considerable hill of very rugged nature, which, when seen from a distance, presents great resemblance to a typical granitoid gneiss hill. On closer approach the rock is seen to have a very coarsely mottled structure which turns out to be due to the presence of enormous numbers of well-rounded pebbles of a granite or compact granite gneiss. The size of the included stones ranges in the part I examined from small pebbles to small boulders, all enclosed in a greenish-grey foliated chloritic matrix. The thickness of the conglomerate here exposed must be very great, as proved by the size of the hill which goes by the name of the Kal Drug (Cull Droog). To the north, the beds are soon lost sight of under the local alluvium of the Kushi (Cooshy) river and they are not seen to re-appear conspicuously in the hilly country on the north side of the valley. To the west of the great conglomerate beds follow more schistose beds, and, as seen on the hill slopes south of the road, a great series of quartzites. Near Tairakerra, and to the north-west of it, very few exposures of rock are met with as far as Bankipoor, but the few that do show through the thick woods which here cover everything, prove the country to be formed of schistose members of the Gneissic Series. About four miles north-west of Tairakerra the road crosses a very small outcrop of typical hæmatite schist, striking in a northerly direction. A good deal of rock shows in the bed of the Bhadra river at and above Bankipoor, but the forms seen are not very characteristic, and at the time of my passing everything was obscured by a thick layer of slimy mud left by a high fresh in the river. This part of the section would be very unsatisfactory were it not that the schistose character of the beds forming the line of hills extending northward parallel with the valley of the Bhadra shows quite clearly the extension of the rocks seen south-east and east of Tairakerra. Between Bankipoor and Shimoga very little rock of any sort is seen, but about half way across the Doab, between the Tunga and Bhadra rivers, a band of fine-grained grey granite gneiss is crossed, while to the east and south of Shimoga town are several conspicuous large masses of a chloritic variety of granite gneiss. The exact relation of these granitoid outcrops to the great schist series further east I had not the opportunity of determining, and am not quite certain whether they represent the eastern border of another great granitoid band, or whether they are part only of an unimportant local band of granitoid rock. I am inclined to think the latter will be found the real condition of things when the country comes to be fully surveyed. The short space of time at my command prevented my making a detour to settle this point. Here, too, the extent and thickness of the jungle growth greatly hide the general surface of the country along the road, while the rainy or misty character of the weather tended much to obscure the appearance of hills at but

Great conglomerates of Kal Drug.

very moderate distances. Though the exigencies of dâk travelling compelled me to make the detour to Shimoga instead of following the line of schistose beds northward from Bankipoor, I am perfectly satisfied as to the fact of these schists continuing northward, and joining those which cross the united rivers forming the Tungabhadra, a few miles below the junction of the Tunga and Bhadra. The country here is much freer from jungle, and many ridges of rock, consisting of quartzites and chlorite schists with rocks of intermediate character, can be traced for miles. This part of the section extends from the bank of the river for rather more than 20 miles,—from the travellers' bungalow at Hollalur north-westward to the Toancull-betta Trigonometrical station, six miles east by south of Shikarpur. Along the twelve miles of road between Shimoga and Hollalur but little is seen of the older rocks, the road lying close to the left bank of the Tunga and Tungabhadra, and passing almost entirely over the river alluvium which at and to the north-east of the Hollalur bungalow forms a coarse bed of rounded shingles, rising a considerable height above the present high flood level of the united rivers.

The most striking features both orographically and geologically of this part of the Mysore country are the quartzite outcrops, which are numerous, but of which only the principal ones require notice. Of these the best marked, longest and highest culminates in the Kalva Ranganbetta, a fine hill rising some 1,200′ above the plain, and 3,388′ above sea-level 16 miles to the north of Shimoga. The outcrop of the great quartzite beds forming this ridge has a distinct dip of some 60°-65° (on the average) to the north-east. The quartzites are underlaid by a schistose (chloritic) series, the south-westward extension of which was not ascertained. Overlying the quartzites which are generally flaggy in character (but which here and there become so highly charged with scales of pale green chlorite as almost to lose their quartzitic character, and pass into chloritic gneiss) are local beds of true conglomerate,—the first I have met with or heard of in the gneissic rock of the Peninsula. The conglomerate has evidently undergone considerable metamorphosis, but its real character and truly clastic origin cannot be doubted when carefully examined. Many of the included pebbles appear to have been fractured by the great pressure undergone, but their truly rounded character is quite distinct and unmistakable. The beds seen by me and traced for several hundred yards, are exposed a little way up the slope of Kalva Ranganbetta peak, and a little to the north-west of a small, but rather conspicuous, pagoda, which stands in a little recess. The included pebbles in the conglomerate consist chiefly of quartz, a few of gneiss, and some of what appeared an older quartzite. A second intended visit and closer examination of this very interesting bed was prevented much to my sorrow by bad weather. The second in importance of the quartzite ridges has its eastern extremity in the bed and left bank of the first west to east reach of the Tungabhadra below the Kudali (Coodly of sheet 42) Sangam, or junction. West of the new high road from Shimoga to Honnali (Honhully) the quartzite beds rise into the Phillur Gudda (hill), and beyond that rise again into a considerable hill some 400′ to 500′ high and may be followed easily for several miles to the north-west. The quartz-

Great conglomerates of Kalva Ranganbetta.

itic character is then in great measure or entirely lost by the rock becoming highly chloritic and the beds can no longer be safely distinguished from the surrounding mass of chloritic schist. In the north-westerly part of this Phillur Gudda ridge several pebbly beds were observed intercalated between the more or less chloritic quartzite. They differed from the Kalva Ranganbetta beds in being less coarse and having a more chloritic matrix, but had undergone about an equal amount of metamorphosis. A considerable number of quartzite ridges are intercalated between Phillur Gudda ridge, and the southern end of the Kalva Ranganbetta ridge, which terminates in the Nelli Gudda Trigonometrical station hill, 7 miles west-north-west of the Kudali Sangam. To these ridges may be ascribed the existence of the group of hills they occur in, as but for their greater durability and resisting power to weather action, they would certainly have been worn down to the low level of the purely chloritic part of the schistose band, both to the north-west and south-east. Unless there has been an inversion of the strata on a rather large scale, or faults exist which were not obvious during the rapid survey, the Kalva Ranganbetta quartzites underlie all the beds to the northward of it. Another series of overlying quartzites is shown to the north-north-west of Kalva Ranganbetta; but the relation between it and the upper beds just described could not be determined without a much more close examination of the district, more especially as the space between the two sets of outcrops is very largely and closely covered by spreads of regur. The chloritic schists offer no specially interesting features, and they are not, as a rule, well seen, except on the slopes of the hills, the general face of the country being much obscured by red or black soil, which both of them occur in great thickness.

Conglomerates of Phillur Gudda ridge.

