RECORDS

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GEOLOGICAL SURVEY

of

INDIA

Vol. I - II

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PREFATORY NOTICE.

During the progress of an extended and systematic survey like that which is now being carried out by the Geological Survey of India, it necessarily happens that information is obtained regarding districts, or minerals, or fossils, which, though imperfect, is still of much value, and which forms a link in the chain of evidence tending to establish the age or character of the several groups of rocks or formations in this country. It has hitherto been impossible to give these isolated facts publicity, as it would obviously be inconsistent with the scheme of the 'Memoirs of the Geological Survey of India' to publish in them detached facts, or minor sketches, only in anticipation of the more finished and detailed descriptions which it would be practicable to give a little later. In several cases, however, to wait for this more full and complete description would be tantamount to waiting for many years. The area of the Indian Empire is so immense, the staff of the survey so limited, that the detailed work of each successive season makes but a very small inroad on the country yet unvisited; while the almost total ignorance of the geological structure of India under which we suffered until within the last few years made it both difficult to anticipate the importance of such isolated observations and impossible to attempt to reduce them to any general system.

The conditions of the case, however, appear to me now to have undergone sufficient alteration to justify, and even to demand, a more rapid publication of such facts, though they may be isolated and imperfect. There are also many other matters, essentially forming a portion of the labors and of the progress of the survey, of which the public may fairly, as I think, expect a knowledge up to the latest practicable date.

It is therefore contemplated to issue independently of the "Memoirs of the Geological Survey of India," and of the "Palæontologia Indica," a separate series which shall bear to these Memoirs somewhat the same relation which in learned societies, the 'Proceedings,' 'Sitzungsberichte,' 'Monatsberichte,' 'Bulletins,' &c., do to the larger and more important 'Transactions,' 'Memoirs,' 'Abhandlungen' 'Denkschriften,' &c. This series will contain a notice of the current work of the survey up to date; a list of contributions to the Museum or Library; a list, and occasionally an analysis, of such books published elsewhere

as bear upon Indian Geology; and, generally, of all facts illustrating the immediate object of our researches, which may from time to time come to our knowledge.

This series will be issued of the same size and general form as the 'Memoirs,' so that it may finally be bound with them, forming a second part of each volume. It will be paged separately, and printed economically so as to be saleable at a very low price; excepting in special cases, it will not contain any illustrations, which in this country are always a source of great delay and cost, and so far as practicable, a part of this series will be issued at intervals of three months. These parts will vary in size as the matter available may vary, but within certain limits the portion referring to each year will be kept nearly of the same extent.

The present is the first issue of these 'Records,' and must be looked upon as an experiment, which will only be continued in the event of its being found really useful.

T. OLDHAM,

Supdt., Geol. Survey of India.

CALCUTTA, *June* 1868.

RECORDS

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GEOLOGICAL SURVEY OF INDIA.

No. 1.] 1868 [June

Annual Report of the Geological Survey of India and of the Museum of Geology, Calcutta, for the year 1867.

The adoption of the ordinary calendar year, from the 1st of January to the 31st of December, as the period to which the annual reports of the Geological Survey of India should in future refer, while the report of last year extended to the close of the financial year, or the 31st of March 1867, necessarily restricts the present report to only nine months out of the twelve. For convenience, however, it may be desirable to consider it as including the three months at the commencement of the year also.

During the past season, the number of the officers of the Geological Survey actually at work has been considerably reduced, by absence on leave, and by other causes. At the commencement of the season Mr. Wynne was still absent on medical certificate, and only rejoined on the expiry of his leave towards the end of the year. Mr. W. Theobald left India on furlough after a continuous and useful service of eighteen years without absence, and he has not yet returned. Mr. F. Fedden obtained six months' leave, and being delayed in rejoining by stress of weather, has since obtained one month's further leave, rejoining at the beginning of December. Mr. R. B. Foote was compelled by ill health to leave rather suddenly in May last, and is still absent. Mr. Tween also, who was in charge of the Museum in Calcutta, was compelled to leave on medical certificate, and is still absent.

Further, Mr. W. T. Blanford was appointed to accompany the Abyssinian Expedition as Naturalist and Geologist. And Mr. H. M. Ormsby officiated as Professor of Physical Science at the Presidency College for six months, during the temporary absence of the Professor.

The working staff has, therefore, been much fewer in number than usual, and the progress made in the geological examination of the country has been proportionally curtailed.

Taking advantage of this reduction of numbers, and the comparatively lighter amount of work in the office, and very desirous of obtaining for the labors of the Geological Survey in India the vast advantages which must always result from an actual comparison of specimens and from the study of such original series as can never be hoped for in this country, I obtained authority to proceed to Europe for a few months during which the climatal conditions of this country prevent the possibility of field-work being carried on. Taking with me Dr. Ferd. Stoliczka, Palæontologist to the Survey, we accomplished much, and returned to India at the beginning of December.

With these few preliminary remarks, showing the diminished strength of establishment with which the Geological Survey has been working during the past year, I shall notice in the usual order the progress made.

Bengal and Upper Provinces.—In the last report I briefly noticed the reconnoissance of the country lying south of the districts which were under detailed examination near Ranigunj and Hazareebagh, and extending westwards to the south of the Rewah country, including a large portion of the great drainage basin of the Mahanuddi. Proceeding from Ramghur to Ranchi, and thence to Pertabgurh, Mr. Medlicott found the greater part of the road to extend over the undulating highland region of Chota Nagpore. About 30 miles east of Pertabgurh,

there is a decided ghât or sudden descent into the wide valley of the Mohun, where the far stretching view over the low plains at once suggests a change in the nature of the rocks; there, in fact, comes in a portion of the great central area of the rocks associated with the coal-bearing series of India. The road itself, excepting in one or two spots where the newer formations still exist, runs upon crystalline rocks, keeping to the north side of the Mohun valley; although westwards from Burwah, the upper members of these newer formations had been noticed capping some of the hills of the upland area, in one case themselves capped by trap.

These rocks extend from Pertabgurh to the Husdoo, through Bisrampur (60 miles), here and there varied by a tongue-like extension of the crystalline rocks, forming prolongations in most cases of hills lying to the eastward. Many of these hills by their outline show that the crystalline rocks extend to their summit, while others form table-lands, on the scarped edges of which the white sandstone is conspicuous. These scarps admirably exhibit the very unequal surface of deposition on which the sandstones were formed. From the Husdoo and the plains of Belaspur, the main mass of the crystalline rocks, which greatly predominate, lies to the north-west, forming the hilly region of Mahtin, while the numerous and almost detached areas of the secondary rocks (chiefly of the Talcheer series) are extensions from the eastwards, where the table-topped hills of Odeypur appear to be formed altogether of the sandstones. With this extension of that series of rocks is connected the small coal basin of Koorbah. On the Mahtin hills themselves a few remnants of the upper sandstones stand up like old fortresses on the highest summits.

Over the area lying between the Koorbah coal-basin and the plains of Belaspur, there is no continuous high ground. Isolated ridges, mostly of inconsiderable elevation and composed of the crystalline rocks, occur.

In this region of the Mahanuddi, as also in that of the Godavery drainage basin, the only knowledge we had of the structure of the country was derived from the Revd. Mr. Hislop's exertions; he had, however, confounded rocks belonging to two distinct series, between the deposition of which there had been an immense interval of time. The great plains of Chutteesghur were colored as belonging to the same series as the coal-field of Koorbah. In reality, however, the rocks belong to that very much older series to which the general name of Vindhyan has been given. These cover an area of more than 12,000 square miles, limestone being the prevalent rock. On the north, they abut against the crystalline rocks; on the west, they pass under the Deccan traps; to the south-west, they stretch to an unknown (as yet) distance up the valley of the Mahanuddi; to the south-east, they rest upon crystalline rocks; and to the east, they are crushed up with, and upon, similar rocks in a complicated manner. The more recent Talcheer rocks are filled with debris from these, but nowhere was the actual contact or superposition visible.

The Talcheer rocks extend from the Odeypur district to very near Sumbulpur. The country towards Gangpur from Chaibassa is now being examined in detail, so that it need not be more specially alluded to here. At Chaibassa itself there is the junction of the newer submetamorphic with the gneissose rocks. There is also a grand exhibition of trappean intrusions, which, it is noteworthy, occur with vastly greater frequency in the granites than in the slates.

This extended reconnoissance of Mr. Medlicott's will prove of very great value when we are able to extend our detailed researches into this vast area.

The Hoharo or Karunpoora coal-field was completed in the early part of the year by Mr. Hughes. This, as stated in my report for last year, is of considerable extent, covering an area of not less than five hundred square miles, but it is poor in coal, few of the seams promising well. Iron is largely smelted within this area, nearly 200 small native furnaces being still at work. Later in the season Mr. Hughes completed the examination of the South Karunpoora coal-field, also of considerable superficial area, and at the same time richer in coal.

We have unfortunately been unable to obtain maps so as to enable us to continue and complete the examination of the coal-field of Palamow, lying to the west of those just alluded to. We had commenced this last year, and in full hopes of being able to proceed steadily to the completion of its examination. It is highly important to obtain some trustworthy information regarding the prospects of good fuel being discovered there, especially in connection with the proposed execution of the Soane canals. As soon as maps are available, the geological examination of the field will not take long.

The smaller and comparatively valueless field near Eetcoora has subsequently engaged Mr. Hughes' attention, and it will be quite completed before the present season is over.

Last year I noticed the serious interruption to the continuity of our work in Manbhoom caused by the maps not being ready for issue. To prevent a similar stoppage during the present season, I obtained, at considerable expense, tracings of all the maps required to complete the area, and join on to the Topographical Survey work to the south. Since the early part of the year, therefore, Mr. V. Ball has been engaged in the Manbhoom country, steadily carrying his geological lines southwards: while Mr. Ormsby has been carrying the boundaries in the adjoining country to the south and to the west, and near Ranchi. Mr. Ball appears to have established some interesting facts as to the connection of special groups of rocks with certain kinds of mineral wealth.

Mr. Mallet has been engaged principally in the neighbourhood of Jhansi and Lullutpore, tracing out the geological boundaries in the country included in the northern portion of Sheet 70 of the Indian Atlas. Mr. Hackett similarly has been steadily carrying his geological lines southwards from the Gwalior country, using as the basis of his researches the admirable maps of the Gwalior and Central India Topographical Survey.

Mr. Wilson is similarly engaged in a detailed examination of the Saugor district, and of the country lying between that and Jubbulpore. This had been very cursorily visited before, but when no maps existed: now we have the excellent maps recently issued of these districts.

Mr. Blanford's labors during the few months at the beginning of the year have been briefly noticed in last year's report. Subsequently to that, he progressed steadily to the south, and carried his lines of boundary down to the Chanda coal, where he examined the field, and ascertained the probable extent of the coal-bearing rocks in that neighbourhood, which is not great. A preliminary report on the coals of this field was submitted shortly after. It is probable that a large proportion of the rocks near Chanda belong to the same series as those in the immediate neighbourhood of Nagpur, which in my last report I stated had been recognized as possibly belonging to a different series. This inference has not been altogether borne out by subsequent and closer investigation, although the necessity for separating the rocks into a distinct group of the Damuda series has been fully established. The full details have still to be worked out.

Mr. Blanford has since then been deputed to accompany the Abyssinian Expedition as Naturalist and Geologist, and has joined the forces from Bombay. This is a duty for which he is singularly well qualified, and I feel perfectly confident the results will amply justify the wisdom of the selection.

Bombay.—Mr. Fedden has been absent on leave for seven months of the year. On his return, he has been deputed to join Mr. Wynne in Cutch. Mr. Wynne has been placed in charge of the Bombay party, in consequence of Mr. W. Blanford's absence in Abyssinia, and aided by Mr. Fedden, he has taken up the detailed examination of Cutch.

Madras.—The labours of the Madras party have been curtailed by the absence, as already alluded to, of Mr. Foote. In my last report I expressed a hope that the close of the season would see the examination of the Kuddapah rocks carried up to the limit of Sheet 76 of the Indian Atlas. This was accomplished in one place; but illness in camp and inclemency of the season prevented the whole breadth being examined so far north. A general reconnoissance to the north of the Kistna has shown that these sub-metamorphic rocks stop out, for a distance at least, a few miles north of the Kistna, the gneissose rocks appearing from beneath them, all across from the vicinity of Juggiapett round by Warupully to Kurnool. Of the portion that now remains to be mapped in, a large area is marked on the maps as an inaccessible tract unsurveyed. Across this there are only one or two footpaths at considerable intervals. And seeing the nature of the ground and the great intricacy of the geological lines, I greatly fear that with only two assistants at work it will be impossible to get over all this area this season. It is certain, however, that a general knowledge of its structure will be obtained.

Of the Madras work two further quarter sheets, Sheet 78. NE. and SE., have been sent to the engraver months since.

Burmah.—I have already in my last report detailed the progress of the work in Burmah for the few months at the commencement of the year. Mr. Theobald left, on furlough, in

April, and is still absent, and it has not been practicable to send any one to take up his work this season. On his return in the autumn, Mr. Theobald will resume his researches in Burmah.

PUBLICATIONS.—During the year the Survey has issued of the *Memoirs of the Geological Survey of India*, the following:—"On the neighbourhood of Lynyan in Sind," where coal was said to occur: "On the Geology of a part of Cutch," where also coal was stated to have been worked; both by Mr. W. T. Blanford. There have also been issued a detailed report on the Bokaro coal-field in the Hazareebagh district, by Mr. T. W. Hughes, and a similar one on the Ramgurh coal-field by Mr. V. Ball. Also a general sketch report on the trap rocks of Western and Central India, by Mr. W. T. Blanford.

In Sind, the coal at Lynyan, which had been the subject of many reports extending over several years, and of considerable expenditure of time and money, proved to be merely a nest or patch of lignite, not extending one hundred yards in any direction. Nor did there appear any probability of other deposits occurring in the vicinity. In Cutch, the only seam of coal seen is a little more than one foot in thickness, of which thickness only about eight inches is fairly good. It is, therefore, obviously not worth working. Mr. Blanford's visit being, unavoidably at the time, a very cursory one, a careful examination of the whole of Cutch has this year been commenced and the results will be of high interest. This coal of Cutch is geologically of a middle jurassic age, while the lignitic coal of Sind belongs to the lower tertiary epoch. The Bokaro and Ramgurh coal-fields belong to the ordinary coal-bearing series (the Damuda) of Indian rocks. They lie to the south of Hazareebagh, and are of considerable extent, but not rich in coal. And, as I have already stated, must I think be looked upon as only useful to meet a local and limited demand, and this, too, only for such rougher work as the inferior quality of coal may be adapted for. Mr. Blanford's report "On the traps of Western and Central India," throws light on their history, extent and character, and on their geological epoch. Mr. Blanford thinks it highly probable that the commencement of these great over-flowings of lava which extend over such an immense area may have occurred even so early as the time of the middle cretaceous period, and have continued up into tertiary ages. These conclusions, however, are based upon evidence, which Mr. Blanford himself admits to be far from conclusive. More detailed examinations must be carried out before they be admitted. The subject is one of great interest in Indian geology.

In accordance with a demand from the Right Hon'ble the Secretary of State for India, I prepared at the commencement of the year a brief summary statement of all that was known regarding the coal-fields of India. Details, as full as the information obtainable admitted of, were given "of the resources and production of coal." During the years from 1858 to 1866, inclusive, these returns showed an actual increase in the amount of coal raised in India, from 61½ lakhs of maunds to 108½ lakhs. The returns were avowedly only careful approximations, as there was no organization for the compilation of such information, but they are probably relatively correct. Arrangements have been made to carry on these statistics of out-turn of coal, so far as the information can be obtained.

A new edition of the Catalogue of Meteorites in the Geological Survey Musuem, has also been issued embodying many more recent acquisitions in Europe. In it are recorded 152 stones, and 95 iron aerolites. These if taken in conjunction with seven others, of which the Geological Museum, has no specimen, but which are represented in the Indian Museum, will form a total number of two hundred and fifty-four distinct falls, represented in Calcutta: a number which fully justifies the statement made by me in the Catalogue, that so far as the number and variety of its specimens are concerned, the series of aerolites in Calcutta stands among the first in the world.

Of the *Palæontologia Indica*, the first half of the detailed figures and descriptions of the Cretaceous Gastropoda of South India, has been published. This contained four parts, issued in anticipation of the regular dates for the quarterly publication, and as for the year from April 1867 to April 1868. This portion contains descriptions of 83 species, under 46 genera, with full analyses of the several families, sub-families, &c., and of their natural history relations, so as to form a standard guide for the student of this very important group of fossils. I have in all cases desired to bear in mind in our publications, the very different circumstances under which Indian readers are placed, as compared with similar students in Europe, from the absence of collections for comparison, and books for reference, and it has, therefore, been a steadily pursued object to render all our descriptions, catalogues, &c., as complete in themselves, and as detailed in their references, as possible. The preparation of the parts for the

coming year is far advanced, and they will be ready for issue punctually at the proper times. The issue for this year (4 parts) will I hope complete the *Cretaceous Gastropoda.*

It was not a little gratifying to find the high appreciation in which the publications of the Geological Survey were held by the geologists of Europe, during our visit last year. From many we had applications for these works, both the Memoirs and Palæontologia, which could not be acceded to, owing to the limited number of copies now available. I am glad also to be able to bear hearty testimony to the friendliness with which any proposals for exchange were invariably received, and I only regret that this excellent system of co-operation cannot be carried out to a much larger extent than at present.

During the year, a report on the coal seams found near Chanda on the Wurdah river, to the extreme south of the Nagpur territory, was submitted. As stated in last year's report, and alluded to above, Mr. W. T. Blanford had been deputed to carry on the lines of boundary of the several rock groups from their known limits to the north past Nagpur to the south, so as to trace out, if possible, the actual connection as he went along. This has been done as far south as about 19° 25′ of north latitude, or about the southern limits of the country included in Sheet 73 of the Indian Atlas. It is not intended to convey the idea, that such an extent of area has been worked out in detail, but the general features have been sketched in.

The rocks belonging to the coal-bearing series of India do not cover any very extensive area in the vicinity of Chanda. They extend from under the great flows of the Deccan traps, a little to the south of Wurrooda and Legaon, in an irregular band of an average width of about 20 miles to the Wurdah river where this band has diminished to about 12 miles in width. The further extension to the south of these rocks has yet to be traced out. It is difficult to arrive at any very satisfactory conclusions regarding the true distribution of these rocks, inasmuch as the area under which they extend, is so thickly and widely covered with recent and alluvial deposits, as almost entirely to conceal the solid rocks beneath. It is, however, probable that a very large portion of these rocks belong to the group developed in the immediate vicinity of Nagpur, and in which no coal seams have been found.

The coal yet discovered near Chanda is confined to two or three localities. One is about 10 miles due west of the station at a village called Kumbari. The bed is seen on both sides of the Wurdah, which here forms the boundary between the Woon district of Berar, and the Central Provinces. It is not easy, as no sufficient exposure of the coal has yet been made, to determine the exact thickness, but it seems to be between five and six feet; the upper part being much decomposed. It dips about 7° to the west-south-west. On the other side of the Wurdah the coal cut into varied from 2 feet to 15 inches in thickness, and as in the distance of less than 250 yards, it had thus diminished from five feet or rather more to less than half that thickness, the probability seems to be that the seam is very irregular if really constant at all, and that the quantity available is therefore not sufficiently steady to justify mining on any large scale. The quality of the coal is also poor. It yielded only 49 per cent. of fixed carbon, that is, not one-half of the weight. There is also present a considerable quantity of iron pyrites.