One remaining point of great interest is the large number of important quartz veins, or reefs, which traverse the belt of chloritic rocks overlying the Kalva Ranganbetta quartzites. They are the source of the gold occurring in the thick red soil which covers the whole face of the low-lying country, and which has been washed for gold, certainly for several generations past, by several families of "Jalgars" residing at Palavanhalli. The gold is so generally distributed through the red soil that it is clear that many of the reefs must be auriferous, and the quantity found is sufficient to justify strong hopes that a profitable mining industry may be developed by working the richer reefs. Several of the series of reefs close to Devi Kop, a little village $3\frac{1}{2}$ miles east-south-east of the Kalva Ranganbetta, had been carefully and deeply prospected at the time of my visit by Mr. Henry Prideaux, M. E., and in one case certainly with very marked success. The quartz in this case was found very rich in gold, which was visible in grains and scales scattered pretty freely through the mass. The quartz in many parts had a quasi-brecciated structure with films and plates of blue-green chlorite occurring along cracks in the mass. Near the surface the chlorite, with which were associated small inclusions of pyrites, had often weathered into a rusty brown mass. The reef which at the time of my visit was regarded as the most promising, and to which the name of "Turnbull's reef" had been given, is one of a series of three that can be traced with some breaks for a distance of six miles nearly

The Honnali gold-field.

parallel with the great quartzite ridge of the Kalva Ranganbetta, the true strike of the reef being from N. 40° W. to S. 40° E. Another important set of three reefs having the same strike occurs about half a mile north of the first series, but they are not visible for such a long distance, their north-western course being covered by the thick spread of cotton soil. To the south-east they, or at least one of them, can be traced across the Nyamti nullah, which divides the gold-field in two. Out-crops of vein-quartz in a line with a south-easterly extension of this set of reefs are to be seen north and east of Palavanhalli (Pulluan hully of sheet 42). Numerous other quartz reefs having the same strike occur in the south-eastern half of the gold-field, *e.g.*, a set of four, rather more than a mile north-east of Palavanhalli, and several others to the north of Dasarhalli and south of Kunthua. A few reefs were also noticed whose strike was different from those above referred to. They represent two other systems of fissures, the one running N. 5° E. to S. 5° W.; the other, W. 5° N. to E. 5° S. Several of both these series are of very promising appearance, the "back of the lode" bearing considerable resemblance to that of "Turnbull's reef." The greater number of the reefs in the Honnali gold-field are well-marked examples of these fissure veins. The richness of the "Turnbull" and other adjacent reefs will ere long be fairly proved, as Messrs. Wilson & Co., of Madras, have, in company with other capitalists in England, formed an association to open up mines on the lands they have taken up from the Mysore Government. Their prospects of success are certainly greater than those of sundry other companies whose shares are or were till lately favourably quoted.

The Honnali gold-field appears to have been known a long time to the natives, but only came under European notice through Colonel R. Cole, late of the Mysore Commission, who not very long since received several small nuggets from a native local official, with the assurance that they came from that part of the country. The occurrence of gold both in the soil and reef has since been amply established by the researches of Messrs. Bill and Turnbull, of Wilson & Co., and of Mr. Mervyn Smith, but specially by the thorough-going system of deep prospecting followed by Mr. Henry Prideaux, the Mining Engineer employed by Messrs. Wilson & Co. Mr. Prideaux's large experience in Californian and Nevada mines had fully convinced him of the absolute necessity of deep prospecting, in other words, of preliminary mining, to get below the weathered backs of the lodes, before attempting to pronounce an opinion as to the real value of prospects. I am indebted to him for much courtesy during my stay at the Honnali gold-field and for much valuable practical information, most willingly and pleasantly imparted.

During my stay at Devi Kop, I watched the results of many washings both of crushed quartz and of the red soil taken from many localities and various levels. The great majority were highly satisfactory. The Jalgars, or local gold-washers, seem to be a fairly prosperous set of men, so their earnings must be fairly remunerative. They confine their attention, as far as I could ascertain, pretty generally to the high lying red soil banks, between Devi Kop and the Nyamti nullah. The head Jalgar, a very intelligent old man and dexterous gold-washer, informed me that the best day's work he had ever done was the finding of a small pocket in the gneiss which contained about Rs. 80 of gold in small grains and scales. I gathered from him that he had not found anything beyond the size of a "pepite." The position of these auriferous banks near Devi Kop would admit of hydraulic mining over a considerable area by a system of dams and channels to bring water from the Nyamti (Namtee of sheet 42) nullah, but the question of the profitableness of such an undertaking could only be decided by an expert after careful examination and more numerous trials by washing.

Notes on the Kolar gold-field.

The schistose band, which bears within its limits the "Kolar gold-field," forms an elongated synclinal fold which in parts rises somewhat over the general level of the surrounding granitoid country. The dip of the rocks forming the basement of the schistose band, and therefore the boundaries of the synclinal fold, is easily traced on both sides; not so, however, is the dip of the uppermost members of the group, for all the beds exposed in the centre of the band have been much altered by great pressure which has superinduced an irregular slaty cleavage to a great extent. This, combined with extensive minute jointing, has so greatly altered the original texture of the rocks that they have assumed to a very great extent a highly trappoid appearance. The lines of bedding are completely obliterated, and it was impossible to decide from the sections I saw whether the central axis of the synclinal represents one great acute fold, or a series of minor ones in small vandykes. The great petrological similarity of the strata forming the upper (central) part of the synclinal makes the decipherment of this difficulty all the greater. The sections I saw in the several shafts being sunk at the time of my visit threw no light on the subject; it is possible, however, that a closer study of these sections would go far to enable this point to be decided.

The succession of formations seen from west to east, after leaving General Beresford's bungalow at Ajipálli on the road from Kolar Road railway station to the gold-field, is micaceous gneiss (resting on the granitoid gneiss), chloritic gneiss, micaceous schist, hæmatitic quartzite, and chloritic schist, on which rests a great thickness of hornblendic schists, which, as just mentioned, are highly altered, and have their planes of bedding almost entirely effaced by the pressure and crumpling they have undergone. The eastern side of the fold shows near the village of Urigam (Woorigum, sheet 78) well bedded schists - dipping west from 50° to 60° and resting finally on the granitoid rocks. The western side of the gold-field is very clearly demarcated by a well marked ridge of hæmatitic quartzite which culminates in the Walagamada Trigonometrical Station hill, from the top of which the majority of the mines can be seen. The bedding is often vertical and highly contorted in places. The texture varies from highly jaspideous quartzite to a schisty sandstone. The hard jaspideous variety generally shows distinct laminæ of brown hæmatite, alternating with purely siliceous laminæ generally of white or whitish drab colour. It is only here and there, and over very trifling areas, that the ferruginous element ever assumes the character of red hæmatite. The beauty of the "vandykes" and complicated crumpling and brecciations of this rock in the Walagamada Konda is very remarkable. The thickness of the hæmatitic band is very considerable and it forms the most striking feature of the western side of the gold-field. On the eastern side of the gold-field the hæmatite quartzite is much less well developed and exposed, excepting in the south-eastern part of the gold-field where it occurs in thick beds forming the main mass of the Yerra Konda Trig. Station Hill. Here the dip is about 60° westerly, and affords one of the clearest proofs of the synclinal character of the schist band. To the southward the hæmatitic beds appear to coalesce the synclinal being pinched together, but I had no opportunity of following up the eastern boundary of the schistose band. The western boundary is a very conspicuous feature, a bold rocky ridge running up into the lofty Malapan Betta peak, the highest summit in this part of the country. South of Malapan Betta the hæmatitic beds appear to lose their importance and no longer form the most striking feature of the schistose band, and micaceous and chloritic beds abound. Owing to the great extent of jungle and the rugged character of the country their general relations were not to be made out completely in the short time at my disposal. The beds run south into the Salem district, and probably occupy the valley lying east and north-east of Kistnagiri and, not improbably, extend on towards and past Darampuri. A subsidiary ridge of lower elevation, which branches off from the western side of Malapan Betta westward and then trends south-west and finally south-south-west, also consists of schistose beds of similar character, amongst which a hæmatitic quartzite is the most conspicuous. The relation of these latter beds to the Kolar gold-field synclinal fold is quite problematical, but it is very probable that several important faults have caused great dislocation of the strata first along the boundaries of the main synclinal fold. The stratigraphy of the several spurs radiating from Malapan Konda is very complicated and interesting and well worthy of careful examination.