Mr. Blanford suggested that the extent of this bed should be proved by sinkings or borings near the village of Belora on the west, and a little to the west of the village of Googoori on the east side of the river.

A second locality is about 10 miles south of Chanda, and about 1½ miles north of Balarpur. It is seen on the right or Hydrabad bank of the Wurdah near the village of Sasti, and in the bed of the river is covered by the water excepting at the driest seasons. In the bank it was cut into for seven feet, of which six were coal, the top of the seam having been denuded, so that the total actual thickness could not be seen. It is all covered by alluvial clay forming the bank of the river. The upper three feet appeared to consist of fair coal, shaly here and there; the lower three feet of better quality, one foot at the bottom being the best. The rocks all round there are so concealed as to render it difficult to form any trustworthy opinion as to the extent or constancy of the seam. This knowledge can only be obtained by a careful series of borings or sinkings.

The sum of Rs. 152-11-3 has been paid into the public treasury, realized during the period referred to in this report by the sale of Memoirs, &c.

LIBRARY.—By the liberality of the Government of India, I was enabled this year to devote a portion of the large amount sanctioned as for the estimated expenses of the Survey, but undrawn in consequence of the absence of so many of our staff to procuring such standard series of works as were not within our reach from the very limited monthly sum allowed for

books, as well as standard series of specimens of fosils, &c., for the Museum. By this means, independently of the usual additions to our most valuable series, we have added more than one thousand volumes, including some rare and important series.

We continue to receive regularly from the societies and institutions with which we are in relationship of exchanges, their valuable transactions, journals, &c. These constitute a very large part of the regular additions to our library. And it is very greatly to be wished that this system of exchange might be extended largely. It would be by much the most effective method of making our own researches known to the scientific world, while the publications we should receive in return would more than counterbalance the cost. The literature of Geology, Mineralogy, Palæontology is rapidly increasing, and we find it impracticable even to keep up the supply of current publications on these subjects, from the small monthly grant appropriated to the purpose.

To our library (independently of the additions noticed above) have been added during the nine months under report (April to December) 630 volumes or parts, of which number 248 were presented.

MUSEUM.—The usual large and varied contributions to our Museum from the labours of the Geological Survey have continued during the season. None of the Survey parties have been working in any richly fossiliferous district, so that the number of fossils obtained in this way has not equalled that of some former years. From Europe we have procured a very extensive and grand series of fossils, both in originals and casts. When visiting European collections last year, I represented to the Right Hon'ble the Secretary of State the great drawback to progress in India, which resulted from the absence of good standard collections for comparison, and ventured to recommend the purchase of a valuable collection then available, the result of some five-and-twenty years' researches by Prof. von Klipstein. This recommendation was sanctioned, and the collection was purchased. It has not yet been all delivered in this country, only a few out of more than two hundred cases having as yet arrived. And I will, therefore, defer entering into detail, until after it has been practicable to go over this series, and open it out, at least partially (for our present premises will not afford means of exhibiting it, even to the most limited extent).

During our brief tour in Europe we also received some valuable donations of fossils, minerals and rocks, all of which have still to arrive. A detailed list of these will be prepared as they are opened out. *Calcutta, 31st March* 1868.

BLANFORD, W. T., on the Coal Seams of the Tawa valley, Baitool District, Central Provinces.—The coals of the Tawa Valley have frequently been reported upon, the last and most complete account of them being that given by Mr. J. G. Medlicott, of the Geological Survey. Full details of the different seams are given in the body of his report "on the Geological structure of the Central Portion of the Nerbudda District" (Memoirs of the Geological Survey of India, Vol. II.) or in the Appendix, page 268.

The principal localities described were the following—

1. Rawundeo, on the Tawa River: 21 feet 2 inches of coal seen in 8 distinct outcrops, besides some repetitions. Two of the seams are 4 feet at least in thickness at their outcrops.

2. Murdunpur and Kotri on the Machna, a tributary of the Tawa: two seams; one 3 feet thick, the other 6 inches only.

3. Sonadi, on the Bora Nuddi, another tributary: two seams, 19 and 10 inches thick respectively.

4. Sooki Nuddi, a 3rd tributary: two thin seams, 3 and 2½ inches thick respectively, and of course worthless.

Besides these, there are two seams, one 2 feet 3 inches thick, and a lower seam of 3 inches occurring on the Machna River between Shapoor and Murdanpoor mentioned in the detailed Section at page 160, but not referred to in the Appendix, being probably considered by Mr. Medlicott merely a repetition of the Murdanpoor outcrops.

No new localities have since been discovered, so far as I can learn. I received information from a native of the occurrence of *kala patthar*, near Kesla, which would be an important locality, being within 12 miles of the railway, while the nearest known outcrop of coal is double that distance, but on visiting the spot, I found the "black stone" indicated to be a sandstone.

But although no new localities have been met with, the progress in our knowledge of the coal-bearing rocks of India during the 10 years which have elapsed since Mr. Medlicott examined the Tawa Valley has been so great that it appeared possible that some additional particulars might be noted, and that a better idea of the mining prospects of the locality could be formed. In this anticipation I have not been wholly disappointed, although I regret to say that the result of my examination is to induce me to take an even more unfavorable view of the coal seams of the Tawa Valley than Mr. Medlicott did. I doubt if a single seam is known to occur in the valley which could be mined to any depth with profit under existing circumstances, and with one possible, but very dubious exception, I am decidedly of opinion that no seam could be worked under any possible circumstances. The possible exception is in the Rawundeo section, to which Mr. Medlicott particularly called attention, but there are some peculiarities, connected with the seams there found, which make me think their availability for mining purposes doubtful.

In order to show my reasons for the unfavorable opinion formed, I shall proceed briefly to describe the several localities. It must be remembered that these are all outcrops exposed in streams, and that the sand in the bed of the stream shifts from season to season exposing portions of rock and outcrops at one time, which it conceals at others. This is especially the case with those coal seams which usually underlie beds of coarse sandstone, and the latter, being hard, stand up in small terrace-shaped masses against which the sand accumulates, concealing the softer coal beds beneath. For this reason it is improbable that any two successive observers will see exactly the same section, if their visit be in different years, and in some cases I was unable to find again seams mentioned by Mr. Medlicott, and, *vice versâ*, I saw some which he, I believe, did not.

1. Sonadi.—I saw coal in three places here. Mr. Medlicott only in two. The highest seam is about 19 inches thick, with 4 or 5 inches of shale overlying it, and, upon this, coarse sandstone. All other seams are thinner. The second seam in descending order is 10 inches thick, with a roof of coarse sandstone. Beneath this comes—

	feet.	inches.
Coarse sandstone, about	10	0
Coal	0	6
Shale and shaly sandstone	4	0
Coal	0	8

About 100 yards further south another seam occurs, about 1 foot 6 inches thick of coal and shale mixed. The roof here also is of coarse sandstone.

2. Sooki Nulla.—Only strings 3 or 4 inches thick occur, as noted by Mr. Medlicott.

3. About 2 miles east of Shapur, in the Machna River, a seam 2 feet 3 inches thick is seen associated with shale, and a lower seam, 3 inches thick, as above mentioned. The upper seam can be traced for a short distance, about 100 yards.

4. Murdanpur, on the Machna.—Mr. Medlicott saw two seams here; one was probably concealed by sand at the time of my visit, but it was only 6 inches thick. The other amounts to 3 feet in places, but is extremely variable. The roof is again coarse sandstone. The seam is seen for several yards along the south (right) bank of the stream, but is not seen, where, if continuous, it should recur on the north bank. It is possible that there may be a fault, but I could find no indication of one; it appeared to me that the associated sandstone reappeared without the coal seam, and my impression was that the latter had thinned out and vanished completely.

5. Rawundeo, on the Tawa River.—A careful description and a measured section of this locality are given by Mr Medlicott at page 154 of the Memoirs. Yet such changes have been produced by the stream in 10 years that I had much difficulty in recognizing several of the beds. I believe the rocks in the upper part of the section to be better exposed on the whole now than they were in 1855, while the lower portion is now comparatively concealed. I counted 11 outcrops of coal, Mr. Medlicott 13, of which he considers several to be repetitions caused by small faults. At the same time he mentions that there was no clear evidence of faulting, and I certainly do not think there is any in the upper part of the section, and I think, so far as the number of seams exposed is concerned, that he has underrated the resources of the spot rather than otherwise. Some of the coal is of excellent quality, and one or two seams are 4 feet thick, in places at all events.

On the other hand the roof is frequently, though not always, coarse sandstone. The seams are not of even thickness throughout, some, perhaps all, being very variable. Most of them are only seen for a few feet, and in only two cases could I trace them the whole distance across the river. One so traced varied but slightly in thickness, being about 1 foot to 1 foot 3 inches; the other was 2 feet thick on one bank of the stream, and gradually thinned away, vanishing completely before reaching the other bank, less than 50 yards distant. Both these seams were associated with flags and shales.

It will thus be seen that, except at Rawundeo, not one seam is known to occur exceeding 3 feet in thickness, and I doubt if any seam of that thickness can be profitably mined in India. I am aware that much thinner seams are worked in England, some, I believe, not exceeding 18 inches, though that is exceptional. But in England there are three advantages at least which are wanting in India. These are—1. A large local demand; 2. Excellence of quality; 3. A skilled mining population.

In India, in a place like the Tawa Valley, there is no local demand, nor is it very probable that there ever will be. The best Indian coal from the Damuda beds is about half as good as the best English coal, that is, if used in a steam engine, for instance, it takes twice as much Indian coal to do the same work. The value consequently, weight for weight, is about one-half, and a 3 feet seam of Damuda coal is, on this account alone, only an equivalent of an 18 inch seam of English coal. Another disadvantage entailed by the inferiority of quality, is of course, increased expense for carriage.

The want of skilled labour causes more coal to be cut to waste besides largely increasing the cost of superintendence.

Taking all the disadvantages into consideration, my own impression is that from 4 feet 6 inches to 5 feet is the minimum thickness of a coal seam which can be profitably mined in India under ordinary circumstances. In the immediate neighbourhood of a railway, or of any other large source of demand, perhaps rather thinner seams might be worked.

Of course a considerable quantity of coal, some thousands of tons in many cases, may be profitably extracted from thinner seams near the surface.

Of course too, the conditions of the profitable mining of Indian coal depend upon a variety of circumstances liable to change. A mining population might gradually spring up, the demand for fuel may, and probably will, increase, while other supplies may fail or increase in value to such an exent as to raise the price of the article permanently. These other supplies, at present, are wood and English coal, either of which may at any time become unprocurable. On the other hand, if India ever attains a civilization at all approaching that of Europe, it will undoubtedly grow timber for fuel largely, as is done in all other civilized countries not rich in coal. At present the principal efforts of the whole Native population of India, and of no inconsiderable proportion of the European population, appear to be devoted to the destruction of the forests, and it is but fair to say that their labours have been rewarded with great success.

Supposing, however, that seams of 4 feet in thickness could be worked or that two or three seams were mined from one shaft, thus diminishing the cost of sinking and of machinery, there appears a possibility that the Rawundeo coal might be mined, especially as the quality is, in some seams, exceptionally good. But there is still one point which must be satisfactorily determined before the seams could be pronounced workable, and that is the question how far the seams can be trusted to be constant in thickness.

Where merely small sections are seen in the banks of rivers, not extending frequently more than 5 or 6 yards, this question is difficult to answer. Of all the seams seen in the Tawa Machna, and Bora streams, the outcrops of not more than 3 or 4 can be traced for 50 yards, and out of these few, one in the Tawa dwindles from 2 feet to nothing in that distance, and a second at Murdunpoor on the Machna, appears to do the same, and certainly, out of a total of barely 3 feet, varies as much as a foot within 20 yards. Moreover, nothing is more common than to find coal seams of variable thickness when their roof consists of coarse sandstone; it appears always to mark slight local unconformity, and denudation of the coal seam beneath. But in the case of the seam at Rawundeo which is seen to thin out, its irregularity is not due to this cause, the roof being of flaggy sandstone.

In describing the Ranigunj coal field, I showed that there were two sub-divisions of the coal-bearing rocks or Damudas, the lower containing numerous coal seams of great size

but so variable in quality and thickness, that it was doubtful if any could be largely mined, The beds were characterized by frequent alternations of shales, flaggy beds and massive sandstones. In the higher sub-division of the Ranigunj beds the alternations were less numerous, the several beds much thicker, and the coal seams more constant. I am inclined to believe that the beds of the Tawa Valley resemble those of the lower or Barakar series of the Ranigunj field in the peculiarities of the coal seams, as they certainly do in their position at the base of the coal measures.*

A very important and interesting question is the probability of the occurrence of coal in the more northern portion of the Tawa Valley near Kesla and Bagra; in the first place, because coal occurring there might belong to the higher and richer beds; and, secondly, because it would be so much nearer to the line of railway. Time did not allow me to examine the valley thoroughly, but a cursory inspection of the neighbourhood of Bordha and Kesla induced me to believe that the rocks there occurring are very possibly higher in position than the true coal bearing beds of the Damudas. *April 4th*, 1866.

H. B. Medlicott, On the prospects of useful Coal being found in the Garrow Hills, Bengal.—My report on the coal resources of the Garrow Hills admits of being very brief. I have only to indicate the very fallacious nature of the statements, upon which expectations have been founded.

The region to which my remarks will be limited, as bearing upon the question of the northern extension of the Eastern Bengal Railway, comprises the hills to the south and east of the Bramahpootra, bordering the Mymensing and Goalpara Districts. It forms the recently created jurisdiction of the Garrow Hills. It thus excludes the Cossiah Hills and Silhet, of which the coal has already been cursorily described, and which would be beyond the range of the object, indicated as the special reason for my mission. It will be seen that the spurious coal of the Garrow Hills is geologically distinct from most of that already so well-known as Silhet, or Cherra coal.

As it was conjectured, and in the main correctly, that the Garrow Hills were geologically, as well as geographically, the continuation of the Cossiah Hills, I formed the plan to begin at Cherrapoonji, and so to work westward from the known to the unknown. Owing to the lateness of the season at which the project was taken up, I started from Calcutta before final orders were received from the Home Office. But in consequence of the great delay subsequently in procuring elephants, the only practicable carriage in these districts, I was unable to leave Cherrapoonji until the 22nd of January. I was, therefore, prevented from carrying on the connection of the sections so closely or continuously as I had wished. I had to hurry on to the ground where the principal object of research lay. However this unavoidable haste may have diminished the scientific results of my season's work, it has not, I consider, affected the judgment I have to give on the practical question proposed. The circumstances of the case are so simple as to admit of a very definite opinion.

I have examined every coal outcrop in the Garrow Hills of which I could obtain any information. They are grouped in two localities; one on the Sumesurri river, north of Shushung-Durgapur in Mymensing, the other in the neighbourhood of Harigaon, at the west base of the hills near the Bramahpootra. It is the latter that has chiefly attracted attention, as being so favorably situated with reference to the great river and to Assam. The former position is more than fifty miles from the Bramahpootra, besides being separated from the plains by a zone or belt of hills, ten miles wide, and being on an unnavigable stream. Both localities are marked on the Revenue Survey maps of Mymensing and Goalpara as coal-bearing; and, as far as I am aware, the coal was first brought to notice by the surveyors. There can be little doubt, that the same coal is more or less continuous between these two localities, and that numerous other outcrops could easily be found by any one having a slight knowledge of the rocks; but, apart from a consideration of the absence of any prospect of improvement in the character of the coal, the difficulties of position with reference to the means of transport, would rapidly amount to prohibition, even in the case of a very good coal, in proceeding eastwards from Harigaon. After seeing the section on the Sumesurri, and finding that I should have little to occupy me in the outermost hills, I wished much to be able to proceed up the Nitai, and so along the band of coal-bearing

* It is possible that the Mopani beds, which, however, I have not seen, belong to the upper or Ranigunj series, as do, I think, some and perhaps all of the Pench beds also.

strata to Harigaon; but I could not have attempted this without long preconcerted arrangements with Lieutenant Williamson, having had repeated official warnings not to venture into the Garrow country unsupported.

The configuration of the Garrow Hills differs considerably from that of the Cossiah Hills; while the corresponding features in each are determined by the same geological structure. The high table-land range of the Cossiah Hills rises almost abruptly from the plains of Silhet, and is formed by undisturbed strata belonging to the cretaceous and nummulitic formations, resting upon a basis of crystalline (metamorphic and granitic) rocks. There is under the Cossiah Hills only a very narrow band of much lower fringing ridges, formed of those same, or of younger, stratified rocks, but greatly broken from their original horizontality. The outermost of these are very low, being composed of the comparatively soft rocks of age later than the nummulitic; while the ridges of intermediate position and elevation are for the most part determined by the nummulitic limestone, or by the cretaceous sandstone. The higher ridges of the Garrow Hills, on the contrary, are scarcely visible from the plains of Mymensing in ordinary weather. Passing westwards from Cherrapoonji, the zone of disturbed rocks and lower ridges intervening between the table-land and the plains becomes wider, the boundary of the main hills having taken a W. N. W. course, while the outer limit of the minor hills maintains its E. W. direction. It is found throughout that the great change in the form and elevation of the hills is consistent with the appearance of the crystalline rocks: on the Sumesurri, the gneiss comes in close to the north of Seju; and Tura mountain (upon which Lieutenant Williamson has just established his head quarters) is the western termination of the great plateau of Shillong and Cherra, and is formed of gneiss with the cretaceous sandstone resting on its S. W. base. In the same continuation, up to the edge of the Bramahpootra at Singmari, the crystalline rocks appear almost continuously, under a thin covering of the same sandstone. No formation seems to be introduced in the western expansion of the lower hills, that is, not more or less represented in the shorter but steeper sections to eastwards. Just about Laour, in Silhet, the lowest ridges of the outer hills are altogether cut away for a considerable length; and the nummulitic limestone rises abruptly from the alluvium. The supra-nummulitic strata, however, soon re-appear to the west, in force: on the Sumesurri they are ten miles across; and further west, on a line S. W. from Tura, they are probably much wider.

There is a contrast in the features as well as in the extent of these minor hills in the Garrow and Cossiah regions. To the east they present much difference of elevation, and variety of outline; whereas from the summit of Tura one overlooks, from its base to the plains, a monotonous expanse of insignificant hills. This seems due to several circumstances, influencing the results of denudation; there is a gradual diminution westwards of disturbance in the strata, accompanied by a less induration of the older rocks; and especially is the difference of features due to the almost total extinction westwards of the limestone, a rock always remarkable for its picturesque forms of weathering.

I have said that the coal of the Garrow Hills has been examined in two widely separate localities. Although, on the Sumesurri, its position alone would preclude the profitable extraction even of an otherwise valuable coal, it will be well to describe this locality, as the section is much more distinct than that of the more westerly region, and the boundaries of the several groups of rocks can be easily fixed approximately. The Rajah of Shushung, who lays claim to the sovereignty of a large tract of hills, although to all appearance his authority is unrecognised by the resident Garrows, has had search made for coal along the banks of the Sumesurri. In this way two outcrops have been opened out; and a little coal extracted for trial. Both outcrops belong, I believe, to the same seam, repeated at the surface by contortions of the strata. It occurs near the base of the whole stratified series, within a few yards of the underlying crystalline rocks.