The auriferous quartz reefs which have attracted so much attention lie in the broader part of the synclinal fold north of the railway. None of any importance were seen by me in the tract south of Malapan Betta. The intermediate tract I had no opportunity of examining closely, but I did not hear of the existence there of any of interest or importance. The reefs make very little show on the surface as a rule; in many cases, indeed, the whole back of the reef, or lodes, has been removed during the mining operations of the old native miners, whose workings were on a rather large scale considering the means they had at command. Much also of the surface is masked by scrub jungle or by a thick coating of soil, often a local black humus. The reefs are so very inconspicuous that I have not attempted to show them on the map. Their run is north and south with a few degrees variation either east or west. The hade of the reefs is westerly in most cases, as far as they have been tested by the shafts sunk. The angle they make with the horizon is a very high one, on the average not less than from 85° to 87°. Much has been said about the reefs in the Kolar not being true fissure veins, but I was unable to find any good reason for promulgating this view, and several mining engineers of high standing and great experience, as Messrs. Bell Davies, Raynor St. Stephen, and other practical miners well acquainted with the locality, have no hesitation about calling them "fissure veins" or "lodes." The quartz composing the reefs is a bluish or greyish-black diaphanous or semi-diaphanous rock, and remarkably free from sulphides (pyrites, galena, &c.) of any kind. The gold found is very pure and of good color. Several washings of crushed vein stuff were made in my presence at the Urigam and Kolar mines with really satisfactory results, the quantity of gold obtained being very appreciable. The samples operated on were not picked ones.

Position of the mines.

The principal new mines now in progress form a line stretching from south to north on the eastern side of an imaginary axis drawn along the centre of the synclinal fold, and this line coincides with that followed by the "old men," many of whose abandoned workings are being extended to greater depth than they had the power of attaining to without steam pumping machinery. The principal mines opened along this line of country are the Madras, Mysore reefs, Great Southern of Mysore, Kolar, Mysore, Uregam (Woorigun), Nandidrug and Balaghat mines, belonging to the several companies bearing those names. On the west side of the axis only one company, the Kaisar-i-Hind, had started workings at the time of my visit. The five most northerly mines of the eastern group appeared to be working on extensions of the same set of reefs.

Intrusive trap rocks.

Numerous large dykes of dioritic trap are met with traversing the gneissic rocks of this region. One set of them runs north and south with a variation of about 5° east or west. The other runs nearly east and west. The presence of these dykes will offer formidable obstacles to the mining works in some places, and it will probably be found that the intrusion of these great igneous masses has added considerably to the metamorphism of the schistose beds along the lines they traverse. As already mentioned the schists are most highly altered along the central axis of the synclinal fold, and the largest of the north and south dykes shows a very little to the east of the synclinal axis.

Stratigraphical relations of the several schist bands.

The Kolar schistose band is the only one as to the exact stratigraphical relation of which to the granitoid gneiss any positively conclusive evidence had been obtained; but there is reason to believe that at least three of the schistose bands to the westward of it, *viz.*, those of Sundur, near Bellary, of Dambal—Chiknayakanhalli, and of Dharwar—Shimoga are similarly superimposed on the granitoid rocks. Whether the superposition is a conformable or an unconformable one, is a point that has yet to be determined by further investigation; at the Kolar gold-field, however, the relation between the schistose synclinal and the underlying granite gneiss appears to be one of distinct conformity. The Hospet end of the Sundur schist band certainly presents every appearance of being the acute extremity of a synclinal basin. The south-eastern extension of this band is as yet unknown, but there is good reason to expect a considerable extension of it to the south-eastward of Bellary.

The remarkable length of the Dambal—Chiknayakanhalli and Dharwar—Shimoga bands precludes the idea that they can be each a simple synclinal fold, rather may they be expected to prove a succession of synclinals and anticlinal in echelon, with their contact boundaries not unfrequently coinciding with faults. The geographical position of these great bands confirms and amplifies the evidences to the fact which I specially pointed out in my memoir on the East Coast from latitude 15° N., northward to Masulipatam—Memoirs, Geological Survey of India, volume XVI—that the Peninsula of India had been greatly affected by tremendous lateral forces acting mainly from east to west and thrusting up the gneissic rocks into huge folds (*l. c*, p. 39). These great foldings have undergone extensive denudation, and the softer schistose beds especially have been entirely removed from large tracts of country which they must have formerly covered, if any of the bands now remaining really represent (as they in all probability do) portions of once continuous formations.

The schistose bands having only been mapped at different points their general width, as shown on the annexed sketch map, is only hypothetical, and it is very possible that at intermediate points they may either spread out or narrow considerably. Their relation to the schistose gneissics of the Carnatic Proper has yet to be made clear, and it is not at all unlikely that a third sub-division will have to be recognized in the crystalline rocks of South India—a sub-division which will include the rocks of a character intermediate between the typically schistose rocks and the typically granitoid rocks of Mysore and the South Mahratta country, namely, the massive gneissics of the Carnatic in which the ferruginous beds are magnetic, not hæmatitic.

Record of borings *for* coal *at* Beddadánol, *Godávari district, in 1874, by* WILLIAM KING, D.Sc., *Deputy Superintendent (Madras), Geological Surveys, India. (With a plan.)*

The outcrop of Barákar (coal-measure) rocks in the neighbourhood of the small village of Beddadánol is about five square miles in extent, situated on the head-waters of a large feeder of the Yerra-Kalwa, some 38 miles west-north-west of Rájamandri, and about four miles from the boundary of the Nizam's dominions near Ashraopet. The nearest large village, Gunnapawarum, lies a mile and a half to the south. It is the most southern known outcrop of the coal-measures in India; but very probably they extend further south beneath the covering barren members of the same Gondwána system, which reach in a straggling fashion to as far as Golapilli, 15 miles west of Ellore.

The Beddadánol outcrop was first detected by Mr. Blanford in 1871 (*supra*, vol. v., p. 24), and notices of the field were subsequently given by me (*supra*, vols. v. and vi., and Memoirs, vol. xviii., p. 247). The detailed record of the trial borings will be of use in future exploration; the work was executed by Mr. Vanstavern.

From T. VANSTAVERN, Esq., Executive Engineer, Public Works Department, to MAJOR J. BEATTY, R.E., District Engineer, Godavery District,—dated Dowlaishweram, 16th June 1874, No. 65.

I HAVE the honour to submit the following report on the boring operations at Beddadánol during this last season:—

The work was commenced in the latter part of February last. On arrival at Beddadánol a place was selected and boring commenced.

BORE-HOLE No. 1.—LEVEL 94 FEET. SUB-SOIL 16 FEET.

After going down to this depth came to sand and water. I tried to force down the

piping and to get the sand up with valve bucket; but this utterly failing I was, for the want of sand tools, obliged to abandon this hole and to commence another.

2nd.—SECTION OF NO. 2 BORE-HOLE.—LEVEL 100 B. M.

Sandstone	89·00
Dark clay	17·00
Shale with coal	11·00
Dark clay	1·00
Light clay	27·11
Black clay	7·00
Sandstone	4·00
Dark clay	4·3
Black clay	5·6
Sandstone	6·6
Light clay (soft)	33·9
Dark clay	6·0
Brown clay	8·0
TOTAL	229·11

water struck in this hole at 5 feet depth close to the main stream.

This hole was commenced in the out-crop of the bed of sandstone in the hopes of it being a solid bed of sandstone overlaying coal; but after getting down the full depth bored, the hole began to give considerable trouble by caving in at the soft clay; half a day was generally spent clearing out the hole before any further boring could be gone on with, and at last it became so bad that the hole could not be cleared out; it had to be abandoned, and another hole commenced.

3rd.—No. 3 BORE-HOLE —LEVEL 105 FEET.

Water struck at 44 feet deep.

Sub-soil	1·0
Gravel	2·5
Sandstone	93·7
White clay	10·0
Sandstone	39·0
Conglomerate	2·0
Sandstone	12·0
Light clay	10·0
Sandstone	51·
Dark clay	5·6
Light clay	3·0
Dark clay	2·0
Sandstone	13·0
Clay	3·0
Sandstone	8·6
Sandstone with pyrites	10·0
Argillaceous sandstone	10·0
TOTAL	274·0

The 10 feet of iron pyrites cost several days' labour to cut through.