The section on the Sumesurri is as follows:—At the outermost skirts of hills, below Bijessur, we find the sands and subordinate clays of the group next above the nummulitic. Here they dip at 40° or 50° to southward, being very much more disturbed than at any point higher up the river. They rapidly settle down to a very small slope and even to horizontality; so much so that through the long windings of the river above and below Salagaon, the very same beds are traceable near the water line. The most distinctive rock of this group is a fine, soft, greenish-yellow or gray sandstone, generally massive and falsebedded, but also in very regularly laminated layers. On the line of the Lekong nuddi, these soft rocks rise

again to the north at about 5°; and a little above the confluence, after some few score yards of blank section, rocks of an older type crop out with dips of 40° and 50° to southwards*.

Ryuk Lamapara is on a ridge of fine, yellowish, white sandstone of the type associated with the nummulitic strata. The dip is here 20° to S. S. W; but it immediately becomes lower, and all through the valley of Ryuk Ujanpara the nummulitic limestone shows on the river bank, quite horizontal. This rock is already greatly changed from its conditions in Silhet; instead of several thick bands of strong pure limestone, there is now altogether about 30 or 40 feet, and for the most part earthy, ochreous and concretionary; selected portions of it might make good hydraulic lime and cement. It seems to be overlaid by earthy shaley beds, that are rarely exposed; but I could not trace any symptoms of a carbonaceous deposit in this position, which is that of the coal at Cherra.

The limestone runs quite horizontally up to the very base of a steep ridge running W. N. W.; but within ten feet it bends up to a high dip, and is seen resting directly on a strong, coarsish, pale sandstone more or less felspathic. The two are thus apparently conformable; and there would be no direct reason for considering them of very distinct ages. This ridge is very narrow; and there is a good section of it in the river. There may be about 200 feet of the sandstone with occasional partings of carbonaceous shale. Along the northern flank there is a thick band of such shale, in the midst of which occurs the coal seam. It is here a good deal crushed, being close to an axis of flexure, and dips at 80° to S. S. W. It is altogether about three feet thick, but very unequally carbonaceous, being locally split by strings of clay and of sand; and it contains but few thin strings of coaly substance. The mass of what would be extracted as coal is a highly resinous batt or shale, full of small nests and strings of a kind of amber; it gives a woody sound when struck, is very tough, and breaks with a large conchoidal fracture; the lamination is observable throughout; but the whole lights readily and burns freely, leaving a skeleton of ash.

There is a blank section of about 100 yards on the north side of the ridge, and then strong sandstone, like that over the coal, appears on both banks, with a very slight northerly inclination, continuing so throughout the long N. S. reach of the river. Where the river turns eastward this dip increases, bringing down a limestone identical with that of Ryuk, and resting on the strong sandstone. There is here a shallow synclinal, the limestone being q. p. horizontal opposite Seju Lamapara, and rising rapidly on the south flank of the ridge at the point of which stands Seju Ujanpara. The streamlets down the face of this ridge undercut the strata, and disclose the coal seam at about the same depth from the limestone as before. These rocks all strike into the gorge of the Sumesurri at and north of Seju Ujanpara; the coal and the soft shales associated with it are of course eroded and concealed, but we now find the beds which underlie them—these are about 100 feet of strong coarse sandstones just like those over the coal; and they rest against and upon the gneiss. There is an excellent section of the junction: the dip of the sandstone increases rapidly, being 80° to S. W. at the contact; but it is a natural junction, parallel to the dip of the sandstone, the base of which contains rolled pebbles and boulders of the crystallines. The chief mass of the high irregular ridge over Seju is of gneiss, great blocks of this rock abounding in the steep watercourses through the sandstones at the base of the ridge.

The coal near Seju is precisely similar to that already described, only perhaps a little better; and the sequences of the strata in the two places so exactly correspond, that there can be little doubt the coal belongs to one and the same band; the southern outcrop being due to the remarkable flexure of the rocks between the valleys of Ryuk and Seju. Whatever little use might be made of this coal, if required on the spot, it is evident that it would not supply any extensive demand, or repay any difficult transport. The latter obstacle seems insuperable: the Sumesurri, although a considerable stream, is choked with silt throughout the greater part of its course below Ryuk, where the rapids begin to be troublesome.

If the great thickness of cretaceous rocks, known in the section of the Cossiah hills, is represented at all on the Sumesurri, it must be by these bottom sandstones and shales containing the coal, here 400 to 500 feet in thickness. All the circumstances support the conjecture that such is the case; as, the description of the rocks and their mode of relation to the nummulitic limestone. In the Cossiah hills too there are frequent symptoms of a carbonaceous element in the cretaceous rocks. Shortly before leaving Cherrapoonji I noticed a bed of shale,

* The limestone noted on the district map of Mymensing—(scale, 4 miles equal one inch) just above Salagaon Ujanpara, does not show on the river; it is probably a mistake.

full of obscure plant remains, associated with the conglomerates at the very base of the section under Mamluh on the west; and it is more than probable that some of the local coal beds of the Cherra region, as, for instance, that at Moubelarka (from which the supply for Shillong is now taken), belong to the cretaceous and not to the nummulitic deposits.

I wished much to go up the Koylas mountain from Seju; but the attempt would have been useless, without some more influential protector than the pretended sovereign, the Rajah of Shushung, through whose assistance I got along the river as far as Seju. The slight sketch given of this tract of the hills on the maps is very misleading, as to the relative importance of the several hills: Koylas, though marked rather more faintly, is about three times as high as any of the hills to west and south of it. One can see at a distance, by the sub-horizontal tiers of cliffs on the S. W. face, that at least the upper half of the mountain is of stratified rocks. It would seem too on the map to stand outside the run of the gneiss boundary at Seju, and to be on the stripe of the band of sub-horizontal rocks just south of Seju; thus suggesting that the whole mass of the hill is of these unaltered sedimentary rocks. If, however, such is the case,—that the cretaceous beds pass under Koylas at the same elevation as in the Sumesurri—the top of the hill must be formed of the younger tertiary rocks, at a much greater elevation than these have as yet been observed west of Jynteah. I rather conjecture that there is a sharp bend in the boundary of the crystalline rocks, and that these form the base of Koylas; in which case the cliffs noticed on the summit may be altogether composed of cretaceous and nummulitic rocks. It is possible, indeed, that the peak of Koylas may be formed of a remnant of the submetamorphic sandstones of Shillong.

As has been already stated, it is in the hills bordering the Bramahpootra, that the question of a coal supply is most important, and where the greatest hopes have been raised by the published statements of discovery. These statements are, as far as I am aware, based upon the investigations of Mr. James Bedford who made a survey of this district in 1842. The published maps of Mr. Bedford's coal discoveries are very imperfect reductions from the original manuscript, of which a tracing was most obligingly supplied to me from the Surveyor General's Office. In these maps the facts given are of two kinds: there are several outcrops of coal noticed in the hills north of Harigaon; and coal is said to exist in the hills south of Harigaon upon the evidence of debris found in the streams. I will first notice the former.

A glance at the geological sketch map will show that Mr. Bedford's coal outcrops at Salkura, Champagiri and Mirampara are on the exact run of the Seju bed; and that the circumstances of the sections are very similar. Those three localities are on the low table-land range of Singmari, which is now much eroded into irregular transverse ridges. All over this range the crystalline rocks weather out from beneath a thin capping of coarse friable sandstone, often conglomeritic; and at the three places mentioned, a local deposit of shale or of clay occurs between the sandstone and the gneiss, and which earthy deposit is very partially impregnated with carbonaceous matter. At Salkura and Mirampara the stuff is mainly a resinous shale, a very poor representative of the Seju coal, but quite of the same character; at Champagiri, more to the north and between the other two places, it is a thick bed of dark stiff clay, with insignificant strings of lignite through it. At Salkura the gneiss shows continuously in the stream at about ten feet under the shale. At Champagiri and Mirampara, besides occurring for some distance in the bed of the streams between banks of the sandstone, the gneiss is seen at the edge of the range at a higher level than the shales, with pebbly sandstone resting on it; the shales having altogether died out. All the streams form rapids or falls over the crystalline rocks at the edge of the range. It seems strange that Mr. Bedford, when he attempts to give definite names to the varieties of the overlying rocks, and although he notices these water-falls, should have failed to make mention of the crystalline rocks, the occurrence of which so gravely affects the prospects of the reported coal-field.

It must have been a very small and carefully selected fragment from these "coal-beds" that yielded the analysis published by the Coal Committee; and it is not to be wondered at, that Mr. Sweetland failed to fulfil his engagement to "put the Committee in possession of more satisfactory samples than they had yet seen." It would require months of labor to obtain a maund of anything that would support combustion. These beds have no relation to "the brown coal formation;" but they were most correctly condemned by the Committee as "belonging to one or more small isolated basins of a spurious coal formation, and are not

likely to lead to any important result." Unfortunately, in the very next paragraph of their report, the Committee pass an encouraging judgment upon much more precarious evidence.

Passing to E. S. E. we find the same conditions to obtain as in the Singmari ridge. The main mass of Harigaon hill is of gneiss with the thick sandstones resting against and upon its southern base either horizontal or with a very slight inclination to the south, and again at Tura, the summit of which is about eight miles to E. 30° S. of Harigaon hill, the station at the south-west base is just to north of the gneiss boundary; and in the stream which drains this flank of the mountain (it is the head waters of the Bunarossi) the gneiss appears in the bed for nearly a mile below the general longitudinal boundary, between spurs formed of the overlying horizontal sandstone. Down this stream I was taken to see a coal bed; it consists of a few sticks of lignite scattered through the sandstone, at six to ten feet above the floor of gneiss.

At Domulgiri, the stage between Harigaon and Tura, I was fortunate enough to hit upon the nummulitic limestone; but for the clearing made for the few temporary buildings, it would probably have escaped notice. The blocks of rusty stone heaped out of the way are evidently derived from a bed in place—the remains of a very thin band, probably a single bed, of ochreous earthy concretionary limestone full of nummulites. The shaly clays that overlie it are exposed on the side cuttings of the road leading up the hill towards Tura; and the cretaceous sandstone occurs in the river immediately below. In kind and in position, everything corresponds with what has been described in the section of the Sumesurri; but the limestone is reduced to this miserable remnant, useless for any practical purpose. This is the completion of the tendency that was already so well marked in the limestone band on the Sumesurri, as compared with the same rock in the Silhet sections.

As far as I penetrated to the south of Harigaon I could not discover even the debris of the rocks overlying the nummulitics; so I am unable even approximately to assign the position of that line of boundary. It must be followed up continuously from the more easterly sections.

The very small inclination, but little removed from horizontality, of the strata in this region would render the tracing of the boundaries between the formations, as carved out by the tortuous valleys through these low hills, a very intricate business indeed.

But there is another geological circumstance that adds much to this difficulty of fixing the boundaries, and greatly aggravates the obstruction to observation offered by the dense character of the vegetation. This is the occurrence of an older diluvial formation. At the point of the spur over Domulgiri, on the spot where Lieutenant Williamson has built his hut, this deposit is betrayed by the rolled blocks of crystalline rocks. But it is often a sand, which, as partially indurated, cannot be certainly distinguished in the small obscure sections, such as almost solely are exposed to view, from the rocks of the underlying formations. Along the outer margin of the hills in the Karibari region, this obstruction amounts to a prohibition of anything like close work. In exploring the hills from Mohindrogunj and Kakreepara, I could never think, with any certainty, upon what ground I was standing. There can be little doubt that this deep deposit in which the low hills are half smothered corresponds with that of the well-known tract in Mymensing and Dacca called the Madhopur jungle. The semi-laterite clay, which is there the chief rock, occurs too among these hills.

We can now discuss the second statement regarding the coal resources of these hills. The Coal Committee remarks, after condemning the only observed outcrops—"This brown-coal formation is not to be confounded with the indications of bituminous coal in the same district, afforded by drifted specimens in the bed of the Bunarossi river." On Mr. Bedford's map, the Kalu above Domulgiri and the Bunarossi above Dumnigaon are represented as trending indefinitely to the south, and are labelled "coal exists in these hills." There are several errors in this information, amounting to a complete misrepresentation of fact. From Domulgiri the Kalu keeps altogether to the north, passing only through the cretaceous band to the gneiss, and drains the northern flank of Tura. From Dumnigaon, the Bunarossi bends steadily round to the north, and drains the western and southern flanks of Tura. I examined the bed of this river for several miles above Dumnigaon: fragments of anything that could be called coal are exceedingly rare in it; and are in quality, as well as in quantity, just what might be expected to be derived from the sticks of lignite I had noticed in the cretaceous sandstone near the source of the river; and

such as might be procured at Champagiri or Mirampara—fragments of pure jetty lignite. I have no doubt that such were what the Committee inaccurately speak of as 'bituminous coal'.

Thus it is plain to me that the unknown, undescribed, and unauthenticated "bituminous coal" came from the condemned "brown-coal formation;" and that no evidence whatever exists of any other carbonaceous deposit in the Garrow Hills.

Having satisfied myself upon the merits of all the evidence before me, and considering that evidence sufficient to form a judgment upon, I did not feel called upon to incur any further loss of time upon the object by hunting for a 'find' without the smallest prospect of success. But should any adventurous man, unsatisfied with the preceding explanations, wish to explore further, I would offer some remarks for his assistance.

The nummulitic formation seems to exist here, on the whole, in as great force as in Silhet, but the valuable coal there associated with it has not been detected here. The case is slightly different from that of the limestone: this rock could scarcely escape observation if it existed; but coal outcrops are habitually eroded and concealed. I cannot but think, however, that some hint of its presence would have been brought to light, even by such search as has been made. The best known (if not all) the nummulitic coal in the Cossiah Hills occurs above limestone.

Of the cretaceous coal it may be said, that the described outcrops are all at the very margin of the original area of deposition, and that the same tendency to form coal may have been much more developed further out in the formation. There would be no asserting the contrary; but also, no *a priori* confirmation can be given to such a conjecture. It is, however, evident, that the horizon of the carbonaceous band in this formation very soon passes beneath the drainage level of the country, and it is only by boring that this supposition of development can be fairly tested; and only by regular pit-mining with a prodigious water discharge, that a coal in that position could be extracted.

It would seem at first sight that the cretaceous beds on the Singmari range had overlapped their general line of boundary, and might extend to any distance northwards, with expansion of the coaly band. The feature is indeed a remarkable one; showing that, to some extent, this terminal configuration of the crystalline axis is of pre-cretaceous origin; but it does not extend far;—at the most northerly points of this range, at Dhepkai and Singmari, the metamorphic rocks are in place, and they occur at all points to the north where rock has been observed in the valley; as at Dhubri, Bengal Khatar, and all along the southern road to Goalpara. *28th March*, 1868.

MALLET, F. R.—COPPER IN BUNDLECUND.—In the 2nd Volume of the Memoirs of the Geological Survey of India, p. 35, notice is taken of the asserted presence of copper near the village of Sorai or Sounrai, west of the Dessaun river, in the Shahgurh district. Mr. Medlicott there states that "when at Nagode, Major Ellis had drawn my attention to this place, Sorai, as having once yielded large supplies of copper." The Rajah of Shahgurh had mentioned it with a view to have the place examined. The specimens he gave were all rounded as if rolled by water, and "with a polish as if for many a long day they had lain in a greasy pocket." None gave any evidence of having been broken from a vein. Mr. Medlicott visited the place, but could get no information. After persisting for sometime he was shown a place just on the south of the village where, it was said, copper had been extracted. It was a shallow trench through the limestone. Mr. Medlicott could not find a trace of anything like a metalliferous mineral. During the past season I heard of this place while working to the north of it, and in consequence I proceeded to the place. It is on the Bijawur rocks, at the edge of the crystallines.

A prisoner had told the Assistant Commissioner that he could show the place where copper existed, and on being taken to the spot had pointed this out. The hole sunk by the Assistant Commissioner was in a fissure formed on a joint in the Bijawur limestone, heading N. E.—S. W., the walls of which were 12 to 15 inches apart. This fissure had been filled up with clay and pebbles of various kinds; Bijawur limestone, hornstone, Bijawur ferruginous beds, Vindhyan sandstones, &c., but none of the crystalline rocks. At two feet from the top were bits of brick and charcoal, and at six feet from the surface, there was a quantity of copper ore in rolled lumps, obviously the debris of some vein,

mixed up with the pebbles of other rocks. It is possible that the lower part of the rubbish is much older than the upper, but there is no clearly marked line between them. There is, however, no copper near the top, and no bricks, &c., near the bottom. If the rubbish be of one age, the bricks would show that the fissure had been filled in within a comparatively recent period, and it seemed not impossible that the ore was the result of former workings washed into the fissure by surface water. I then tried to find any lode; the pebbles associated with the copper are so various as to give no clue to its locality if it exist, excepting the probability of it being in the Bijawur and not in the crystalline rocks. I carefully examined the neighbourhood for any indications of copper without finding a trace. I also searched the bed of the stream which drains the locality for any loose pebbles, but without any result. The only way to prove it really, therefore, seemed to me to sink trial pits. I discussed the matter with the Assistant Commissioner and gave him what information I could on the subject; he expressed his determination to carry on the investigation which he had commenced, and it is to be hoped that his researches will be successful. *April*, 1868.

METEORITES.—It is well known to those who have studied the structure and character of meteorites that, while no single element has been found in these bodies which does not occur on our globe, and while a very large number of the combinations of these elements to form mineral species which occur in meteorites occur also on the earth, there still remain a few minerals which are specially confined to these bodies. The most important of these are Native iron; Schreibersite (or the phosphide of iron and nickel); and Troilite, or what is generally supposed to be the protosulphide of iron. Every extension of accurate research which tends to diminish this number of minerals special to meteorites is of very high interest as bearing on the conclusions to be drawn from their composition regarding the origin and physical condition of the planetary bodies. And in this point of view, the recent researches of M. Stanislas Meunier, the able adjunct to Professor A. Daubrée, in charge of the mineralogical collection at the Jardin des Plantes, Paris, possess a very wide interest. At present we will only allude to his researches on the nature of Troilite, of which we give here a summary. M. Meunier has also recently published a very excellent treatise, Étude descriptive theorique et experimentale sur les METEORITES, 8vo., Paris, 1867.

On the nature of Troilite, S. MEUNIER. "It is known that certain meteorites, that of Orgueil, for example, contain small crystals of the second system formed of a sulphide of iron, having the composition and characters of magnetic pyrites, or Pyrrhotine. This sulphide, of which the formula is $Fe^{7} S^{8}$, enters into the composition of many terrestrial rocks also.

Besides Pyrrhotine, meteorites very often present another mineral of very similar composition and which up to the present never has been found crystallized. To this the name of Troilite has been given. A certain number of Mineralogists, following Mr. Lawrence Smith, attribute to it the formula Fe S, and consequently regard it as constituting the protosulphide of iron. This distinction between Troilite and Pyrrhotine is probably not so marked as is generally supposed. As seen, the difference in composition is very slight, and the physical properties of the two appear very similar.