During the working in this hole some delay occurred, owing to the breaking of the winch frames which had to be repaired before any more work could be done.

This hole when deep also commenced to give trouble by caving in.

One day it did so when the valve bucket was down, and after four hours' labour was got up with it and the rods twisted. Another attempt was made to clean out the hole, but after a whole day's work was unsuccessful and obliged to abandon it.

In this hole no shale or coal was struck, although I expected that the shale of No. 2 would have shown itself, for this reason shale in No. 2 must be of very little extent to the eastward, is either a pocket, or the sandstone beds dip more than they show at the surface. To the westward of No. 2 no borings have been sunk and no certain idea can be formed at surface of the extent of the bed of shale, but it may be naturally supposed to run in that direction according to the dip of the sandstone and the shale in No. 2 may represent the outrun.

4th.—No. 4 BORE-HOLE.—LEVEL 107.

Water struck at 65 feet depth.

Surface soil	1·6
Light clay	18·6
Conglomerate	0·6
Sandstone	47·0
Dark clay	3·0
Light clay	2·6
Red clay	19·0
Sandstone	2·0
Dark clay	13·7
Sandstone	3·5
Dark clay	12·6
Sandstone	6·0
Dark clay	21·0
Sandstone	1·6
Dark clay	7·6
Shale and coal	0·8
Dark clay	1·0
Black clay	7·0
Dark clay	2·6
Clay with mineral charcoal	5·6
Iron Pyrites	3·0
Hard sandstone	4·4
Black clay and shale	4·10
Coal	4·6
Dark clay	6·6
Hard stone	0·8

This gave also continual trouble by caving in, and took daily some hours to clean out before work could be commenced.

Coal has been struck in this hole; in appearance it is poor and could be anything but the outrun to the east. Further borings would be required to find the extent of the bed, and probably it would improve as is generally the case in these beds.

By the depth it lays at it has apparently no connection with No. 2.

The dark and black clays in this hole have all carboniferous matter in them, apparently plants or leaves, but being so cut up with the boring tools, it is impossible to determine them.

The last 8 inches in this hole took some four days' boring; the rock is very hard, and apparently metamorphous, but I have no means of testing it; a sample accompanies the clays.

From W. KING, Esq., Deputy Superintendent of the Geological Survey of India, to the HONOURABLE D. F. CARMICHAEL, Acting Chief Secretary to Government, Madras,—dated Calcutta, 12th August 1874, No. 21.

5. The result of the coal explorations so far is that four seams of coal, or carbonaceous shale, have been struck in the field; one of these in bore-hole No. 2, and three in No. 4. There is a little discrepancy between the lists of strata in the bore-holes given in

Mr. Vanstavern's report and the specimens now sent up; but practically this does not alter the case. There are four specimens marked as *coal*, while, in the bore-hole lists, they are given as "shale with coal" in No. 2, "shale and coal," "clay with mineral charcoal" and "coal" in No. 4.

6. The four specimens of coal are all dull and earthy; that from the 4½ feet seam being the best looking, the others are more or less associated with clay and shale. Nevertheless the fact remains that there are four seams with coal in them, thick and poor coal in one, and thin and poorer coal in the others. It is possible that each of these seams may be greatly better in quality and thickness in other parts of the field.

7. On a private application of Mr. Vanstavern, after I had heard that the specimens had been sent down to Madras, he sent me a sample of the lower two feet of the thick seam, which is evidently the better part of the deposit. An assay of this sample, made in the Survey laboratory by my colleague Mr. Tween, gives the following result:—

Carbon	16·4
Volatile	30·6
Ash	53·0
	100·0

As a coke

Carbon	22·5
Ash	77·5
	100·0

8. At first sight the large percentage of volatile matter indicates a fair gas coal, but Mr. Tween tells me that there must be from 12 to 14 per cent. of moisture included in the volatile element. Thus it is emphatically a poor coal.

9. The samples forwarded from Madras are evidently inferior to that assayed, and are not therefore worth examination.

10. The remaining specimens forwarded are clays, a piece of the "sandstone with pyrites," and the rock of the "last cut" in No. 4 bore-hole which, owing to its hardness, practically stopped Mr. Vanstavern, and led him to look on it as a metamorphic rock, that is, that he had reached the floor of the field. Among the clays there is a very dark grey variety, which my friend Mr. Hughes of the Geological Survey recognises as similar to some of the fire-clays he has met with in the Raniganj coal-fields.

11. The rock of the "last cut" is not really so hard as it appears to be in the bore-hole when examined as a hand specimen, and it is easily pounded down to a fine powder of clayey constitution, without any appreciable calcareous matter in it. It is a rock of brownish-green colour, consisting of minute granules of darker substance in a pale green paste, the surface being roughened with these granules; and it is evidently a form of volcanic rock approaching perlite, or perhaps an ashbed. In its mottled appearance it is not unlike "snake stone" or "Water of Ayr stone." It is impossible to say whether it is associated naturally with the sandstones and clays, *i. e.*, as a boulder, or as an intercalated bed. This can only be found out by further borings, or, as is advisable, by a further attempt to pierce it in No. 4.

I do not think it can be considered as a rock forming the floor of the coal-field.

12. As previously stated in my paper on this field, the beds are all, on the average, dipping about 10° west-south-west except in the northern part of the field, where they are N. W., thus having a strike N. N. W.—S. S. E, and then N. E., and, therefore, had the bore-holes been put down in lines starting from the eastern side of the field and going

westward, we should gradually have got through the whole thickness of strata. The work was not commenced till very late in the season, and thus I wished, if possible, to get at coal at once. With this intention, and in the hope that the river itself might hide strata in which were seams of coal, I instructed Mr. Vanstavern to begin on the river near the village. The first bore-hole was a failure. No. 2 bore-hole was then put down and carbonaceous shale was got in it; but it had to be stopped owing to falling in of clays and want of piping. To get lower than we had done in No. 2 it was necessary to look eastward, but no suitable place showed until in the nullah to the north of the village, and this would be in strata much below those examined in No. 2. Still an idea could be got from No. 3 of the lowest beds in this line, and as is shown in the list, they are all sandstones of good thickness with fewer and thinner clays than in the other bore-holes, but without the slightest trace of coal.

13. By these two bore-holes—in the line from No. 2 to No. 3—we know of 229 feet in No. 2, below which there is an unexamined thickness of strata of about 250 feet, when the beds at the top of No. 3 bore-hole ought to be reached. That is, supposing that the lie of the strata is tolerably uniform over the field and that there is not an irregular floor.

14. On seeing that No. 3 was not likely to produce any favourable result, and that it was becoming a troublesome hole, I suggested that a convenient spot should be selected to the south of the village in the nullah on that side, as I thought we should here be in the continuation of the unexamined beds between No. 2 and No. 3, and it is in these that the three other seams have been found. In other words, I expect that these seams would be found at very nearly the additional depth below the 229 feet of No. 2. This would of course be at an inconvenient depth for boring, more especially as the extent of the seams can be ascertained by other short holes.