I have had lately opportunities of analysing many specimens of Troilite from the meteoric irons of Charcas and Toluca, and the numbers which I have obtained lead me to think that this mineral is more closely allied to magnetic pyrites, than to the protosulphide of iron. The results of these analyses will be published separately when they have been completed and extended to a larger number of specimens, but I wish at once to call attention to a reaction, which seems in all cases easily to distinguish the protosulphide of iron from magnetic pyrites, and, *a fortiori*, from compounds more highly sulphuretted.

It seems, at the first view, that this distinction would be very easy, but in reality it is not so. The two minerals are of the same bronze yellow colour, their specific gravities are very close (4·5 for Pyrrhotine, 4·7 for Troilite), and variable within certain limits in different specimens: the *mean* composition differs very little, Pyrrhotine contains (in the mean of results) 39·6 of sulphur to 60·4 of iron, and Troilite, in the mean, has 36·4 of sulphur to 63·6 of iron; both are feebly attracted by the magnet; both fuse freely in the reducing flame to a black globule, strongly magnetic; both finally dissolve easily in Hydrochloric acid, with a very abundant discharge of sulphuretted hydrogen.

It is known also that magnetic pyrites is distinguished from the protosulphide by the deposit of sulphur which it gives, when treated with acids, but this reaction, very marked when

we are dealing with masses very pure and very abundant, is not applicable to the sulphides of meteorites. Besides the fact that we can only operate upon very small quantities of Troilite, and can therefore in every case only obtain a very trifling deposit of sulphur, it must be remembered that this mineral is very far from dissolving entirely in acids. It gives a residue, in which we find carbon in the form of graphite, small hyaline grains which have a composition very close to that of quartz, and small crystals which can be referred to various silicates.

In the practical point of view, therefore, we must seek for some reaction characteristic for one at least of the two sulphides in question. With this object I have submitted the protosulphide of iron and Pyrrhotine to a very large number of comparative trials.

I shall not stop to show that the protosulphide precipitates metallic copper from its solution exactly as iron itself does, whilst the Pyrrhotine does not; the chemical reaction in virtue of which copper is so reduced offers some interesting peculiarities, and I have submitted these to a special study. (1) Without anticipating the details, I may say that the protosulphide of iron obtained by the wet way gives rise to a metallic precipitation, as well as the same compound obtained in the dry way; nevertheless the phenomenon is more easily perceived in the latter case, inasmuch as the extreme sub-division of the black sulphide leads the copper to deposit itself in grains not discernible by the eye.

I have been able to replace the chemically pure protosulphide of iron by a compound containing a little more sulphur, produced by the preparation of sulphuretted hydrogen, in fusing together iron and sulphur. But as soon as the proportion of the sulphur approached that demanded by the formula of Pyrrhotine, precipitation ceased to be possible.

With a sufficient quantity of protosulphide of iron, a copper solution can be deprived of all the copper it contains. This experiment can be easily made with a solution of the sulphate of the binoxide of copper; again, with a sufficient quantity of sulphate of copper, all the iron can be removed from the black precipitate which is obtained by the action of sulpho-hydrate of ammonia on an iron solution.

These two facts show well that we have here to deal with a true chemical phenomenon, and not with a physical action due to capillarity or any other analogous cause.

Having established this distinctive character so easily recognized between the protosulphide of iron and magnetic pyrites, I commenced a series of comparative trials on specimens of Troilite from different sources. All these specimens placed in the presence of solutions of sulphate of copper, of which I varied both the concentration and the temperature, *proved absolutely inert.* In this respect, therefore, as also in regard to its composition, Troilite, according to my experiments, approaches closely to magnetic pyrites (Pyrrhotine).

It would doubtless be rash to conclude from this its absolute identity with Pyrrhotine, although that identity appears very probable. But the experiments appear to justify the absolute separation of Troilite from the protosulphide of iron, of which it possesses neither the composition nor character, as is easily proved. *Cosmos*, 18th January 1868.—T. O.

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(1) Certain phosphides of iron produce an analogous precipitation.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 2.] 1868 [August.

BLANFORD, W. T., F. G. S., on the Coal Seams of the neighbourhood of CHANDA.

DURING the last few days I have been engaged in examining the coal seams discovered by Captain Lucie Smith, Deputy Commissioner of Chanda, in the neighbourhood of that station. I have the honor to forward the following report upon the prospects of the coal being profitably mined. It will be seen that, although one seam is very promising, some further research is necessary before a decisive opinion can be formed upon this subject. I have had the advantage of Captain Lucie Smith's company during my examination of the coal, and I have received from that officer all the information and assistance it was in his power to afford.

Coal has been found near Chanda in two localities, both upon the banks of the river Wurda. In one of these places a seam is exposed on both banks of the river; in the other, only upon the right bank. The river, it should be remarked, forms the boundary between the Central Provinces and the Nizam's Territories (including Berar)—the left bank belonging to the former.

The more northern of the two localities is about 14 miles due west of Chanda station. It is here that the coal is found upon both banks of the river—the right bank belonging to the south-east or Woon district of Berar. The coal is met with upon that bank in lands belonging to the deserted village of Kumbari. It is exposed in the bottom of a small nulla running into the river; a hole dug in the bed of the nulla showed the coal seam to be between 5 and 6 feet in thickness, the uppermost portion being much decomposed, so that the exact amount of coal is difficult to determine. Below is grey argillaceous sandstone. The dip is about 7° to the west-south-west.

Both above and below the coal seam there are massive felspathic sandstones, good sections of which are exposed in the river. There is a possibility that the sandstone seen north-east of the coal seam, and which appears to underlie it, may be the upper bed repeated by a fault, but there is no trustworthy indication of such being the case. The band of sandstone resting upon the coal can be traced across the country for a considerable distance, and passes just west of the village of Belora. A shaft sunk on the west side of that village would, in all probability, cut the seam, if it extends so far.

The exposure upon the Chanda, or left bank of the Wurda, is at the edge of the river in the lands of Googoos village, and west of the village of Chendoor. There is a bare possibility of the seam being different from that seen on the right bank; but every appearance is in favor of its identity. An excavation made by Captain Lucie Smith, while I was on the spot, gave the following sections:—

1. Coarse white sandstone seen in the river bank, and the same as that on the opposite bank of the river over the Kumbari coal ... ... very thick.
2. White sandy shale with carbonaceous layers ... ... 2 feet seen.
3. Carbonaceous shale ... ... 1 foot „
4. *Coal* variable ... ... 1 foot 3 inches to ... 2 feet „
5. Micaceous sandy shale, cut into to the depth of a foot ... ... bottom not seen.

The dip was the same as on the opposite bank of the river.

The coal in the small hole dug, which was not above 3 to 4 feet across, varied from about 2 feet to 1 foot 3 inches in thickness, and as it has further diminished from 5 feet, or rather more, in crossing the river, a distance certainly not exceeding 250 yards (assuming the two beds to be the same, of which there can, I think, be scarcely any doubt), it appears improbable that the seam can be profitably mined upon a large scale, it being likely that the quantity of coal will be limited.

The quality is only moderately good. Fair samples from the Kumbari portion of the seam and from Googoos analysed in Calcutta by Mr. Tween at the Geological Survey Office, gave the following results:—

	Kumbari.	Googoos.
Fixed carbon	42·5	40·
Volatile	36·0*	43·5
Ash	14·5	16·5
	100·0	100·0

The proportion of volatile ingredients is unusually large,† especially as the coal is from an outcrop, while the fixed carbon, which for steam purposes is alone of any value, is in very small proportion. From a greater depth the quality would be better; but the coal is below the average even of Indian coals.

At Kumbari there is a considerable quantity of iron pyrites scattered through the seam in nodules and strings, which is a drawback. The coal also appears remarkably liable to decompose; blocks which had been dug for about six weeks, and exposed to two or three days' rain, having been broken up into minute fragments. This liability to decomposition is doubtless partly due to the coal having been dug from so close to the surface, and in so unfavorable a spot as the bed of a nulla; nevertheless it appears excessive.

Altogether it appears very doubtful if much use can be made of this seam. For local purposes a considerable quantity of inferior fuel can doubtless be obtained from it. It is possible that it may again thicken to the north and south. This may be tested by sinking shafts or by boring west of the Wurda, on the west side of the village of Belora, and east of the river about 300 yards west of the village of Googoos. I cannot help doubting if the bed extends so far in either direction.

The second locality in which coal has been found is about 10 miles nearly due south of Chanda, and about 1½ miles south of the village of Balarpur. The spot is on the right or Hyderabad bank of the river Wurda, near the village of Sarte, and the bed is covered by the water of the river at all times, except in the hottest and driest weather. At the time of my visit, in the middle of April, owing to some recent showers, the river had risen slightly, and the bed was entirely concealed. A cutting into the bank close by, however, exposed the coal, and a hole was dug into it to the depth of 7 feet, of which the upper 6 feet were coal, and the lowest foot carbonaceous shale. Coal may, of course, recur beneath this. But the sinking with the means at our disposal had become very difficult and slow, owing to the reflux of water, and sufficient had been ascertained to prove the coal of workable thickness, *if constant*.

The top of the seam is not exposed, at least no rock is found overlying, and it is therefore impossible to say whether any of the coal has been removed with the overlying rocks or not. Upon the coal rests an accumulation of alluvial clay forming the bank of the river. All therefore that can be positively stated is, that the bed at this spot is not less than 6 feet in thickness.

As regards quality the upper portion of the seam is, of course, somewhat decomposed, less so, however, than might have been anticipated. The uppermost 3 feet, so far as the state of the coal allows of an opinion, appear to consist of fair coal, but shaley and impure here and there. The lower 3 feet are decidedly superior, indeed one foot at the bottom appears to consist of an unusually pure and bright coal. Taking the seam as a whole, I anticipate

* This gave water 8·0, sulphur ·85.

† The best seam in the Pench Valley, near Chindwara, that of Sirgori, gave on analysis—

Fixed carbon	61·6
Volatile	28·0
Ash	10·4

that it will yield fairly useful fuel for all purposes. The quantity of pyrites appears to be considerable, but not excessive. It is interspersed throughout, and not in nodules as at Kumbari. It is, however, difficult to form a correct estimate of the amount from an inspection of the specimens procured from so near the surface. The seam may be considered as highly promising. But before it can be considered as available for mining purposes, its thickness and quality must be ascertained to be constant throughout a considerable area. It is also very desirable to ascertain whether it recurs on the Chanda side of the river. I regret that I am unable to throw much light upon these points. The concealment of all rocks near the outcrop of the coal is so great that scarcely any indications are afforded even of the general dip, and the few that are met with are somewhat contradictory.

The dip of the seam itself is obscured. The angle is very low—certainly below 5°, and appears to be to the north-east or north, but at the same time to vary. About 200 yards up the river, on the same bank, a large quantity of coarse sandstone is exposed with an apparent general dip to the east of about 5°, but the rock is so excessively false-bedded that its real dip can only be guessed at. Still further up the river, towards Balarpur, there is more sandstone, also with an apparent low eastwardly dip; but at Balarpur the beds are either horizontal or dip to the north-west.

About 300 yards below the coal also, on the right or west bank of the river, sandstone is again exposed, but no trustworthy indication of a dip could be discovered. All around, on both sides of the river, is an alluvial plain, and I could find no trace of rock. The general appearances are in favor of an east or north-east dip. The sandstone seen to the north up the river may underlie, and that seen down the river rest upon, the coal, but this is little more than a guess. If the dip be to the east the coal should be found in a shaft or boring on the left or Chanda side of the river, at a depth not exceeding 50 or 60 feet below the bottom of the bank.

It is extremely desirable that an attempt should be made to find the coal by sinking or boring through the sandstone on the river bank below (south-west of) the outcrop on the Hyderabad side of the river. His Highness the Nizam would doubtless order the necessary exploration if made acquainted with the facts. In sinking upon the Chanda side it is far from improbable that only alluvial clay may be met with to the depth mentioned. In this case it would be well to make deeper explorations further from the river bank, the persistency of the seam can, in all probability, meantime be settled by a few sinkings or borings on the Hyderabad side of the river. Further exploration on the Chanda side, with the exception of one or two shafts on the river bank, would best be deferred until this important question is decided.

Assay yielded the following results for these coals:—

	Balarpur.	Balarpur, 'best part of seam.'
Fixed carbon	51·2	49·9
Volatile	39·0*	42·4
Ash	9·8	7·7

Probable existence of other seams.

The existence of the seams discovered by Captain Lucie Smith renders it probable that others, as yet undiscovered, may exist in the neighbourhood, especially as the rocks are greatly concealed by alluvium. The area occupied by the true coal-bearing rocks of the Damuda series does not, however, appear to be very large; and owing to the superficial accumulations beneath which they are buried, boring must, in all probability, be resorted to in order to explore them. The discovery of the localities already known is clearly due, when the difficulties of the case are considered, to most persevering enquiries and research, and I have no doubt but that the same energetic search, if further prosecuted, will, as at Chindwara, lead to further discoveries.

Still I think it improbable that the neighbourhood of Chanda is equal in mineral wealth to the Pench Valley near Chindwara. As stated above, the area occupied by the coal-bearing rocks appears smaller, and their thickness is less. The far greater facility of communication with the Railway, and the possible future demand for fuel for the navigation of the Godavery, Pranhita and Wurda,† give a great advantage to the Chanda localities, and

* This yielded sulphur ·77, water 4·5. All burn with a strong long-sustained flame and no caking.

† The localities where coal has been found near Chanda are on the navigable portion of the Wurda, and if the proposed works for the improvement of the Godavery navigation be carried out, they will be in direct water communication with the whole of the river.

thinner seams, or inferior coal, than could be profitably mined near Chindwara, might be worked with advantage at Chanda. *Camp; Chanda District, April 20th*, 1867.

During the present season, borings have been carried out close to the town of Chanda itself, and have proved the existence of coal, about 2 feet 6 inches in thickness. The coal is said to be hard, but as no trial of it has yet been made, its quality is really unknown. It is highly probable that this bed will prove to be an extension of the beds seen on banks of the Wurda by Mr. Blanford. A shaft has also been sunk at Googoos, noted above. Up to present date (July) it had been carried down perpendicularly to a depth of 30 feet, giving a section of 16 feet, broken ground; 7 inches, clay; 6 inches, *coal*; one foot shale; 5 inches, *coal*; 5 feet 9 inches shale, hard and firm; and then 9 feet 6 inches, of coal; in which the men were (on the 13th July) still working without any sign of change, the coal improving in quality. All the beds were found to dip at 10° to 11° to the west-south-west, lying conformably one on the other.

These excavations have been carried out by the energetic Deputy Commissioner Captain L. Smith, who has also had the able co-operation of Mr. A. Binnie, F. G. S., Executive Engineer. The results seem to place beyond a question (what from the evidence visible at the surface, Mr. Blanford was inclined to doubt), that the coal beds are continuous, and afford promise of a large supply of fuel. It is highly probable that the two thin seams of coal, with intervening shale, amounting altogether to 2 feet in thickness, represent the bed seen by Mr. Blanford on the left bank of the Wurda, and that this is therefore distinct from that visible on the right bank; the latter being, possibly, the representative of the lower and thicker bed cut through in the shaft noticed above. Mr. Blanford fully pointed out the impossibility of arriving at any sound conclusion in a country so covered as that around Chanda.—(T. O.).

BLANFORD, W. T. Coal near NAGPUR, being copy of a letter to the Secr. to Chief Commissioner, Central Provinces—(dated Camp, Chanda District, 12th February, 1867).

I have just finished the examination of the various sandstone rocks which are found on the edge of the trap area in the Nagpur district, and as the Chief Commissioner will doubtless be desirous to have early information as to the possibility of coal being found in them, I will state briefly the results of my examination.

The sandstone of Taklee and Seetabuldee and all which occurs along the edge of the traps to the south of Nagpur as far as the boundary of the Chanda district belongs to beds of later age than the coal-bearing series. The sandstone hills east of Oomrair consist of beds older than the Indian coal rocks. In neither, I think, is there any chance of coal being found. The sandstones of Kamptee, Sillewara, Bokhara, and all met with west and north-west of those places as far as Kailod, also the rocks of Hootkyree and Chorkyree, and probably the sandstones near Bazargaon, belong to the Indian coal-bearing series, but I can find in them no indication of the occurrence of coal, nor of the rocks, such as carbonaceous shales, which generally accompany coal. Indeed there is a very remarkable and unusual absence of carbonaceous matter throughout; even the plant fossils have everywhere lost every trace of carbon.

By far the greater portion of the beds belonging to the Indian coal-bearing series near Nagpur are concealed by thick alluvial soil, and it is impossible to say whether coal exists among the concealed rocks or not. For the reasons just mentioned, I think it improbable that it does occur, so improbable indeed that I cannot recommend search by boring.

Still if it be thought that, in so important a matter, the question should be definitely set at rest, I would point out the following spots where borings to a depth of 200 or 250 feet would explore rocks not visible at the surface:—

1. Bokhara, north of the little hill just east of the village.
2. Sillewara, north of all the quarries. This bore to be stopped at once if metamorphic rocks are reached.
3. Bhuruthwara, at the village.
4. Soonair, in the river.
5. Kailod, south of village.
6. Agra, near Chorkyree, the Nulla west of the village.
7. Shahpore, north-west of Bheead and east of Bazargaon; at the village.

Geological Notes on the Surat Collectorate, Season 1862-63, by A. B. WYNNE, F. G. S.—The Collectorate of Surat lies in the Bombay Presidency on the west side of India between the 20th and 22nd parallels of North Latitude and the 72nd and 74th degrees of East Longitude, Greenwich. Its southern extremity reaches to the Damaungunga river, about 100 miles north of Bombay, and passes between the small maritime Portuguese settlement of Damaun, and a somewhat larger territory called Nuggur Huvellee, about 30 miles to the east, also belonging to the Portuguese. On the west it is bounded by the Arabian Sea, and on the north for some 40 miles by the little river Keem. Beyond the village of Keemchokey the northern boundary becomes irregular, extending, however, generally eastward for 50 miles to the Rajpeepla hills. The eastern boundary of this Collectorate is very irregular: it runs for some 30 miles through the above named hills till it reaches the Taptee river; there it turns to the west with the stream for a few miles, and then strikes off to the south, keeping outside the hilly district called the Daung, and after many bends approaches the sea between it and the Dhurrumpoor country, so that the district becomes of very small width compared with that which it has to the north.

The principal places in the district are the city of Surat and the towns of Bhodan on the Taptee, Turkeesaur and Oolpar in the north, and Nosaree, Gundavee and Bulsar to the south.

General form of the ground.—This district lying, as it does, between the hills forming the northern end of the Western Ghâts range and the sea can only be called hilly in the north-eastern corner, which includes some of the Rajpeepla group. The rest of it consists of one great plain nowhere quite level, in some places undulating sharply, and in others rising into wide, swelling, smooth eminences, and it is here and there at intervals broken by abrupt isolated hills, like those south of Turkeesaur, outliers of the Rajpeepla group; one north of Mota village, a few more on the eastern side of the district, the conspicuous hill of Parneira surmounted by its ruined Mahratta fort, and others at and near Bugwarra. The whole country slopes slightly to the west; it is crossed by numerous streams from the east. And as the tide flows for a considerable distance up the channels of these (in the Taptee, for instance, to beyond Surat), the whole country can have but a small general elevation above the sea probably not more than 150 feet, if so much.