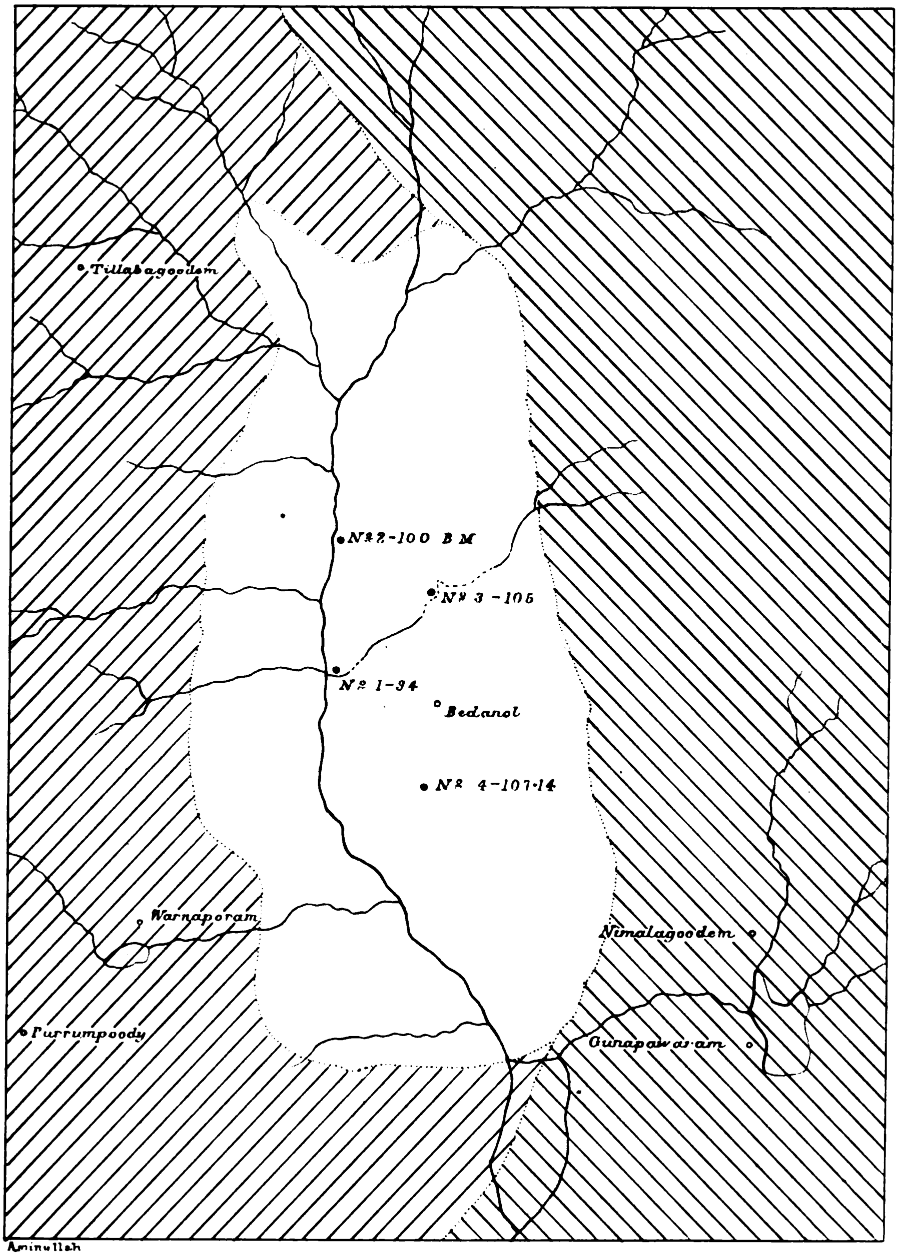
15. Bore-hole No. 4 has not yet told all that may be made from it if the hard "ash" rock can only be pierced, for there are still some few feet to be got through before reaching beds corresponding to those at the surface of No. 3. Otherwise, another bore-hole should be put down about 400 yards back, *i.e.*, eastward and in the nullah south of the village.

16. I examined the different streams in the field even more closely than hitherto, and saw that the strata seem to lie in a very regular succession at angles varying from 10° to 15°; the dip, if any thing, becoming easier to the westward of the main stream, as also to the N. W., where the beds are nearly flat and with fewer undulations, so that the thickness of the whole field is much more than I at first concluded. There is thus more room for seams over the western half of the field. Indeed, from this greater thickness I am more inclined to expect a greater extension of the coal-measures under the Kamthi sandstones of Namiapolliam to the westward.

17. With regard to the coal in these measures, that now known to exist is on the eastern edge of the field, and it is reasonable to expect that the seams go on thickening with the strata, or that there are more seams.

18. There is about the same area of coal-measures exposed on the western side of the main stream, but the strata here are all higher than those on the east side. No borings have been put down in these upper beds, but they are just as promising in their characters as those below. Indeed, my colleagues who have worked in the other coal-fields of India have observed that seams are more prevalent in upper beds of the Barákars. The lie of the strata on the right bank of the river is also somewhat easier, so that if coal be found on this side the probability is that the trial borings will not vary much in depth as they are carried out further west or north-west.

19. It is, however, very premature as yet to try and reckon on what may be from the few indications obtained so far; for where, as is evidently the case here, there is only an outlying patch of the coal-measures, not an area left so much by denudation as merely the



BEDANOL COAL FIELD, BORING SITES.

Kamthi — Barakar — Gneiss.

Scale 1 Inch = 1 Mile.

filling in of a detached basin by a formation which was existent only in an attenuated condition, the occurrence of coal to a greater or lesser extent in each patch is a question attended with a great deal of uncertainty. There may be only a few seams as at Kamarum, or many seams as at Singareny in the Nizam's Dominions; or seams hardly any of which are continuous in different bore-holes as in the British field below Dumagudium.

20. The main and first thing to be done now is to continue No. 4 bore-hole, or to sink a fresh one to the eastward of that, as suggested above, and then to work down the nullah to the main stream; after that, the nullah on the other side of the field higher up the main stream, and coming from Namiapolliam, ought to be tried. This latter examination would tell if the poor seam in No. 2 hole is of any extent. It would certainly be premature to try any of the ground south of the tributary nullah near bore-hole No. 4 until more is known concerning the succession of the seams now struck.

21. In conclusion, it is necessary, from my views of the relations of the strata in this field, to remark on two passages in the Government Order, No. 1953 of the 21st July. It is therein stated:—"But the very slight indication of shale and coal found about 30 feet above the coal deposit in No. 4 may be analogous to that of No. 2, with which it agrees in the strata immediately over and underlying." My observations do not bear out this analogy; for unless unforeseen accidents—of which there is no indication in the adjacent nullah sections—have interfered with the normal position of the strata, everything seems to lead to the conclusion that the beds of No. 4 are lower than those of No. 2. Besides, if the upper seam in No. 4 be analogous to that of No. 2, it is difficult to account for the non-occurrence of the 4½ feet seam in No. 2, which is the deeper bore-hole.

22. There is then the further statement that "the conclusion arrived at to bore next season to the south and west seems a correct one." On this point it will be seen from this letter that I do not advocate such a procedure, but to keep for the present rather to the north and north-west as soon as the west side of the field is taken up. But, apart from this, I would respectfully submit that a conclusion as to the future sites of bore-holes ought more properly to be based on the recommendation of the Geologist, as long as he is not absolved from the office of advising, as to the possible *locale* of the coal. In this, however, it is not for a moment implied that there is any likelihood of a difference of opinion between Mr. Vanstavern and myself on the mode of pursuing the work; on the contrary, I have to thank him for having always so willingly co-operated with me.

Note on the supposed occurrence of coal *on the* Kistna, *by* H. B. MEDLICOTT, M.A., *Geological Survey of India.*

The Records of the Geological Survey of India would be incomplete without some mention of the reputed discovery of coal near Jaggayapet, in the Kistna District of Madras, that has so often within the last thirty years been urged upon the notice of Government by General Applegath. It has this year been brought forward again with unabated confidence; and the following Note upon the question was drawn up for the information of the Government of Madras. It affords a curious contemporary illustration of science *in excelsis*.

1. I have the honour to acknowledge receipt of your letter No. 230 E., dated 13th June 1882, forwarding for remark a letter, dated the 19th May, from Major-General F. Applegath, on the subject of his alleged discoveries of coal in the Kistna District. I had already noticed in the newspapers, English and

Indian, the revival of the Kistna coal question, and I am glad of this opportunity of submitting some remarks thereon for the consideration of the Right Honourable the Governor of Madras.