The coast is everywhere low, and for some distance inland in the north part of the district barren, salt and sandy, plains extend. Being thickly populated and much under cultivation the country is only here and there overrun by jungle, which is, however, very dense in some places, chiefly along the streams at the east side of the Collectorate.

In such a country it is difficult to find characteristic features, and yet it has a characteristic aspect produced by the repetition of similarities.

The many undulations of the plains are too slight and too numerous to take any definite direction at a glance, but the larger of them forming the watersheds of the rivers run like the latter more or less east and west; and when the isolated hills take anything of a ridge-like form they run most frequently, like the coast and the neighbouring limits of the hills, more nearly north and south than east and west.

If the plains, however, present few rising grounds as projections they are broken by numerous deep ravines—nullahs and kharries along the courses of the rivers and their tributary streams. These ravines are, of course, deepest towards the sea, but further inland the rivers run between cliffs frequently from 50 to 80 feet in height.

Taken generally the district may be described as flat, with isolated hills in the south, and bordered on the east by a hilly and jungly tract.*

Relations between the form of the ground and its Geological Structure.—These are not so obvious as they at first sight might appear. The reason of this is, apparently, that the limits of the space under description, although embracing a considerable tract of country, are not sufficiently extensive to enable us to generalize.

Certainly as we approach the south the hills are more numerous, and it is ascertained that all the underlying rocks as well as the hills themselves consist of trap. On the east side of the district this is also the case, and glancing at the whole country in the neighbourhood, we find a group of trappean hills (extensions of the 'Western Ghâts' of India) on the east

* Famous for the prevalence of fever at nearly all seasons of the year, and bearing the name of the Daung.

and south, between which and the sea is a wide plain covered to a great depth with cotton soil, alluvium and detrital accumulations, and forming almost the whole of the Surat district. Although the superficial deposits are very thick, the underlying rock occasionally approaches and appears at the surface of the plain, and where it begins to rise almost imperceptibly towards the hills. It is not in all cases found to consist of trap, but in the northern part of the district in the Taptee river and other places, a series of conglomeritic, calcareous, arenaceous and argillaceous, rocks are found dipping at a very low angle westwards, and in some places containing a profusion of nummulites and univalve shells: in others further up in the series they contain large bones, teeth of shark-like fish and vegetable remains as well as other fossils. These rocks have been provisionally termed the *nummulitic series*, and from their very low and sometimes undulating angles of dip, their soft nature and their present position, it seems more than probable that the forces of denudation which must have acted with great power over the whole country reduced the surface of the portion formed of them below that of the harder trappean hills, wearing down these overlying rocks so as to form the basement of the plain. Thus we should expect to find the *nummulitic series* wherever the rock becomes visible in the plains. And this is generally the case; however, large portions of the low ground are so deeply covered by the surface deposits that the rocks beneath are entirely concealed, and as the well known readiness with which trappean rocks yield to the disintegrating action of the atmosphere, &c., may not have differed greatly from that with which the overlying series did so, particularly when, as here, the stratification of both dips in a similar direction at very low angles, it is possible that the line of demarcation between the two formations may be so slightly defined that the place of junction forms no stronger feature in the ground than is traceable here, and is easily concealed by overlying detrital accumulations, although further from the junction where either the *trap* or the *nummulitic series* occupies the whole country *en masse* the characteristic shapes of the ground forming hills in one case, or plains in the other, become very apparent.

The *formations* which occur are—

Recent	Cotton soil.
	Alluvium and river beds.
Tertiary	Nummulitic series.
?	Trap.

Trap.—The lowest of these formations in geological order is the trap which occupies the eastern side of the district, extending into it from the hilly country to the east, nearly as far westwards as Turkeesaur in the north. Its boundary is concealed by the alluvium of the plains, but it would appear to strike south by west so as to come out upon the sea shore near Bulsaar. It forms part of the great trappean group of Central India, and the Western Ghâts, and precisely as in those precipitous and highly picturesque mountains, it is everywhere found to form part of a regularly stratified series* intersected by numerous dykes of very similar material which are frequently porphyritic.

The trap beds or flows, although all very similar, consist of considerable varieties, ranging from solid basaltic trap to soft shaly-looking amygdaloid, the variously sized cavities of which are filled with zeolites of different kinds, and sometimes by transparent or amethystine quartz. Beds which are locally highly ferruginous are of common occurrence, and in many instances these have a red colour, and weather rapidly away into a rusty soil, but in others the action of the atmosphere appears to have hardened them into a variety of laterite. It is sometimes observed that the upper surface of a bed only has the deep red color as if an alteration had been caused by the overflowing trap resting next upon it.

Concretionary structure is very common among these traps, none within this district were observed to be columar, if we except a lateritic mass, which will be alluded to further on. No regular order of arrangement seems to obtain among the traps, the different kinds

* This enormous accumulation of trappean rocks, whether we consider its wide superficial extent or its great thickness, which in the neighbourhood of the Ghâts must exceed 3,000 feet, exclusive of the unknown upper portion removed by denudation, may well excite our astonishment. It is perhaps the largest group of stratified trappean materials in the world, and the vents through which these found their way to the surface have never been discovered. The dykes, although in some places numerous, are very insignificant both in number and quantity compared with the rest of the group, and seem quite inadequate to having afforded exit for the bedded traps, whose regular lines of stratification may be traced by the eye for many miles ranging terrace-like along the sides of the Ghâts' mountains with a parallelism to the horizon and each other, which it seems difficult to separate from the supposition of their having been deposited in water.

lying one upon another, and beds passing from one texture to the other without any kind of sequence, but at several places where from the considerations given above we might infer an approach to the upper portion of the group visible in this country, there is a predominance of the red lateritic beds as the trap rocks first become visible in ascending the streams. Connecting these different points of eminence there would seem to be a zone of ferruginous traps either among the highest trap beds of the Surat district or along the border of the Nummulitic series which rests unconformably upon them.

This zone seems certainly to belong more to the traps than anything else. As an instance, however, of what may be a somewhat analogous occurrence, I may mention that at the unconformable junction of the old red sandstone and silurian formations in the interior of the south of Ireland, the silurian rocks over large districts and to a considerable distance from their boundary, but always apparently in consequence of the vicinity of the old red, change from gray to red and are highly ferruginous; in some places containing veins of hæmatite; this ferruginous appearance increases as the unconformable boundary limit is approached notwithstanding any circumstances of dip or strike in the (silurian) rocks of which it is quite independent; and so plainly is it marked that upon observing it I used to know I was approaching the old red boundary. It has generally been attributed to infiltration from the overlying ferruginous red rocks, and as the nummulitics here contain laterite beds near their base similar causes may have produced like results.

The *Nummulitic series* is the next geological sub-division in the ascending order, resting unconformably upon the traps,* and spreading in gentle undulations under a large portion of the district. It consists of a very varied series of beds comprising hard lateritic ferruginous rocks, coarse conglomerates, dull yellow earthy limestone, sandy and clayey beds, and beds of loosely cemented gravelly conglomerate. The following table compiled from various sections will show the general features of the exposed portion of the series with its preponderance of sandy and gravelly beds above and ferruginous ones near the base:—

Conglomerates, sandstones and hard calcareous breccia.
Yellow limestones, sandy and gravelly conglomerates and shales *(Oyster shells* and *Balanidæ)*.
Calcareous sandstones, gravelly conglomerates, sandy limestone and shales *(fossil wood, shells and spines)*.
Sandy conglomerate, sand layers and ferruginous partings.
Calcareous concretionary clay and pale yellow sandstone *(bone fragments)*.
Sandstone and clays (sandstone containing *plant* fragments).
Agate conglomerates.
Limestone (with *Nummulites*).
Stratified ferruginous conglomerates and sandstones and sands.
Stratified ferruginous sandstones, blue clays and variegated beds.
Yellow ochreous sandy clay, bluish and pale lilac clay.
Shales, sands, clays and sandstones.

The above list indicates the general features only, and is not a detailed representation of any one particular succession. Calcareous beds are often met with, but though these here and there become represented by thin bands of limestone, it was only in one locality (the country about Turkeesaur) that this was observed to occur in sufficient quantity to occupy a large space of ground.

From the position of this series it is difficult to arrive at an estimate of its thickness, which must, however, be very considerable, although the angles are so frequently low, for sections with a vertical thickness from one to three hundred feet may be seen in many of the streams. Many of the beds are highly fossiliferous; some are largely made up of *nummulites*, others of the separated valves of *Balanidæ*, some contain a number of univalve and other shells with which the teeth of sharks, segments of the carapace of a turtle, and of large ribs

* The evidence for this assertion is but small, only one junction, or rather very near approach to a junction, is seen. Here the rocks have the appearance of unconformity, but in other places where the two formations occur at short distances from each other there is reason to believe that the ground is traversed by faults. The deduction is made from the occurrence of conglomerates in the upper series containing agates derived apparently from the traps, also from local appearances and observations upon the same rocks made at a distance from this district.

and portions of other bones as yet undetermined, have been found. From the evidence of the fossils, a '*Parisien*' age has been assigned to this series of beds.*

The *alluvium* includes all the deposits which so extensively occupy the district, concealing and covering up the above-mentioned rocks over the low ground and forming the mural precipices which edge all the larger streams at a little distance from the sea.

It is almost universally composed of a fine light coloured argillaceous loam seldom pebbly or gravelly, and always formed from the decomposition of the local rocks. It sometimes presents lines of stratification, but more frequently is quite amorphous—its only characteristic being that like other Indian deposits of the kind, it contains numerous concretions of impure carbonate of lime (kunkur). Its quantity and depth are its most striking features, and the mass of it appears to be older than that forming the flats along the large rivers, but they pass so insensibly into each other that it is impossible to distinguish one from the other; its surface is frequently moulded into hillocks and vallies over small spaces bearing a very great resemblance to those of the Irish drift, but whether these are the results of mere atmospheric or other aqueous action it is difficult to say.

Associated with this alluvium and generally passing beneath it are numerous beds of recent conglomerate with a calcareous cement, but even of these it is not possible to speak with certainty as to age, for they appear to be in process of formation at present along parts of the coast, and their consolidation might take place at any time; some, however, are old enough to have been cut through by, and to form in places the beds of, the rivers.

Cotton Soil—covers the alluvium over many large tracts of the country, indeed it overlies it almost everywhere upon the open slopes as well as on the flats and in the hollows. It is often of considerable depth, presenting the usual desiccation cracks, but without any circumstances to throw additional light upon its source or formation. It seems in this country at least to be the ultimate result of the decomposition or recomposition of an alluvium largely made up of trappean materials; its colour may be due to decayed vegetation, or to iron or both, and its light loamy or compost-like character to the changes from wet to extreme drought, its great exposure to the influence of the air by means of the deep cracks, and its frequent disturbance by ants, &c., great quantities of whose excuviæ it must contain.

We will now proceed to give some detailed notes of the rocks in various localities, commencing at the north end of the district.

In the country lying about Oolpar the rocks proper may be said to be wholly invisible. The country is covered by alluvium, and only changes its aspect along the sea shore where a belt of salt marsh and barren sandy ground washed by the high monsoon tides forms the coast. The *kharries* or streams for long distances inland are all salt, and efflorescences of the salts of soda and (?) alumina exude from the ground. In the Keem river at Elao and above that village near Sahol, there are hard white calcareous sandstones and breccias, some of which are worked into stones for hand mills at the last named villages. They belong to the upper part of the *nummulitic series*. Near Obah further up this stream the alluvium is worn through by the river exposing yellow limestone and soft yellow clay with ferruginous bands. These limestones occur again in the country to the north-east. More yellow limestone and sandstone with calcareous concretions and ferruginous layers occur: some of these beds are conglomeritic in places and in others strangely cellular, with a knotted and angulo-concretionary

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* The following is a rough list of fossils procured from these beds, in the Taptee river, a little below Bhodan, near the junction of a small stream called the Rhea. They have been identified by Dr. F. Stoliczka:—

Rostellaria Prestwichii, D'Orb.
Terebellum, sp.
Cerithium, sp.
Cypræa (Cypræovula) elegans, Lam.
Natica longispira, Leym.
Conus, sp. (near *C. brevis*, but thinner).
Trochus, sp. (like *T. mitratus*, Desh.).
Pholas, sp.
Pecten Hopkinsi, D'Arch. and Haime.
" *Favrei*, D'Arch.
" *corneus*, Sow.
Vulsella legumen, D'Arch. and Haime.
Ostrea Flemingi, D'Arch.
" *lingua*, Sow.
Hornera, sp. (near *H. verrucosa*, M. Edw.).
Echinanthus, (fragments).
Cidaris, (spines).
Fragments of other *Echinidæ*.
Stylocœnia Vicaryi, M. Edw. and Haime.
Trochoseris (?)
Trochocyathus Vandenbeckii, M. Edw. and Haime.
Nummulites perforata, D'Orb.
" *Brongniarti*, D'Arch.
" *exponens*, or *spira*, (probably both).

The 'bone fragments' were portions of ribs, &c., not in a state sufficient for identification.

structure. The alluvium in the river banks is here only about 15 feet thick. Conglomeritic and calcareous beds are seen occasionally from this to Kuthoora near Keemchokey, where one of the latter contains several shells, portions of spines, &c. Calcareous beds occur again in the Keem river, about 3 miles above Keemchokey.

Near Turkeesaur is a considerable exposure of light buff and gray nummulitic limestone and agate conglomerate. A low range of hills rises near this town and stretches southwards to the Taptee; they are formed of ferruginous or lateritic beds intercalated between agate conglomerates, and having a low dip to the west, they pass beneath the limestone just mentioned, which, however, is traceable along their flank and re-appears in the Taptee river at the end of the range, being let down by a fault to a lower level, but preserving its westerly dip, and seen to be overlaid again by another band of laterite.

From this eastwards the country, which now becomes hilly, forming part of the Rajpeepla group, is all occupied by the traps, amygdaloids, &c., already described in general terms and possessing no variety except a curious pale flaggy band which extends from near Ooskir to Monjelao. The Taptee river at Bhodan and above it for many miles exposes the traps which are seen to have a very general but low and undulating dip to the west, and to be intersected by numerous dykes of dark green-gray porphyry and solid trap. From Gulla to Palree the rocks of the nummulitic series overlying those of the Turkeesaur neighbourhood are seen in the banks of the river; they consist of fine gravelly conglomerates, calcareous beds, and fine smooth pale gray mudstones. The latter were not found to be fossiliferous, but the others contain many bones, fossilized timber, univalve and bivalve shells, the teeth of sharks, and plates of the carapace of turtles. The finest locality for fossils, however, is in the limestone let down by the fault, near a ruined village on the north bank of the Taptee, about 3 miles east of Gulla.

In the neighbourhood of Surat city the country is covered with the fine brown alluvium, which extends all over this part of the district and eastwards for many miles beyond Mota along the valley of the Taptee.

An isolated hill, rising to a height of about 100 feet from the alluvium 4 miles north-north-east of Mota, is formed of compact and brecciated laterite of very similar character to that occurring east of Gulla; its beds appear to undulate nearly horizontally. A small quarry in the east side of the hill exposes a soft purple and white mottled rock like a decomposed and lateritified amygdaloid, in which occur sub-angular lumps of red hæmatite.

More red lateritic beds occur interstratified with the traps in the river due south of Mota and below Bordolee. Eastward of this the country rises and undulates, and the usual kinds of gray traps and amygdaloid are seen along the streams and protruding from the surface of the ground.

The Poorna river exposes the traps at Muhoowa, and above and below this place they are of the usual kinds with some reddish beds, and the last seen as the river enters the alluvium near Kohureea are associated with red lateritic beds.

In the Umbeeka river which flows from Wulwarra past Gundavee the traps are also exposed, and likewise a quantity of recent conglomerate. This river affords a good example of the character of all the streams in this country, the banks wide apart formed sometimes of alluvial cliffs and sometimes sloping into the stream, the bed of which is often rocky, and in the dry weather contains but a rivulet, here trickling among the stones and again forming still deep pools. Several instances of the manner in which the traps yield to the abrading forces occur, amongst which alternations of hard and soft beds (as at Nagthera near Poonea), frequently present most varied outlines.

North of Gundavee at a bend in the Poorna river there is a quantity of red lateritic rock, which from its peculiar prismatic jointing assumes a columnar appearance when viewed in one direction. It seems to dip to the north at 15°, and a few yards above it in this direction with a similar dip are some red shales and a band of loose conglomerate or coarse sandstone a foot thick which probably belongs to the upper series. Unfortunately very little of these rocks is seen projecting from the alluvium, but although the want of a good section is felt, there is little doubt that the boundary of the two groups passes near the place and perhaps includes the lateritic rock in the Nummulitic series.

At a little more than 100 yards north of this spot parts of the skulls and several bones of two human skeletons were found exposed in the alluvial cliff on the left bank of the river,

at a depth of several feet from the general surface of the ground and 18 inches below the local surface, which in this place seemed to have been excavated by rain.*

From this neighbourhood the alluvium rapidly becomes thin to the east, and although it does not possess any marked natural boundary, it is seen to grow narrow towards the south, the trap country approaching the coast and the plain becoming dotted with hills all formed of trap. High ranges of hills are seen away to the east and south beyond the limits of our district and trap rocks occur in all the rivers. Some of the isolated trap hills rise to a considerable height. That at Parneira, the most conspicuous among them, roughly measured by a barometer is at the summit nearly 200 feet above the plain at its base, but it looks much higher. The trap of this country does not differ from that stretching along the whole of the east side of the district, and although it is not to be seen everywhere, there is no want of evidence to show that the whole country is composed of it. Dykes are perhaps more numerous than in several other parts of the district: where the Railway crosses the Damaun river and where there are a great number, their general direction approximates to north and south.

From near Teetul on the coast west of Bulsar and re-appearing at intervals to the south, is a growing deposit of recent conglomerate formed of the materials of the beach cemented by carbonate of lime; it is stratified, the strata dipping at a low angle seawards, and the dead shells which it contains have been in many instances completely fossilized and replaced by carbonate of lime even when they happened to be a large variety of *Murex*, whose shell is very thick; but in few instances, if any, was the interior of the shell filled up by either sand or the cementing matter.

ADDITIONAL OBSERVATIONS REGARDING THE CEPHALOPODOUS FAUNA OF THE SOUTH INDIAN CRETACEOUS DEPOSITS, by *Ferd. Stoliczka*, Esq., Ph. D., Palæontologist, Geol. Survey, India.

Since the completion of the volume on the *Cephalopoda of the cretaceous rocks of Southern India*,† at the end of 1865, several additional observations have been made regarding this portion of the fauna. No fresh materials have been procured, but having had last year the opportunity of examining, in London, Prof. Forbes' original collection, made by Messrs. Kaye and Cunliffe, and also in different European Museums a large number of other species with which Indian Cephalopoda have respectively been identified, I have obtained additional information of various kinds. Some of this is very important, inasmuch as it throws a new light upon the determination of the species, requiring alterations in the names, &c.; it appears, therefore, desirable that these changes should be noticed at an early date. The observations must be considered as a supplement to the volume on the Cephalopoda, already published.