2. General Applegath must believe that the patience of the Madras Government is inexhaustible, and well he may; for surely, since the dawn of science, no claimant to discovery has anywhere met with so much indulgence as he has from his Indian masters. Time after time has he found favour and encouragement, after repeated demonstration by most competent authority that his assertions and promises were baseless, and after repeated failures on his part, with liberal aid of public money, skilled labour and appliances, to verify his assertions. It is no wonder that he should now again come forward in bolder form than ever. I must confess that, to the qualified and responsible ministers and advisers of Government in these matters, any further countenance to such pretensions would be "heart-breaking."

3. I will presently give an abstract and analysis of this remarkable case: it is desirable, first, to clear the question of irrelevant matter, and to fix attention upon what has been the mainstay of so much discussion. It is not to be believed that the Government or the public would, for a moment, place the judgment of one so completely uninstructed in such matters as General Applegath, that the rocks of the Palnád belonged, in whole or in part, to the already established coal-formation of the Peninsula, in competition with that of the Geological Survey, that they were all of Transition or Lower Vindhyan age, the two being as widely separated stratigraphically as are the Jurassic and the Silurian systems of Europe. The "fossils" sent by the General in support of his contention were not fossils at all; and his rock specimens scarcely bore any resemblance to the standards to which he referred them. The occurrence of coal in those older rocks would, of course, be an independent question; and although a very extensive survey of them in that very field and in other parts of India had revealed no trace of a coal-measure group, there would still remain the possibility of a local deposit. The question is thus brought within very definite limits of fact, and it would never have taken shape but for General Applegath's assertion, that at a particular spot, within 20 feet of the surface, he had once upon a time quarried coal and burned it.

4. To any one whose ideas on the subject were not altogether in the air, nothing could be simpler than a complete verification of such a statement. It is practically impossible that several tons of coal could be extracted and leave no trace to tell the tale; yet with every appliance of tools and skilled labour, funds and time, General Applegath has never again been able to produce an ounce of any substance that would support combustion. He has, however, never ceased to reiterate his assertion; and his confidence has imposed upon others no better informed than himself; the strong wish for the realization of his assurance being on both sides the efficient motive of assent. It is a striking instance, and an instructive caution, upon the persuasive influence of unflinching testimony in a credible witness, for no one that I know of has ever cast a suspicion upon General Applegath's truthfulness.

5. In its successive orders giving sanction and encouragement to General

Applegath's explorations, ignoring its own previous adverse decisions upon the case, Government did not, of course, give reasons for so doing; but we may safely take these to be the same as those that guide public opinion in the matter. In a Calcutta daily paper of the 28th March last, *à propos* of General Applegath's recent manifesto, it is said: "This case of coal in the Kistna District is probably another instance in which practical men have been ahead of the geological theorists." Nothing but the diffusion of knowledge can remove the popular delusion that is revealed in this sentence; but as it contains the only approach to direct argument that I have seen, it is of practical importance to point out that the instance referred to as parallel is of a wholly different nature. It refers to the discovery of the coal measures in the north of England by deep sinking through newer over-lying formations. The writer of the article implies that the geologists were false prophets on that occasion, and no doubt the pit-sinkers were practical men; but in the Indian case the facts are all above board; the rocks at the surface in the Palnád are immensely older than any known coal-measures, and the only evidence to warrant any outlay on exploration is General Applegath's assertion that he once quarried coal there within a few feet of the surface. Surely a practical man would require the General to make good his assertion before starting on, what would otherwise be, a wild-goose chase.

6. The acts and arguments referred to imply more or less of credence in General Applegath's frequent animadversions upon what he takes to be the carelessness, the contradictions and the obstructiveness of the Geological Survey. I do not care to exhibit the ridiculous misunderstandings upon which such remarks have been based. Too much time has already been wasted over this tiresome business, and I have shown that the whole question turns upon a simple matter of fact. The supposition that a body of professional men could be so infatuated as to pooh-pooh a project founded on so circumstantial a basis, which, if true, must inevitably be presently substantiated, is only further evidence of the hazy view taken of the conditions. Until this ground had been visited, the Survey gave every encouragement to the investigation. It has been said that Dr. Oldham's visit to the Palnád, in company with General Applegath and others, was made in a perfunctory manner. But this, again, is unfair. Dr. Oldham went to see all that General Applegath had to show regarding the existence of coal, and finding no vestige of real evidence, it would have been foolish of him to sit by while a boring was made in slate, on the chance of unearthing a coal-seam. Dr. Oldham officially and publicly (Madras G.O., No. 1125 of 27th April 1868) denied the statement that anything like "burnt shale" or "burnt outcrops," or "a substance rich enough to support combustion," had been seen. Since then, and before it, General Applegath has had ample means and leisure given him to make good the statement that he had once burnt coal extracted from the site in question, but all his endeavours have been in vain.

7. As it is not a ghost story, some intelligible explanation of the mystery must be forthcoming. The most likely one was suggested by Dr. Oldham, that to please their master, the natives had put some real coal in the hole and produced it for his satisfaction. A hoax of this kind was shortly after successfully practised upon Dr. Oldham himself, and all the officials concerned, in

the famous case of the Midnapur borings.[1] In the Kistna case, however, there was hardly room for this without culpable blindness on the part of the victim, for the excavation is said to have been a shallow drift, and accordingly General Applegath repudiated the "insinuation," averring that he had himself conducted and seen the operations, and repeating his statement in the following emphatic and expanded form:—"I adhere to my assertion that I have actually quarried and burnt coal in large quantities on the spot, as much as eight or ten tons"—(Madras G. O., No. 606 of 7th March 1868.) There thus remains a cut-and-dry choice between a physical anomaly (amounting to impossibility) and a case of mental delusion, such as is unhappily of too common occurrence in history. In going through the documents for the present, I hope final disposal of the case, I have been greatly struck by the fact that General Applegath's assurance becomes clearer and stronger and larger as the event recedes in time.

8. The oldest papers I have on the subject are a manuscript map and two sections, with a brief list, all signed "F. Applegath, Lieutenant, Assistant Civil Engineer," and dated "Camp Moogetalah, 18th December 1850." The map is entitled "Plan of the Marble fields near Jaggiapetta on the Kistna and Pallair Rivers," and, with the sections, it is coloured geologically (after a fashion). There are five pits marked on the plan, and the list annexed is headed "Description of the pits, &c., that have been sunk in searching for coal." One of these pits is at the very place assigned for the coal discovery, on the left bank of the Pallair, about half a mile above its confluence with the Kistna. This pit is figured on one of the sections to the full depth ever said to have been attained there, and the only legend is—"shaft 20 feet through slate, with a soft material below, thickness unknown." In the List the same is described as—"Pit No. 3, shaft sunk 20 feet through slate, small but distinct traces of vegetable deposit at the lowest excavation, and a soft, white deposit at the bottom of the shaft, thickness unknown." In these original documents the word "coal" only appears in the title of the List as a desideratum; the rock in the pit being correctly noted as "slate." The date usually assigned by General Applegath for his discovery of coal is 1851, so it might be surmised that these notes are anterior, and not to the point; it seems not improbable, however, that they represent the total result of his operations before going on leave, when he reported his discovery to the Court of Directors, and, before leaving, to the Madras Government; for the map is endorsed "Lieutenant Applegath's supposed coal sites; from Walter Elliot, Madras C. S., August 1851." If this be the case, there would be no escape from the

[1] An European convict was employed as brace-headman on a boring for water in the Central Jail at Midnapore. The place stands on a spread of laterite connected with the old alluvium occurring as a fringe between the Gangetic delta and the upland of gneissic rocks. At a depth of 148 feet coal was reported to occur for a thickness of more than two feet. Samples were sent by the Executive Engineer to Calcutta to Dr. Oldham, who pronounced the coal to be good, and indicated sites for other borings to test the extent and the lie of the supposed seam. In these, also, the coal was brought up from appropriate depths. This took some time; meanwhile the convict, having completed his term, was awarded with a post of some trust in charge of the work. As matters were coming to a crisis and more extensive operations about to be taken up to work the coal, the ex-convict took the occasion of an advance of cash to disappear from the scene of his exploit, and no trace of him could be discovered. The imposition was then brought to light.

judgment that the quarrying and burning of coal must take rank as a myth: so important a piece of evidence would certainly not have been left out in the contemporaneous account. No doubt many tons of the black slate were excavated, and nothing is more likely than that some pieces of it were put into a good camp fire, after which ordeal they would bear a tolerable resemblance to ash, and such may have been the small basis of fact which has grown so portentously. The samples of this stuff deposited at the Madras Museum would excusably have been thrown out as rubbish.