NAUTILIDÆ.

NAUTILUS, *Auctorum.*

NAUTILUS DANICUS, *Schlotheim.*—(Ceph. l. cit., p. 24 and 208).

Nautilus delphinus, Forbes (Trans. Geol. Soc., Lond., 1846, VII, pp. 98 and 99), which was described from two specimens in Messrs. Kaye and Cunliffe's collection of Pondicherry fossils, must be considered as identical with the above species. Forbes' figure on p. 99 is reduced to one-half the natural size, being taken from a larger specimen, which is, however, very much corroded at the surface. In consequence of this erosion the outline of the septa became rather different and the thickness of the whorls has decreased. Both the specimens and also some others in our collection appear to have had originally the whorls somewhat more flattened laterally than typical *Naut. danicus* usually have them, but there are again in our collection some other specimens which fully agree with Sowerby's original figure in Trans. Geol. Soc., Lond., 1840, vol. V, pl. 18, figs. 4-7. Another apparent distinction of

* There appeared to be no trace of a burial ground on the bank of the river here, and the lower extremities pointed in the direction in which the stream runs, but as the natives of India are often buried near wherever they happen to die, while some castes bring dying people to the rivers, it is thought more safe merely to record the fact, than to build any geological theory upon so questionable an occurrence.

† Palæontologia Indica, Vol. I, 1866.

the two original specimens of Prof. Forbes is the small number of septa, one of the specimens having 10 and the other 12 of them, while of two specimens of *N. danicus* from Rügen, in the Geol. Soc. collection, one has 16 and the other 18 septa. I have compared all our available specimens of this species, and I find that the number of the septa appears greatly to vary. Inflated specimens usually have a smaller number of septa, as few as 10 in one circuit, but this number always increases in somewhat greater proportion with the size of the shell; more compressed specimens usually have 16—20, but occasionally as many as 24 septa, these being arranged much closer to each other the more they approach the body whorl.

AMMONITIDÆ.

AMMONITES, *Auctorum.*

AMMONITES BLANFORDIANUS, *Stoliczka*, Ceph. l. cit., p. 46.

This species is closely allied to some of the compressed varieties of *Am. varians*, but always distinguished from it by a much narrower back, higher and serrated keel; the septa are in both species almost identical, but appear to be a little less serrated in the Indian fossil.

Am. varians and *Coupei* stand in about the same relationship to each other as do *Am. Mantelli* and *Am. navicularis*.

AMMONITES ROSTRATUS, *Sowerby; Am. inflatus*, Sow., Ceph. l. cit., p. 48. This last name must be replaced by the former, inasmuch as it is not only more characteristic, but also has priority, the species having been first figured and described under the above name.

AMMONITES SIVA, *Forbes*, Ceph. loc. cit., 39. The terminations of the saddles of this species are phylliform, exactly as in the *HETEROPHYLLI*, for which Suess proposed the name *Phylloceras*.

AMMONITES REMBDA, *Forbes*, Ceph. loc. cit., p. 63.

One of Forbes' specimens of *Ammonites Durga* is a young shell of this species, having the upper layer of the shell removed and the keel therefore obsolete. The specimen figured by me (loc. cit., pl. 71, fig. 5) as a young specimen of *Am. Durga* also belongs to *Am. Rembda*.

AMMONITES IDONEUS, *Stoliczka*, Ceph. loc. cit., p. 64.

Another specimen apparently of this species has been subsequently found in the greyish, siliceous sandstone from near Andoor. It is about the same size as the one figured on plate 36, but has no trace of tubercles, the transverse ribs becoming, however, somewhat obsolete at the centre of the back. It is also slightly irregularly coiled at the inner edge of the umbilicus, giving the shell an appearance of a young *Scaphites*.

AMMONITES VICINALIS, *Stoliczka*, Ceph. loc. cit., p. 84, pl. 44.

It is, as formerly stated, very doubtful whether this species is distinct from *Amm. Saxbii*, Sharpe. I have compared the original of the English fossil, which in general character fully agrees with the Indian species, merely differing from it by a larger number of intermediate shorter ribs and a more squarish section of the whorls, while all our specimens of *Amm. vicinalis* are conspicuously compressed towards the back. Until more and better preserved specimens of the English species have been found they cannot be pronounced to be identical; the outlines of the lobes are in both the same.

AMMONITES DISPAR, *d'Orbigny*, Ceph. loc. cit., p. 85.

I have seen a specimen of this species in a collection of fossils of the Hanoverian cretaceous deposits in the Museum of the Mining Institute at Berlin.

AMMONITES GUADALOUPÆ, *Römer*, Ceph. l. cit., p. 90.

Römer's original specimen, which is in the University collection at Bonn, is rather badly preserved; it has the umbilical tubercles somewhat more distantly placed from the suture, than in most of our specimens, but this does not appear sufficient to be a specific distinction between them.

AMMONITES ORBIGNYANUS, *Geinitz*, Ceph. loc. cit., p. 92.

Young specimens of this species have a few small, sharp tubercles at the edge of the umbilicus, and the lateral ribs being strongly flexuous on the outer half of the whorls become

almost obsolete on the inner one. Our fossil perfectly agrees with Geinitz's original specimens in the Museum at Dresden.

AMMONITES SUBOBTECTUS, *Stoliczka*, Ceph. loc. cit., p. 96.

In Sharpe's collection, presented to the London Geological Society, there are one large specimen and three fragments of *Am. obtectus*. The row of tubercles in the middle of the back is distinctly traceable, though it sometimes appears to become obsolete; the transverse ribs are present in the same number as the lateral ones; the distinction mentioned (loc. cit., p. 97) as existing between the European and the Indian fossils must, therefore, be retained.

Ammonites Cunliffei, Forbes, Ceph. loc. cit., p. 97, is a *Scaphites*, and will be noticed subsequently.

AMMONITES PAVANA, *Forbes*.

1846. *Ammonites Pavana*, Forbes, Trans. Geol. Soc., Lond., VII, p. 110, Pl. VII, Fig. 5.

Amm. testa compressa, lateraliter applanata, moderate umbilicata, costis flexuosis prope marginem dorsalem sub-tuberculatis, longioribus et brevioribus alternantibus, ornata; dorso obtuso, paullulum rotundato et lateraliter compressiusculo.

Height of outer whorl	: the whole (considered as 1·00)	... ...	0·50.
Width of umbilicus	: ditto ...	" " "	0·29.
Thickness of whorl	: its height	" " "	0·42.

Prof. Forbes' original specimen, though not very perfect, appears to be distinct from all other *Ammonites*, as yet known from the South Indian cretaceous deposits. It has the appearance of a young *Scaphites*; but for this the shell is too regularly coiled, and besides most of the species of that genus have the ribs at the back generally recurved, not bent (or at least not so strongly) anteriorly. The lateral ribs are in *Am. Pavana* strongly flexuous, double curved, becoming gradually thicker towards the edge of the back, where they are provided with small tubercles; obsoletely continuing across the back, which is obtusely rounded; each long rib alternates with one or two shorter ones.

The specimen appears to be from the *Arrialoor sandstone* near *Pondicherry*.

AMMONITES GANESA, *Forbes*, Ceph. loc. cit., p. 106.

Amm. Soma, Forbes (Trans. Geol. Soc., London, 1846, VII, p. 102, pl. VII, fig. 7) must be considered as a synonym of the above species, the name having been proposed for a young specimen of the same. Forbes' remark on the tablet of the original specimen in the London Geological Society's collection was already to that effect.

AMMONITES INDRA, *Forbes*, Ceph. loc. cit., p. 112.

Amm. Garuda, Forbes (Ceph. loc. cit., p. 149, pl. 74, fig. 5) is, remarkably enough, only a young specimen of the above. There are three specimens of this species in the London Geological Society's collection; all show the furrows on the back. The young shell has really a very different aspect from the old one, inasmuch as the whorls begin to increase very rapidly in width as soon as the specimen has attained a certain size. The specimen figured as *A. Garuda* has a markedly large umbilicus. The outlines of the septa are quite the same as those of *Am. Indra*.

AMMONITES VELLEDÆ, *Michelin*, Ceph. loc. cit., p. 116.

Amm. Nera, Forbes (loc. cit., p. 106, pl. 8, fig. 7) is only a young specimen of the above European species.

AMMONITES KOLOTURENSIS, *Stoliczka*, Ceph. loc. cit., p. 127.

Amm.? indicus, Forbes (loc. cit., p. 114, pl. 8, fig. 9) may be a fragment of a whorl of the above species, but the original is so much mutilated that it is impossible to form any decisive opinion. The fragment is valueless in point of identification.

AMMONITES DIPHYLLOIDES, *Forbes*, Ceph. loc. cit., p. 119.

The specimen described by me, loc. cit., p. 120, pl. 59, fig. 12, under the name of *Amm. Yama*, Forbes, is identical with the above species. It has the shell partially preserved, and the transverse furrows consequently not traceable; the difference then pointed out as existing between the division of the sutures was due to the small diameter in which the sutures were observed on that specimen. The original specimen of *Amm. Yama*, Forbes, is the same which I have referred to *Amm. Beudanti*, which now must stand under the former name, being distinct from the European fossil.

AMMONITES VAJU, *Stoliczka*, Ceph. loc. cit., p. 132.

Prof. Geinitz in Dresden directed my attention to a few specimens in his Museum, being apparently identical with those described under the above name, but on the other hand not easily distinguishable from *Amm. peramplus*. The relations of the two species are indeed remarkable, and *Amm. Vaju* would only seem to be a compressed variety of *Amm. peramplus*, still the distinctions pointed out by me (loc. cit., p. 132) are remarkably constant; none of our specimens of the former had the distinct furrows of the latter developed; besides this the direction of the ribs in both species also is somewhat different. Until more specimens of the present form have been found the specific distinctions must be retained.

AMMONITES YAMA, *Forbes*,

1846. *Amm. Yama*, Forbes, Trans. Geol. Soc., London, 1846, VII, p. 107, Pl. VII, Fig. 4; not *idem*, Ceph. loc. cit., p. 120.
1865. *Am. Beudanti*, Brong., Stoliczka, Ceph. loc. cit., p. 142.

I am indebted to my friend Prof. Hebert in Paris for having directed my attention to the most constant and distinguishing character of the European Gault species, *Amm. Beudanti*, Brongn., as compared with our Indian species, which in general differs from the former by having the whorls less high compared to their width, laterally a little more convex, along the back not contracted, and the umbilicus slightly larger in proportion. There are, however, of the European fossil occasionally specimens to be found, which are extremely closely allied to our species, and only differ by a scarcely traceable greater compression of the whorls (compare Pictet's figures in Pal. Suisse, 2nd Series). The most important difference between the two species lies in the form of the outline of the septa. Those of *Amm. Beudanti* are comparatively broader, less high, and the laterals gradually diminish in size as they approach the umbilicus, on the edge of which the sixth lateral saddle is situated; only one or two very minute ones are present on the umbilical slope. In our Indian species the outlines of the septa have higher, more ramifying saddles and lobes, and the third lateral saddle lies on the edge of the umbilicus, there being at least three additional and very oblique saddles situated on its sloping side. All the lobes of *Am. Beudanti* are arranged in an almost straight line, while those of the present species form a distinct curve. The number of the septa is tolerably well marked in d'Orbigny's figure in the "Pal. Francaise."

Prof. Forbes' original specimen of *Amm. Yama* is a young shell of the present species, and I therefore retain the older name, which appears the more justifiable, as the specimen which I have previously (loc. cit., p. 120) described under that name has proved to be only a somewhat abnormal form of *Amm. diphylloides*.

AMMONITES SACYA, *Forbes*, Ceph. loc. cit., p. 154.

The species described by Coquand from the cretaceous beds of Algiers under the name of *Amm. Pauli* is probably a young shell of this species (Geol. and Pal. Province Constantine, 1862, pl. 35, figs. 1-2).

SCAPHITES.

SCAPHITES CUNLIFFEANUS, *Forbes, sp.*

Ammonites Cunliffei, Forbes, Ceph. loc. cit., p. 97.

Scaph. testa lateraliter compressa, costis ad intervalla fortioribus, flexuosis, numerosis brevioribus ac tenuioribus interpositis ornata, primis ad marginem umbilicalem et dorsalem acute tuberculatis; anfractibus junioribus regulariter involutis, ultimo antice paulo-extenso, dorso subconvexo.

The original specimen figured by Forbes in Trans. Geol. Soc., London, 1846, VII, pl. 8, figs. 2 a and 2 b, is unmistakably a *Scaphite;* it has the last whorl somewhat more produced at the umbilical line, than is shown in the figure. The shell is flattened laterally, ornamented with numerous flexuous ribs, which terminate in sharp tubercles at the edge of the back and of the umbilicus, the former being slightly rounded; the sides of the umbilicus are perpendicular.

The young shell has the lateral ribs more straight, and the tubercles on the umbilical edge almost obsolete (see pl. L, fig. 3).

The outline of the sutures, as represented in fig. 3 c, pl. 50, is also characteristic of a *Scaphite*, there being only the first and second lateral lobe present, while the auxiliary lobes and saddles rise suddenly in an oblique line towards the umbilical suture.

SCAPHITES SIMILARIS, *Stoliczka.*

1866. *Scaphites æqualis*, Sowerby, Stoliczka, Ceph. loc. cit., p. 167, Pl. LXXXI, Figs. 4-6.

I have compared in the British Museum the original specimens of Sowerby's *Sc. æqualis* and *obliquus* as recorded in that author's Mineral Conchology; the figures are in general correct. The inner whorls of both the species are usually of the same thickness and not to be distinguished from each other, but the form described as *Scaph. æqualis* has on the last whorl the transverse ribs less numerous, thicker, the sides somewhat more flattened, and the general form is usually a little longer than in *Scaph. obliquus*. Both are very closely allied, and, when examining numerous specimens in Sharpe's collection and others in Paris and Dresden, the frequent occurrence of the two forms together in the same beds and the same localities so very much struck me that I thought they very probably only represent different sexes of the same species. Still so long as the distinctions, formerly noticed, exist, and no other direct proof in favour of their specific identity can be produced, we cannot but retain them as distinct forms under separate specific names.

The species which I have noticed as *Scaph. obliquus* (Ceph., p. 168) is in every respect identical with the European form, but the other which I have identified with *Sc. æqualis*, and for which I now propose the name *Sc. similaris*, is distinct from it, though it undoubtedly must be regarded as a representative species. It differs from *Sc. æqualis*, by having the first whorls less involute, flattened at the sides, almost smooth, and by the want of the peculiar projection in the umbilical space at the base of the body-chamber, which projection is distinctly traceable in both the European species. *Scaph. similaris* also appears to be a more compressed form than *Sc. æqualis*.

ANISOCERAS,* *Pictet*, Ceph. l. cit., p. 170.

ANISOCERAS RUGATUM, *Forbes*, Ceph. loc. cit., p. 178.

Anisoceras sub-compressum, Forbes (Ceph. loc. cit., p. 179, pl. 85, fig. 7) is based upon a fragment of the above species. Forbes' figures of *Anis. rugatum*, *sub-compressum*, and *indicum*, are taken from fragments which do not exactly agree with the specimens in the London Geol. Society's collection, so far as the form of those specimens is concerned, but there are fragments of all the species represented in the collection. Some of the specimens determined by Forbes as *Anis. sub-compressum* belong to *Anis. indicum*.

TURRILITES, *Lamarck*, Ceph. loc. cit., p. 184.

TURRILITES PLANORBIS, Forbes, Ceph. loc. cit., p. 185.

This name has most likely been applied to a small cast specimen of *Amm. Sacya*, Forbes, of which I found several small specimens, but I have in this single instance not succeeded in procuring Forbes' original specimen, from which fig. 5, pl. 9, in the Trans. Geol. Soc., London, was taken.

TURRILITES, *Conf.*, BRAZOENSIS, *Römer*, Ceph. l. cit., p. 189.

Römer's original of *Turr. Brazoensis* is very like our fossil, but it shows a slight difference in the direction of the ribbings connecting the tubercles; still their identity is very probable; neither of the two respective fragments are, however, sufficiently preserved to give a direct proof of this assertion.

HAMULINA, *d'Orbigny*, Ceph. loc. cit., p. 192.

HAMULINA SUBLEVIS, *Stoliczka*, Ceph. loc. cit., p. 193.

I have seen specimens of this species in the National Museum at Prague; they were collected from the lower beds of the Bohemian cretaceous deposits at Korizany.

Summing up the most important changes regarding the different species, it will be observed that *Ammonites Pavana*, Forbes, has been newly added to the list of the Cephalopoda;

* My friend Prof. Gabb writes word, under date of June 2nd, 1868, Philadelphia, that he has a new form, intermediate between *Anisoceras* and *Ancyloceras*. He also suggests a new generic name for species like *Ptychoceras Forbesianum*, distinguished by having two links, but it seems to me that our materials of good specimens of *Ptychoceras* are hardly sufficient to support any essential changes in the nomenclature of these and others allied Ammonitoid forms.

the species formerly described as *Amm. Beudanti* is different from the European fossil, and has to stand under the name *Amm. Yama*, while the specimen formerly noticed under that name is identical with *Amm. diphylloides*. Several other species formerly described by Forbes under the names of *Amm. Soma*, *Amm. Nera*, *Garuda*, and others have been found to be identical with other known species; the specific name *Amm. inflatus* has to be replaced by that of *Amm. rostratus*; *Amm. Cunliffei* is a *Scaphite*, and the species noticed as *Scaph. æqualis* has to be changed to *Sc. similaris*, n. sp.; and last *Anisoceras sub-compressum* has been found identical with *Anis. rugatum*.

These changes reduce the number* of Cephalopoda from 148 to 146, three species having been identified with others, but one was newly added; the genera represented are, *Belemnites* with 3 species, *Nautilus* with 22, *Ammonites* with 91, *Scaphites* with 4, *Anisoceras* with 10, *Helicoceras* with 1, *Turrilites* with 6, *Hamites* with 2, and *Hamulina* with 1, *Ptychoceras* with 3, *Baculites* with 3. The list of the 38 species identical with those of Europe and other countries must be reduced by one, for though *Amm. Yama* and *Sc. similaris* must now be considered respectively as distinct from *Amm. Beudanti* and *Sc. æqualis*, I have recorded the occurrence of *Hamulina sublevis* in the Bohemian cretaceous deposits.

LEAD in the district of RAEPORE, Central Provinces.—In the month of May last, a specimen of lead ore was received from the Deputy Commissioner of Raepore, with a request for information as to its nature and value. It was stated by Captain Twyford to be found extensively in the hills between Raepore and Balaghat, and also near Chicholee, where there is a Dâk Bungalow on the great eastern road. On examination it proved to be galena in crystalline masses imbedded in green fluor-spar forming a vein in quartz. On assay only a trace of silver was found to be associated with the lead. The impossibility of forming any idea of the commercial value of a metallic vein or lode from a hand specimen was also noticed.

Subsequently very similar specimens were forwarded by Colonel J. E. Gastrell, Deputy Surveyor General, together with copies of letters from Mr. R. B. Smart, Revenue Surveyor, who had collected these himself on the spot. He describes the locality thus: 'The hills in which the ore is found are situated in the lands of Khyragurh and Nandgaon, and three miles to the west of Chicholee Dâk Bungalow, near the village of Raneetalao, and Nandga. The hills consist of large masses of quartz imbedded in black earth. The metal runs through the quartz in veins and crusts.' Mr. Smart considered it to be not galena, but the tersulphide of antimony.

These better specimens enabled us to cupell a larger portion of the ore, but with the same results; the amount of silver present, although appreciable, is not sufficient to be of any practical value. There is no antimony present. Fluor-spar is more abundant than was at first thought, and the colour is quite as frequently of a rich purple as greenish.

From Mr. Smart's description the specimens sent appear to have been derived from loose blocks, but there can be no question that they formed part of a regular vein, which must have existed where these loose blocks were derived from. And in all probability this was at no great distance from the spot where they were found. It will be desirable to trace out this lode, and prove its extent or value. It looks, both as to rock and gangue, decidedly promising.—*July* 1868.—(T. O.)

COAL IN THE EASTERN HEMISPHERE.—The vast importance of any local supplies of coal in the eastern seas, both as bearing on the development of navigation and commerce, and as tending to relieve the intensity of the strain on the limited resources of Great Britain, from which hitherto most of the supply has been derived, renders peculiarly interesting at the present time any trustworthy information regarding the various sources from which coal may possibly be procured, their exact locality, probable extent, and the character and value of the fuel obtainable. We have therefore abstracted, as briefly as possible, a paper

* Those like *Amm. Soma*, *Amm. Nera*, *and pavana*, etc., were not included in my paper published in Quart. Journ. Geol. Soc., London, 1865, vol. XXI, p. 408.

by Cuthbert Collingwood, M. B., on the Formosa, Labuan, Siberia, and Japan coal, which is printed in the Quar. Jour. Geol. Soc., London, No. 94, May 1st, 1868.

Formosa coal district is near Kelung, in north-east corner of island. Mines, about one mile to east of town, on the hills bordering on Quar-se-Kau Bay, are reached by boat. Leaving the boat you pass a range of red sandstone hills, dipping about 16°-17° to south-east. All the country around Kelung is of red sandstone, the weather-worn outcrops forming the depression in which the coal appears to have been deposited. The workings when visited consisted of two small caverns at right angles to each other in the coal-seam, which was, at outcrop, 2½ feet thick. It rested upon a thin bed of stiff whitish clay, and was covered by a bank of rubbly clay, 40 to 50 feet high. Workings were nearly on the level and of very primitive kind. No machinery is used, no shafts are sunk; the coal is picked out and removed in small baskets to boats, by which it is conveyed to the harbour and is deposited in the coal-stores, where it is not in any way protected from the weather, and rapidly deteriorates. The mines are exclusively worked by Chinese. Coal is of recent formation, and lies over the sandstone.

Another thin seam of indifferent coal was seen near the town of Skiddow, about the middle of this part of the island, 'over which was a bed of stiff clay, abounding in large 'oyster-shells, seven or eight inches long, of a species (probably the recent *Ostrea Canadensis*), 'which I have seen brought to Canton in vast numbers for the purposes of lime-making.'

The Kelung coal is light, burns very rapidly, and gives out a great heat, so that it readily sets the funnel on fire. It is extremely dirty, produces a vast number of blacks of a soft and soiling character; the flues get rapidly very foul, requiring frequent cleansing. It leaves 50 per cent. of ash: its cheapness being therefore doubtful.

The *Labuan* coal-field is in a dense jungle, where the coal crops out conspicuously not far from the sea. The coal district is chiefly composed of a soft yellow sandstone, dipping 30° north by east. There are several seams of coal; the lowest is 11 feet 4 inches thick, but in quality this is not the best seam. The coal roof is a stiff blue clay, not fire clay. The highest seam is 4 feet 6 inches in thickness; the second 2 feet 9 inches; the third is 3 feet 9 inches; the fourth 11 feet 4 inches. Above this fourth seam there are 8 fathoms of grey shale in which fossil shells are occasionally found. There are two shafts, one to the first seam, and the other 45 fathoms deep. A third is being put down, which will go to 100 fathoms. There are also 7 or 8 level workings. There is great difficulty in getting labour. Nominally the Company have 600 of various nations, but only 300 are at work. The present out-turn is 80 tons per day. This is conveyed down a tramway, less than a mile in length, to the coaling pier. With more labour it is said 200 tons per day could readily be raised.

Labuan coal is better than that from Kelung, heavier, close grained, tolerably clean, very free from sulphur, and forms but little clinker. It burns fast, gives out much heat, flames issuing from funnel often extending 6 or 8 feet, and endangering the rigging. It produces a large quantity of soot, which renders everything filthy. It would seem to be like the Kelung coal, a *lignite*. Mr. Low, of Labuan, states that he has found in "the stiff "clay roof of some of the seams impressions of leaves in very perfect preservation identical "with those of trees at the present moment growing in the jungle."(?) There are in the coal itself frequently found tears of 'pure Dammar resin', and the Dammar pine is still a common tree. On one occasion a mass, 6 lbs. in weight, was found. It has a remarkable tendency to occur in veins.

Petroleum is found in immediate vicinity of coal districts, both at Kelung (Formosa) and at Labuan. The Chinese also have an idea that Formosa is rich in gold; gold has been found. There is a petroleum spring not far from the mines; in Labuan a pathway to the spot in the jungle has been cleared, but no workings have been undertaken. There are other springs in the neighbourhood.

Russian coal.—This is at Possiette on the coast at south point of East Siberia, and at Dui on the island of Saghalien, at the head of Castries Bay. The latter is a convict settlement; the coal is worked by the convicts, and used solely for the Russian ships of war. This coal is small, of excellent quality, presents longitudinally a conchoidal, and transversely a cubic fracture, like Welsh coal, producing a moderately dense dark brown smoke. Steaming qualities said to be equal to Newcastle coal, and owing to its caking qualities it would probably burn very well mixed with any small Welsh coal, too small to burn by itself. Amount of ash, cinder, and soot 20 per cent.

The Possiette coal has a vitreous fracture, more like English Cannel coal, is very bituminous, and burns quickly; leaves a large residue of whitish brown ash, with a moderate quantity of clinker; deposits soot much more than Newcastle coal.

The Dui coal appears to be a lignite.

In *Japan* also several kinds of coal occur, only small quantities are obtained, and the Daimios will not allow it to be sold for public use, so that not much is known regarding the qualities of the coal. There are five kinds, known as Gorio, Hirado, Korkora, Emakbodkh, and Korgah, which appear to possess good qualities. And several others which are very inferior, forming an immense quantity of clinker, and unfit for steaming purposes, though no doubt valuable for domestic use.

The Korkora coal is of two qualities; one inferior, dirty brown, showing thin red layers when broken and conchoidal in fracture. The better kind is bright, clean and hard, liable to form clinker, so that it was found desirable to increase the apertures between the fire-bars with the ordinary tubular boilers. It resembles Sydney coal in appearance, and appears to have a waste (ash, soot, and clinker) of about 30 per cent.

Korgah coal recently brought to Nagasaki is very similar in appearance and quality.

Emakbodkh coal shows clayey layers, and conchoidal laminations of a white calcareous substance, either carbonate or sulphate of lime. This scaly appearance is characteristic. It burns well, though with much smoke.

Hirado coal is either hard or soft. The soft kind cannot be used for steaming, as it is reduced to powder by being shaken up in the bunkers, otherwise it is a good coal. Of the harder coal there are two varieties; one abounds in earthy matter and silica, producing a vitreous glaze on the clinker, and the other is light in appearance, resembling Welsh coal, and contains about 72 per cent. of carbon. It has a cubical fracture. Consumption is about ¼ more than best Welsh coal, with which, however, it might be advantageously mixed.

The best of the Japanese coals is the Gorio; a clean hard cubical coal, like Welsh, and with 73 per cent. of carbon. Only small quantities, however, have been brought to Nagasaki; and the mine has fallen in in consequence of heavy rains, so that some time will elapse before the old workings can be made use of.

A remarkable coal has been brought in small quantity from Ivanai, in the north part of Nipon, where there appears to be a large mine of it. The Daimio to whom it belongs is not friendly to foreigners, and the coal is therefore procured with difficulty. The coal is worked by the Japanese. It is a clean highly bituminous coal, and will burn with flame in the light of a candle. "It appears like the rest to be a lignite." Quar. Jour. Geol. Soc., London, Vol. XXIV, p. 98.—(T. O.).

METEORITES.—Through the kindness of Dr. M. Hörnes, Director of the Imperial Mineral Cabinet, Vienna, we have received a valuable addition to our series of meteorites. This is a very fine specimen of the fall which took place near Pultusk in the vicinity of Warsaw on the 30th of January in the present year.

Through the Austrian Consul General in Warsaw Dr. Hörnes had procured a specimen, the third largest which fell. This was divided into three parts for examination, and of these three Dr. Hörnes with his usual liberality has sent to me the second in size. It weighs 6oz. 398grs. The largest specimen which fell was in possession of a private party; the second largest went to the Imperial Mineral Collection in St. Petersburgh.

The fall occurred on the river Narew, about half way between Pultusk and Ostrolenka, about 36 English miles north-east of Warsaw. The stone sent to Vienna was actually picked up in the village of Sielč Nowy.

Dr. W. Haidinger, in a brief notice of this fall (read to the Imperial Academy of Sciences at Vienna on 12th March 1868) says: "From the various reports which have appeared, it is clear that we have here again to deal with a truly magnificent phenomenon, beginning as a shooting star, afterwards appearing as a fireball of half the diameter of the moon, then vast detonations, at last a fall of meteoric stones, over a tolerably large extent of ground."

'The stone received in Vienna was perfect, that is, it was covered on all sides with a distinct crust, but at the same time, judging from its shape, it was truly an angular fragment of a rock-mass, which burst long prior to its reaching our atmosphere. It was a somewhat conical fragment, rather sharply angular in one direction, where the sides, 2 to 3 inches broad, meet at an angle of about 60°. In the other directions, the three sides meet at angles of from 90° to 105°.'

'The surface is rather uniformly coated with a crust of about $\frac{1}{100}$th of an inch in thickness. This black crust is dull, fine grained, and on all planes covered with the well known and characteristic round shallow impressions. The stone was about 4 inches long, 3 broad and 2 thick. One side was rough, the other more even, before the incrustation, but both are similarly incrusted. Even at the sharp angles, no molten edges are traceable which would indicate that the stone had passed through the atmosphere only in a given direction.'

'The fresh fracture of the stone, and especially the cut and polished surfaces, showed that the stone undoubtedly belonged to the group of falls indicated by Partsch, and including Eichstädt, Barbotan, Bielaja Zerkow, Timochin, Zebrak, Gross-Divina, to which must since be added Pokra (Bustee). These are all grey, more or less dark coloured, locally brown, with more or less globular portions distinguished from the rest of the mass by a nearly black colour with much finely divided iron, a little pyrites, and probably troilite. The Pultusk stone is very similar to that from Gross-Divina. Its specific gravity is 3·660 (Schrauf.), which indicates the large proportion of iron it contains. The average specific gravity of the group was determined by Partsch as 3·55 to 3·70.'

The stone would belong to the third class, *sporadosidéres*, and to the second sub-division of that class, *oligosidéres*, of Mr. Daubrée's classification.—(T. O.).

DONATIONS TO THE MUSEUM.

Specimens of the following minerals have been presented by David Forbes, Esq., F. R. S., &c., &c.

Titanoferrite, with hornblende	... Krageroe, Norway.
Eisen-nickelkies (original typical form) ...	... Espedalen, ditto.
Nickeliferous Pyrrhotine	... Ditto ditto.
Bismuthine, with Pyrites	... Sorata, Bolivia.
Gersdorffite	... Dolschau, Hungary.
Phosphorite	... Estremadura, Spain.
Native Bismuth, with Bismuthine	... Sorata, Bolivia.
Native Silver	... Thunder Bay, Lake Superior, Canada.
Staffelite	... Staffel, Nassau.
Tyrite	... Hamfernyr, Norway.
Titanoferrite, with Aspidolite	... Krageroe, Norway.
Gadolinite, with black Yttrotitanite ...	... Ytterby, Sweden.
Hornblende	... Krageroe, Norway.
Tourmaline...	... Ekeland, Norway.
Chlorapatite	... Tambillos, Chili.
Rutile	... Krageroe, Norway.
Cerite	... Riddarshyttan, Sweden.
Alvite	... Arendal, Norway.
Native Alum	... Smyrna.
Scapolite	... Krageroe, Norway.
Cryolite	... Greenland.
Moroxite	... Canada.
Titanic Magnetite	... Norway.

FROM THE ROYAL SCHOOL OF MINES, LONDON.

Large mammillated mass of Hæmatite	Whitehaven, Cumberland.
Three specimens of fibrous hæmatite	Ditto ditto.
Specimen of ditto showing tendency to fracture into paraboloids	Ditto ditto.
Specular Iron, crystallized, with quartz crystals, on hæmatite	Ditto ditto.
Copper pyrites, in mica schists (vein)	Fahlun, Sweden.
Veinstone, showing deposits of Galena, Zinc-blende, calcite, &c.	Przibram, Bohemia.
Asphalt, from great Pitch-Lake	Trinidad.
Tin ore with topaz	Durango, Mexico.
Fahlerz, crystallized with quartz	Saxony.
Celestine, from new red marls	Bristol.
Quartz crystals, group of	Dauphine.
Tinstone	Huel Spearne, Cornwall.
Tinstone, two large specimens	Huel Owles, ditto.
Pyromorphite	Wheatley, Mine, Pensylvania.
Cerusite	Ditto ditto.
Anglesite	Ditto ditto.
Chromo-molybdate of Lead	Ditto ditto.
Copper glance	Monte Catini, Tuscany.
Antimoniate of Lead	Spain.
Graphite, Alibert mines...	Irkutsk, Siberia.
Zincite, with Franklinite	New Jersey.
Mica	Cornwall.
Magnetic Iron	Dannemora, Sweden.
Ditto ditto	Bispberg, ditto.
Red iron ore	Langbau, ditto.
Ditto ditto	Nassau.
Schistose red iron ore	Ditto.
Copper Pyrites	Ditto.
Malachite, on brown iron ore	Ditto.
Green carbonate of copper in gossan	Dillenburg, Nassau.
Pyrolusite	Nassau.
Cyano-nitride of Titanium, artificial, from Iron furnaces ...	Workington, Cumberland.
Fibrous gypsum	Nottingham.
Pectolite	Ayrshire, Scotland.
Carbonate of Lead	Zillerfeld, Hartz.
Scheelite	Caldbeckfells, Cumberland.
Titanite, in Granite	Norway.
Sulphur	Valais.
Calcite	Strontian, Argyleshire.
Green fluor spar	Cumberland.
Plumbo-calcite	Leadhills, Lanarkshire.
Vanadinite	Wanlock-head, Dumfriesshire.
Scapolite	Norway.
Beryl	Gweebarra Mts., Donegal.
Garnet, with Idocrase	Dunglow, Donegal.
Wulfenite	Bleiberg, Carinthia.
Rutile, in quartz	Perthshire.
Specular iron ore	Elba.
Manganite	Hartz.
Baryto-calcite	Alston Moor, Cumberland.
Barytes, in clay iron ore	Workington, Cumberland.
Actinolite	St. Gotthard.
Zinc-blende	Cumberland.
Texasite, on chrome iron ore	Texas, Pensylvania.
Green talc	St. Gotthard.

Sanidine in Trachyte ... ... Drachenfels, Rhine.
Green Pyromorphite .. .. Cumberland.
Selenite with sand, from the basement bed of London clay, Upnor, near Rochester ... ... Kent.
Purple fluor spar ... . Cumberland.
Brown fluor spar, with carbonate of iron ... ... Allenheads, Northumberland.
Albertite ... ... Nova Scotia.
Quartz crystals ... ... Snowdon, Wales.
Phosphorescent fluor spar, from East-pool mine, near Redruth ... ... Cornwall.
Lithomarge, Restormal iron mine, near Lostwithiel ... Ditto.
Fibrous Carbonate of Copper, with pyrites ... ... Ditto.
Gun Flints, showing effects of intense heat on flints, from the Tower of London, after the great fire of October 31, 1841.

From J. CALVERT, ESQ., C. E.—Specimens of Schorl from Beerbhoom, and of Gold soil from Nicaragua.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

No. 3.] 1868 **[November.**

GENERAL RESULTS OBTAINED FROM AN EXAMINATION OF THE GASTROPODOUS FAUNA OF THE SOUTH INDIAN CRETACEOUS DEPOSITS, by FERD. STOLICZKA, Ph. D., F. G. S., Palæontologist, Geol. Survey, India.

The second volume of the "*Palæontologia Indica*," recently completed and published, contains the descriptions of 237* species of Gastropoda from the cretaceous deposits of South India. The fauna is very rich and varied, though probably not quite so extensive as might have been expected relatively to the large number (146) of Cephalopods which were described from the same beds. Still as many species, only represented by specimens in the state of casts, have been laid aside, further examinations of the ground will no doubt furnish large additions.

Taking a general review of the fauna of the Gastropoda, it will be interesting to point out some of the more important families and genera which were found to be represented.

The first family which in this respect is deserving of special attention is that of the *HELICIDÆ*, represented by four species, three of which belong to the genus *Angystoma* and one to *Macrocyclis*. Nearly all are found in the uppermost beds, stated by Mr. H. F. Blanford to have been deposits in shallow water. The extremely rare occurrence of land shells in cretaceous rocks increases the interest connected with those four species, especially as they mostly belong to types which are still found living in the same or neighbouring districts.

The sub-order PROSOBRANCHIA counts 174 species, of which the larger number belongs to the SIPHONOSTOMATA CTENOBRANCHIATA. Among the *ALATA* the genus *Pugnellus*, which up to the present has only been found in cretaceous rocks of North America, has yielded three very interesting species; it is in the recent fauna represented by species like *Strombus gallinula*. The *CYPRÆIDÆ* are remarkably numerous, being represented here by almost as many species as were previously known from cretaceous deposits in general, in which, as a rule, they are very rare. Among the types described are some which belong to *Cypræa* proper, several to *Luponia* and others to *Aricia*, *Epona*, &c. From the large number of *CYPRÆIDÆ*, as also from that of the *VOLUTIDÆ*, the peculiar forms of the *MURICIDÆ* and of the *PURPURIDÆ*, I draw the conclusion that the genera and species belonging to these families were already during the cretaceous time somewhat more numerous in the eastern than in the western hemisphere, or, in other words, that the present distribution of a portion of the Gastropoda, at least, was already indicated at that remote period.

The *OLIVIDÆ* are represented by a species of *Dipsacus*, the *CASSIDIDÆ* by a very interesting small species of *Oniscia*, the *PLEUROTOMIDÆ* by *Cythara* and *Pleurotoma*, the *CONIDÆ* by that peculiar form *Gosavia*, intermediate between this and the next family. Of the *VOLUTIDÆ*, 18 species are described belonging to the genera *Scapha*, *Melo*, *Ficulopsis* (n. gen.), *Fulguraria*, *Athleta*, *Volutilithes*, *Lyria*, *Volutomitra*, *Mitreola* and *Turricula*.