9. The next evidence tends to confirm this view. It consists, again, of a coloured map and sections, with a report entitled—"Captain F. Applegath's description of the geological strata on the north bank of the Kistna," dated Madras, 28th of April 1861. In this the same shaft, apparently, is referred to (here marked as No. 1), thus:—"An attempt was made some years ago to sink No. 1 shaft for coal through the red shale in the southern part of these fields; the red colour appears to be superficial, for, at a depth of 10 or 15 feet, the colour changes from red to greenish grey, and blue, and sometimes black. * * * * This occurred in 1851." There is no specific mention of the horizontal drift, 17 deep, from which, in later accounts, the coal is said to have been obtained, but I here find, for the first time, a notice of this circumstance, and only in a casual way, as a by-gone event, and as secondary to what is considered more important observation, thus:—"The limestones, shales, sandstones, and the fossils found, all tend to confirm and strengthen the belief that these rocks of the Kistna are of the age of the Indian coal-bearing strata; moreover, the bituminous rock that I quarried and burnt contained upwards of 30 per cent. of carbonaceous matter." The authority for this determination is not given, but it at least fixes a maximum value for the "coal" of later statements. At all events, in a concluding summary of the case, this point is left out of count, and the whole question stated as problematical—"All that has hitherto been done has been at private expense, and thus, for eleven years, the suggestion of the probability or the reality of there being coal on the Kistna has been a source of anxiety of mind on one side, with incredulity on the other, and therefore it is a question still to be decided on its own merits; at least, I think, there is presumptive evidence of the fact of the existence of coal on the Kistna, for, in Bengal, the arenaceous shale with fibre-like impressions of plants is coal-bearing, also blue shale, and at Nagpore the greenish-grey shale overlies bituminous shale and coal, the same in Bengal."

10. After this, the enquiry took a more official form. In August 1866, Major Applegath submitted a memorial to Government, soliciting aid for further exploration, again urging the identity of the rocks with the Indian coal-measures, but the "myth" now takes distinct shape, thus:—"I here most distinctly state that, on the occasion of one of my visits to the locality I have described, on the Pálár and Kistna Rivers, I burnt, in several large heaps, the coal I had quarried, and that I even carried some and burnt it in the Sherehomedpettah Bungalow compound. I believe that not less than nine or ten tons were quarried and burnt, and that while burning it gave out great light and intense heat, and, except that it was much heavier, it was not unlike the Torbane hill mineral." Due mention is, however, made, of failure to re-discover that combustible rock:—"Having once quarried and

burnt the coal on the Kistna, I am not discouraged by my recent failure to reach the coal, and this dear-bought experience will prove invaluable in the next attempt. I am confident that coal exists there, its extent and thickness it is impossible at present to estimate." This application was referred to Dr. Oldham for opinion. Dr. Oldham deprecated boring until some fair evidence of the probability of coal being found should be established, remarking that "it would appear only reasonable to expect that Major Applegath should be able to show where he had quarried the coal, and the expenditure of very few rupees, not one-hundredth part of what borings would cost, would in a few hours prove the existence or non-existence of any bed of coal." He offers to arrange for a geologist to visit the ground in company with Major Applegath. This visit took place in January 1868, Dr. Oldham going himself. He was accompanied by Colonel Applegath, Mr. Stuart, Assistant Collector of the district, and Mr. C. Oldham, who had been for some time engaged upon the examination of the same rocks further to the south. In the report of his observations Dr. Oldham remarked: "After this careful examination, I regret to report that, in my opinion, there is no ground for any hopes whatever of coal being found within this area. The rocks are all of types well known, and covering a very large area of the Cuddapah and Kurnool Districts, and in no respect that I could see do they, in this part of the country, offer any feature which would induce one to suppose that there was a greater probability of coal being found here than at a thousand other localities within the very extensive area over which similar rocks extend to the south, and at some one of which it would, I think, certainly have become known did it exist." As no more of the so-called "coal" or combustible rock could be found, the suggestion is made that it may have originally been provided for the occasion. In General Order No. 590, dated 5th March 1868, the Government of Madras accepted this report as proving, beyond all doubt, the non-existence of coal in the valley of the Kistna.

11. At this juncture the episode of the Midnapore coal adventure occurred, raising sanguine hopes that coal might be found anywhere. In April 1870 a memorandum was forwarded by the Madras Government, urging further search in that Presidency, saying there seemed no reason why coal should not be found beneath any of the vast tracts of laterite in Southern India as well as at Midnapore. Dr. Oldham (being then under the deception as to coal at Midnapore) gave a reasonable answer (June 1870), explaining the different conditions—how all the measures of the Raniganj coal-field passed eastwards under the alluvium of the Ganges delta, and how impossible it was for any one to say how far they might or might not there spread out to north and south on the buried slopes of the gneissic upland; that there were no analogous circumstances in the lateritic regions of Madras, &c. But all this was as moon shine to the promoters of such a scheme, and a profound distrust of geological insight remained; nor was faith restored when the fiasco of the coal at Midnapore was made known, for had not the geologists been taken in just as others.

12. General Applegath was not slow to take advantage of these favourable conditions. In July 1870 he applied for a grant of money and a detachment of Sappers and Miners, equipped with boring and blasting tools for exploration in the

Kistna District. The geological affinities of the rocks were not referred to, the one tempting assurance given being that he had once seen coal quarried and burnt in large quantities in that district. Approval and sanction were at once accorded (G. O., No. 1024, 15th August 1870). When the two months allowed were nearly expired, an extension of time and an additional grant were asked for on the following plea:—"The Sappers have to this date been employed in opening out the rocks; and as some of the pits are now 25 and 30 feet deep, I am enabled to offer an opinion on the probability of finding coal in this district; and, after a very careful comparison of the Kistna rocks with all the other coal-bearing districts in India, I am most decidedly of opinion that their representatives are found in this locality—I do not mean on the surface of the ground, but that they have been excavated by the Sappers in the present investigation. I have, therefore, to express my firm belief in the existence of coal here, and the prospect of obtaining it very shortly from one or more of the pits now being made by the Sappers and Miners under my charge." The request was at once granted (G. O., No. 42, 11th January 1871). The total results of the explorations were submitted in a paper headed "Conclusions," dated 16th February 1871. There is no allusion even to the non-discovery of anything combustible, or to the sanguine hopes so recently expressed regarding coal. There is nothing in the paper but a rambling discussion of a collection of the rocks, attempting to identify them with the Indian coal-measures. Colonel Applegath was thanked for his exertions, and the specimens were ordered to be sent to the Geological Department for opinion (G. O., No. 336, 15th March 1871). Dr. Oldham's memorandum (12th May 1871) on these specimens gave a complete demonstration that Colonel Applegath had no rational idea of what he attempted to describe, and pointed out the utter waste of investigations so conducted.

13. In this interval the survey of the great basin of the Cuddapah and Kurnool rocks, of which the Palnád forms the northern extremity, was completed by M. M. King and Foote, as published in Volume VIII, pt. 1, of the Memoirs (June 1872). There had been some discussion as to whether some beds in the Palnád should be placed in the Kurnool or in the Cuddapah series of transition rocks; but no possibility presented itself of any belonging to the Gondwana system, although, of course, the Surveyors were fully informed of the coal controversy. This transition basin is the area which General Applegath now presents as likely to become the largest coal-field in India. From there Mr. King went northwards, and at once identified the coal-measure rocks in the Singareni field, and found coal there.

14. Nothing daunted, and absolutely impervious to professional criticism, General Applegath, in September 1873, submitted to Government another map and description of the Jaggayapet District, with suggestions for further borings for coal, and remarks on some diamond strata in the neighbourhood. It is simply a repetition of all the old fallacies and assertions,—giving names to the imaginary fossils, and impossible correlations to the rocks, with heroic composure, as if nothing had ever been said to the contrary. The maps and notes were ordered to be printed and circulated; twelve copies to be furnished to Colonel Applegath, with the best thanks of Government for the valuable

information they afford (G. O., No. 1020, 30th September 1873).[1] I happened at the time to be officiating for Dr. Oldham, and I was called upon by the Government of India for any remarks I might have to offer. My answer may not have been forwarded to Madras. In March 1874 I submitted to Government a detailed note on this map by Mr. Foote, who had surveyed that ground; his remarks would satisfy any one having some knowledge of geology. In April 1874 I had the pleasure of an interview with Colonel Applegath, on his way through Calcutta, prior to leaving India. He informed me there was a proposal on foot for a renewed search for coal in the Palnád by the Public Works Department; and as he expressed himself satisfied in every way with this arrangement, I got him to mark on his own map the spots at which he most desired borings to be made. In the hope of putting an end to this tiresome craze, I forwarded these indications to Government, recommending that the borings should be undertaken when Mr. Vanstavern could be spared from the borings in the Bedanól coal-field in the Godávari district. Mr. Vanstavern's account of his operations was submitted by the Superintending Engineer, Major Hasted, R.E., in whose report the following remarks occur:—"The instructions conveyed have been fully carried out, and even more borings than were directed have been made. Mr. Vanstavern remarks that 'no coal-bearing rocks nor outcrops of coal or any combustible matter was met with,' and expresses his opinion that 'by the nature of the rocks there certainly cannot be any coal.' It is with some regret that I am obliged to express my entire concurrence in Mr. Vanstavern's views, but the explorations have been so complete, that I feel sure if coal existed at all in these places, some signs of it must have been discovered. The borings have been made as close as possible to the pits dug by Colonel Applegath, and in every instance have been sunk considerably below the bottom of the pits; in addition to this, Mr. Vanstavern, at my request, cleared out the horizontal shaft in which it was understood Colonel Applegath found something resembling coal which he was able to burn, but nothing was met with except shale. I am puzzled to know what the substance was which Colonel Applegath supposed to be coal, but some of the stuff brought up from the borings, which is described as 'black clay shale with graphite' and 'dark brown clay' might, it appeared to me, be supposed to be taken from the immediate neighbourhood of coal. My own opinion is of little value, but I am anxious to state that I watched the operations with much interest, and was rather predisposed to think Colonel Applegath's views were correct. I believe I may say that, up to a certain point, Mr. Vanstavern seemed to agree with me; but after several borings had been made, and the country round explored, he informed me that he had little or no hope of finding coal." On this report, His Excellency the Governor in Council declared himself to be quite satisfied as to the completeness of the investigation carried out for the exploration of Colonel Applegath's supposed coal-field on the Kistna (Madras G. O., No. 761, 18th March 1875).

15. Not so, however, General Applegath; as, indeed, might have been expected from the obduracy he had formerly exhibited in the face of previous ample refutations by himself and others. In the letter under reply and the annexed

[1] See *supra*, Vol. VII, p. 3.

statements made before the Society of Arts,[1] as well as in the newspapers, General Applegath protests against the insufficiency of this examination, and declares his position as a discoverer of coal in Madras to be unshaken. His words imply that these trials were made by the Survey Department, but that is an error; no Survey Officer went near them; they were made by officers of the Public Works Department, who declare their initial persuasion to have been favourable to his view. As already stated, I do not notice General Applegath's frequent and now recurring misrepresentations of quotations from the reports of the Survey, as they evidently proceed from his complete ignorance of the subject; but it would be impossible to make a like excuse for his misrepresentation of the simple facts of these trials. In a letter to the *Madras Mail* he says: "I was in England at the time these borings were made, and so I could not have selected the sites." This is something more than a *suggestio falsi;* the indication of sites for borings by marks on the map of ground well known to the marker is a completely recognised act of professional responsibility. He objects that at one of his localities three borings were made, only to depths of 7, 8, and 23 feet; but he omits to mention that all three came upon metamorphic rock. He objects that all the places he had recommended were not explored: this would indeed have been a trial of patience, and a culpable waste of time after the principal places, those selected by himself, had proved complete failures; one of these indeed should have sufficed, the one where coal was said to have been once extracted. Four borings were made at this spot, all deeper than any of the original pits; but what is most important, the actual drift from which the supposed coal was obtained was opened out and explored, but no vestige of combustible matter was found. The General offers no remark upon this collapse. I have no doubt whatever that a jury of practical men would give an unanimous verdict of 'proven' against General Applegath's coal in the Palnád.

16. One very interesting observation in General Applegath's remarks to the Society of Arts remains to be noticed, as it throws much light upon the mystery that attaches to this romance of coal on the Kistna. I pointed out at the beginning that the General's *cheval de bataille* throughout the whole contention has been his assertion that, once upon a time, he had quarried and burned coal on the spot where now it has been shown no coal exists. But for this unmistakable evidence he would never have been listened to; in fact, he did not obtain a practical hearing until he mounted this charger in full panoply. In the original contemporary documents (1850) there is no mention of this discovery; in the unofficial report of ten years later, it is casually quoted as a combustible rock having 30 per cent. of carbonaceous matter; but in the official memorial of 1866 it has become coal giving out great light and intense heat. This is the familiar process of genesis of the myth; and such I take General Applegath's coal to be. In paragraph 7 of his "Record of the Kistna Coal" (from the Journal of the Society of Arts) there is another very neat and instructive example of the same kind of performance; the old steed having broken down, a fresh one is trotted out from the depôt of memory. Of the black clay from Mr. Vanstavern's boring

[1] April 28th, 1882, on the occasion of Professor V. Ball's lecture on the Mineral Resources of India.

No. 6, it is remarked: "I believe that this black stuff is coal that has been partially burnt, as it has the appearance of coke, or burnt coal, and, under a magnifying glass, it presents every appearance of coke, or burnt coal, and, when ignited, *burns like a coke fire.* It may even be a natural bed of coke." The italics are mine. I am not aware that any of this clay was sent to General Applegath, but that would not signify; it is assumed to be the same as some black stuff he had once thrown into a fire and beheld to become red hot. The General evidently "walks by faith:" in a letter to the *Overland Mail,* refuting the conclusive evidence of Mr. Vanstavern's borings, he remarks: "Quite on the contrary, the very important question of coal or no coal near Juggyapettah may (D. V.), I believe will, be definitely settled in the affirmative, if a little trouble can now be taken by the authorities in Madras." It would be sacrilegious to gainsay this final appeal to Providence, but I think the game is played out.[1]

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THE AUTHOR.

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THE AUTHOR.

[1] The Government of Madras (G. O., 15th August 1882, No. 2096 W., Public Works) has decided not to re-open the question.

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