* Including some new specific forms, which on account of the imperfectness of the specimens have not yet received specific names, though acknowledged as distinct from other known species.

Of the *MURICIDÆ* I would particularly mention *Pollia Pondicherriensis*, because it so much recalls the form of our common, recent *Pollia melanostoma*, and a species belonging to the genus *Trophon*.

The *TRITONIIDÆ* have representatives in species belonging to *Hindsia*, *Tritonium* and *Lagena*; the *BUCCINIDÆ* in those of *Nassa* and *Pseudoliva*; the *PURPURIDÆ* in *Tudicla*, numerous species of *Rapa* and one of *Rapana*. Not less interesting are also two species of *Trichotropis* and five species of the *CANCELLARIIDÆ*, representing the genera *Cancellaria*, *Euclia* and *Narona*. No *TEREBRIDÆ* have occurred, and the *PYRAMIDELLIDÆ* offer no peculiarities, nor are they very rich in species or genera.

The *CERITHIIDÆ* mostly belong to marine sub-generic types, the absence of the very large number of *POTAMIDINÆ*, occurring in the deposits of the Alpine-Gosau formation, being remarkably conspicuous as one of the most important differences between the two faunas. The same applies to the *MELANIIDÆ*, their absence in Southern India being equally due to the apparent want of brackish or fresh water deposits, so far as they are known at the present. The *TURRITELLIDÆ* have yielded five forms identical with European ones, *T. multistriata* being probably the best known, *T. nerinea*, *nodosa*, *affinis* and *Neptuni*. The rest of the species peculiar to the Indian deposits do not differ in general character from European types. Of the *SCALIDÆ* three out of four are identical with European species. Of the *VERMETIDÆ* two interesting species have been referred to a new genus *Tubulostium*, being very characteristic for the Ootatoor beds, which are the lowest of the series. Of the *LITTORINIDÆ*, the occurrence of which in cretaceous rocks was always disputed, six different species have been met with. Of the *RISSOIDÆ* I may draw attention to two rather large species of *Rissoa*, one smooth *Rissoina* and three species of that peculiar genus *Keilostoma*, differing from *Rissoina* by the great thickness of the apertural margins. The *NATICIDÆ* are characterized by the usual large number of species belonging to the genus *Euspira*; three genera, *Naticina*, *Velutina* and *Amplostoma* of the *VELUTINIDÆ* also deserve specially to be noticed.

When speaking of the family *NERITIDÆ*, the *UMBONIIDÆ*, *TURBINIDÆ* and *TROCHIDÆ*, &c., I had occasion to remark that most of the recent so called sub-generic forms are already to be found during the cretaceous period. Some of the generic types are very interesting and new to the fauna, as, for instance, *Velates*; *Teinostoma* and *Vitrinella*; *Oxytele*, *Gibbula*, *Euchelus*, *Cantharidus*, &c.

The *PLEUROTOMARIIDÆ* are not very varied in genera, but one species of the peculiar type *Leptomaria (L. indica)*, is very common, occurring almost through all the successive groups from the lowest to the highest; it greatly resembles several of the European forms.

The OPISTHOBRANCHIA are also worthy of notice, being represented by 24 species; these belong to *Actæonina* (2), *Actæon* (6), *Trochactæon* (3), *Bullina* (2), *Bullinula* (1), *Avellana* (4), *Ringinella* (1), *Ringicula* (2), *Euptycha* (3) and *Cylichna* (1). This unusually large number of species of that sub-order is the more interesting, as the recent species are far from common shells. The genera *Trochactæon*, *Avellana*, *Ringinella* and *Euptycha* are chiefly cretaceous forms, and therefore in comparison with the present fauna of very great importance. *Actæonina* is one of the oldest genera, but I believe there are a good number of species of recent shells which ought to be transferred to that genus. Of the *DENTALIIDÆ*, being the only representatives of the PROSOPOCEPHALA, merely four species of the genera, *Dentalium*, *Antale* and *Fustiaria* (n. gen.) were recorded.

After this general review of the fauna I may now enter upon the distribution of the species in the different groups which, beginning with the lowest, are the *Ootatoor*, *Trichinopoly* and *Arrialoor* in the Trichinopoly district, and the *Valudayur* and *Verdachellum* groups near Pondicherry. These last two are equivalent to the first and third named one, respectively. Geological details respecting these groups and their fauna will be found in Mr. H. F. Blanford's Report in the IVth Volume of the Memoirs of the Geological Survey of India. The present remarks regarding the distribution of the species of Gastropoda will therefore be very general.

The 237 species of Gastropoda, described from the cretaceous deposits of South India, divide themselves into the different groups, thus: 113 species are peculiar to the Arrialoor group, 59 to the Trichinopoly and 36 to the Ootatoor; 20 species are common to the Trichinopoly and Arrialoor groups, 4 to the Ootatoor and Trichinopoly, none, however, with sufficient certainty to the Ootatoor and Arrialoor solely. Only five species, *Fulguraria elongata*,

Ampullina bulbiformis, Gyrodes pansus, Solariella radiatula and ***Leptomaria indica*** are common to all the three divisions of the deposits. The Gastropodous fauna of the different groups is therefore tolerably well defined, the distinction between the Ootatoor and the Arrialoor groups being especially prominent. The large number of species common to the two higher groups is principally due to the uncertainty of the geological boundary between them. When this point has been more satisfactorily settled, it may show that an equal distinction exists in the Gastropodous fauna between them, as does between the two lower groups. All the species occurring in the Arrialoor group belong to such genera as are now commonly found living in shallow water, while many of those of the Ootatoor group are littoral forms, living on rocky coasts or on coral reefs.—The fauna, as a rule, is purely marine, and there is a remarkable absence of the *POTAMIDINÆ*, of the *MELANIIDÆ* and others which are very characteristic for some of the beds of the Alpine cretaceous deposits. The comparison of our rocks with those of the Alps only applies, therefore, to the purely marine fauna. The Arrialoor beds were probably deposited over a large, very slightly undulating ground in from 2-10 fathoms of water, but at some distance from the coast.

In point of comparison of our fauna with that of other countries I must direct attention to the following table, giving a list of those species which are also found elsewhere :—

No.	Name of Genus and Species.	Geological position.		Remarks.
		In India.	Not in India.	
1	Alaria Parkinsoni, Mant.	Oot. and Trich. ...	Gault and Greensand, (Cenomanien).	
2	„ papilionacea, Goldf.	Trich. and Arr. ...	Turonien ...	(Middle Plæner).
3	Cypræa Kayei, Forbes, (Globiconcha ovula, d'Orb.)	Trich. and Arr. ...	Senonien.	
4	Pleurotoma subfusiformis, d'Orb. ...	Trich. (Arr.?) ...	Turonien.	
5	Fulguraria elongata, d'Orb.	Oot.? Trich. and Arr.	Cenomanien and Turonien.	
6	Fasciolaria rigida, Baily	Trich. ...	Middle cret. of Sth Africa ...	(Probably Cenomanien).
7	Neptunea rhomboidalis, Zekeli ...	Arr. ...	Turonien ...	(Gosau-deposits).
8	Tritonidea Requieniana, d'Orb. ...	Trich. ...	Turonien.	
9	Trichotropis Koninckii, Müll.	Trich. ...	Senonien near Aachen.	
10	Nerinea incavata, Bronn	Oot. ...	Turonien ..	Gosau and Transylvania.
11	Cerithium inauguratum, Stol.	Trich. and Arr. ...	"Craie pisolitique" near Paris.	I have observed these two species in Prof. Hebert's collection.
12	„ Arcotense, Stol.	Arr. ...	Ditto.	
13	„ trimonile, Mich.	Arr. ...	Gault and Grès verts, (Cenomanien)	
14	Turitella affinis, Müll.	Trich. ...	Senonien near Aachen.	
15	„ Neptuni, Münst.	Trich. ...	Turonien ...	(Middle Plæner).
16	„ nerinea, Röm.	Oot. ...	Senonien ...	(Upper Plæner).
17	„ nodosa, Röm.	Oot. ...	Cenomanien ...	(Lower Plæner).
18	„ multistriata, Rss.	Trich. and Arr. ...	Turonien ...	(Middle Plæner).
19	Scala (?) Clementina, Mich.	Oot. ...	Gault.	
20	„ subturbinata, d'Orb. (Haidingeri, Binkh.).	Arr. ...	Senonien of Maestricht. [Aachen.	
21	„ striatocostata, Müll.	Arr. ...	Senonien near	
22	Burtinella concava, Sow.	Arr. ...	Chalk (Turonien).	
23	Rissoina acuminata, Müll.	Arr. ...	Senonien near Aachen.	
24	Euchrysalis gigantea, Stol.	Trich. and Arr. ...	Cretaceous beds in Sth. Africa.	Probably Cenomanien.
25	Ampullina bulbiformis, Sow.	Oot., Trich. and Arr.	Turonien beds of the Alpine cretaceous deposits.	Probably also occurring in Texas.
26	Euspira rotundata, Sow.	Arr. ...	Chalk (Turonien).	
27	„ lirata, Sow.	Arr. ...	Turonien.	
28	Ziziphinus Geinitzianus, Rss.	Trich. and Arr. ...	Turon. beds of Germany.	
29	Solariella radiatula, Forbes, (Trochus glaber, Müll.).	Oot., Trich. and Arr.	Senonien near Aachen.	
30	Avellana elongata, Guér.	Oot. ...	Cenomanien.	

Of these 30 identical species, forming very nearly one-eighth of the entire fauna, 10 species occur in the Senonien, 12 in the Turonien, 4 in the Cenomanien (including 2 species from the South African deposits); 1 species is common to the first and second, 1 to the second and third, and 3 are quoted from the Gault, 2 of which, however, are also found in the Cenomanien. Applying these results in detail to the groups distinguished by Mr. Blanford among the South Indian cretaceous deposits, it will be found that they do not correspond exactly. Thus, species which in Europe occur in the Cenomanien are in India occasionally found in the Arrialoor beds, not as would be expected in the Ootatoor beds only; and again there are Senonien and Turonien species found in the Ootatoor as well as in the Trichinopoly beds. As a rule most of the species from our Arrialoor beds are identical with those from the Senonien; but there appears to be an equal difficulty experienced in India in separating the Arrialoor and the Trichinopoly group, as is felt in Europe in distinguishing properly between the Senonien and the Turonien. The general conclusion, therefore, derivable from the examination of the Gastropoda regarding the age of the South Indian cretaceous deposits is that they *represent only the beds above the Gault*, that is, the *Cenomanien, Turonien and Senonien.*

It is possible that the Ootatoor beds represent the Cenomanien, but the number of fossils obtained from these beds is, in one respect, comparatively as yet very small; in other respects the boundaries between this and the other groups may not have been sufficiently worked out. It appears more justifiable to regard the Trichinopoly beds as the representatives of the Turonien, and (as already stated) the Arrialoor as those of the Senonien. Stratigraphically this tri-division has also great probability.

When reviewing the Cephalopoda of the same rocks (Quart. Jour., Geol. Soc., Lond., 1865, p. 407, etc.), I have stated that the largest number of the identical species of Cephalopoda occurs in Europe in the middle cretaceous strata and especially in the Gault; thus I placed the lowest beds of our South Indian cretaceous rocks as equivalents of the Gault. After having gone over the Gastropoda I found that no Gault species were represented, and conferring with some of my friends at home on this point, Prof. Hebert specially directed my attention to several species of the Cephalopoda which are strictly speaking not typical Gault fossils. I had already occasion to mention* that the identification of *Am. Beudanti* (now *Am. Yama*, Forb.) was found incorrect; but several other species which undoubtedly appear to be identical with European fossils, like *Nautilus elegans, N. sublævigatus, Am. rostratus, Am. Rotomagensis, Am. Candollianus, Am. navicularis, Am. Mantelli, Am. peramplus, Am. Timotheanus* and *latidorsatus, Turrilites costatus and Bergeri* and others, are such species as pass from the Gault into the Cenomanien and the Grès verts. Prof. Hebert† is of opinion that the true Gault beds must be considered as the uppermost group of the Neocomien or lower cretaceous series, all the beds above being included in the upper cretaceous series. There appears to be a relation of several of our species to such Gault species as *Am. Beudanti, serratus, lautus, denarius, splendens* and to some Neocomien forms, but, on the other hand, the numerous *Cristati* and *Ligati* of our rocks are strongly marked upper cretaceous types. The fauna of the Gault is undoubtedly an intermediate one, and possibly when the stratigraphy of the rocks has been better studied many corrections in points of identifications, at present doubtful, may be made. Some of the species like *Nautilus pseudo-elegans* and *Neocomiensis*, and *Am. Rouyanus* and *Velledæ* I am still unable to distinguish satisfactorily from the typical Neocomien species; the number of these species is, however, so small that they cannot outweigh the other facts which would place the cretaceous deposits of South India higher in the series.

Considering, therefore, that most of the so-called Gault species of our Cephalopoda are equally common in the Cenomanien, and that the Gastropoda have not yielded any undoubted Gault forms, I believe I am more justified in stating that the South Indian cretaceous deposits only represent the *upper cretaceous strata, beginning with the Cenomanien.* The larger number of representative species were found to agree with the Turonien, which is a very wide spread formation, though its limits must be considered rather different from those given to it by d'Orbigny. I have reason to suppose that the present statement regarding the age of our cretaceous deposits will also be supported by the examination of the

* Records Geol. Surv., India, I. pt. 2, 1868, p. 35.

† Bull. Soc. Geol., France, 2d ser., t. XXIV, p. 323, etc.

Pelecypoda, especially the various *Inoceramus*- and *Hippurite*-types. Thus the original notion of representatives of Neocomien beds in South India more and more loses support, as already pointed out by me in the first volume of the "Palæontologia Indica."

In conclusion I should like to draw attention to a parallel of our cretaceous deposits with those of Bohemia, Saxony, North Germany, etc.; this parallel being indeed a very remarkable one. Dr. Gümbel, who has lately (Sitzb. Gesellsch. Isis, Dresden, 1867, p. 72, etc.), devoted a little time to the study of the Bohemian and Saxon cretaceous deposits, states that they generally begin with a kind of fresh-water deposit containing numerous plant remains, and being sometimes represented by a coarse conglomerate, both filling up cavities in the older rocks, which in many instances are metamorphic or crystalline. Immediately above these plant beds follows the series of Quader- and Plæner-beds, the oldest of which are characterized by *Am. Mantelli, Inoceramus striatus, Ostrea biauriculata, Exogyra columba*, etc., as Cenomanien or the Upper Greensand of English Geologists; the highest beds are the equivalents of the upper chalk with *Inoceramus Cuvieri* and *Crispi, Rhynchonella octoplicata*, etc., or Senonien. Dr. Gümbel consequently acknowledges an upper, middle and lower Plæner, which may approximately be called Senonien, Turonien and Cenomanien. Dr. Schlönbach, in a very valuable paper, printed in the Official Report of German Naturalists, etc. (Hanover, 1865, p. 160, etc.), expressed similar opinions on the French equivalents of cretaceous beds in Hanover. Zittel, in his admirable work on the Bivalves of the Gosau-deposits (Denksch. Akad., Wien, XXV, 1866, part. II, p. 174, etc.,) enters upon the question of parallelism of those deposits with others in great detail and corroborates the opinion of most of his predecessors that they principally represent the Turonien and the Senonien. Were I to give at this early stage of examination of the fauna an opinion regarding the parallelism of our South Indian cretaceous rocks, I could, as I stated, only compare them with those of North Germany (Aachen, Saxony, Hanover) and Bohemia, but it is impossible to say which of our beds exactly correspond to the Cenomanien, Turonien, and so on; probably the parallel must remain only a general one. To the Gosau-deposits our Trichinopoly and Arrialoor beds appear to form a correlate. What characterizes the Cenomanien of our beds are the Cephalopoda; these are, however, very scarce in the Gosau-deposits. Those lately described by F. v. Hauer have fully the character of Cenomanien species.

There is one point which deserves special attention during any subsequent examination of the ground of the South Indian cretaceous deposits, and this is respecting the plant beds, which underlie all the undoubted cretaceous rocks. Some time ago the Geologists, engaged in the survey of the Madras Presidency, have sent numerous plants and a large number of bivalves, etc., from these strata in the neighbourhood of Sripermatoor. A few small Ammonites belong to the Dentati group, but they are insufficiently preserved for identification. Of bivalves there is a large number of species belonging to *Leda, Yoldia, Tellina, Psammobia, Lima, Pecten* and others; all forms with a remarkably thin shell and the allies of which are at present usually found living on sandy ground in from 8-10 fathoms of water. Several exhibit a resemblance to species from the cretaceous rocks of Trichinopoly, but *none* appear to be specifically identical. At another locality, fragments of an *Inoceramus*, which belong to a flattened ribbed species like *I. mytiloides*, have been found with the same plants. Of the plants there have been several species (*Palæozamia Cutchensis* and *acutifolium*, and a *Dyctyopteris?*) recognized as identical with those from the Rajmahal beds and again with those found associated with the jurassic Cutch fossils. Thus this would distinctly prove that the South Indian plant beds below the cretaceous rocks are jurassic. I cannot express the slightest opinion on this matter, but in pointing out the parallelism existing between the Indian and North German cretaceous beds, the similar structure of those whitish clay plant beds underlying, in both countries, the above formation appeared to me deserving of marked notice. Special attention must at any subsequent examination be devoted to tracing out the relations of those plant-bearing beds to the cretaceous beds of the Trichinopoly district.

September, 1868.

NOTES on route from POONA to NAGPUR, *vid* AHMEDNUGGUR, JALNA, LOONAR, YEOTMAHAL, MANGALI and HINGUNGHAT, by W. T. BLANFORD, F. G. S., &c.

Almost throughout the entire route the rock is trap.

Poona to Ahmednuggur.—Leaving Poona the traps between the Moota Moola and Bheema rivers present but few peculiarities. They are the usual stratified amygdaloids, more or less compact, with some bands of ashy, or of basaltic varieties. Dykes are scarce, and very small, if they occur at all.

The beds are nearly, if not quite, horizontal. There is an apparent very low dip to the south-west not amounting to 1°.

The hills east of Wagoolee appear to be formed of beds absolutely horizontal. Upon their top, which is quite flat, is a plain of cotton soil, cultivated in places, which must have resulted from decomposition of the trap.

Crossing to the north bank of the Bheema, the traps have the same low dip. The country is an undulating plain, and the flat hills which dot it near the Bheema disappear entirely further on. Cotton soil occurs everywhere; it is more sandy near the river where there is alluvium in places.

Beyond Koondapoor the plain is traversed by streams which have cut valleys, with steep sides and more or less flat bottoms. The whole country has very much the appearance of a plain formed by marine denudation, through which plain the streams have cut. But the general uniformity of the surface is doubtless due to one hard bed of trap. Where this has been cut through by a stream, the rocks beneath are easily removed till another hard bed is met with, and this generally forms the base of the valley.

Over a large area the principal bed is seen to have a very low easterly dip, not nearly amounting to 1,° at the most ½ to ⅓ a degree. It is a very flaggy bed.

About a mile east of Bangungaon the beds appear to roll over and to dip at a very low angle to the south. This is at the watershed between the Bheema and the Goor rivers. A more rubbly bed of trap comes in decomposing into round boulders. There is an apparent undulation in the beds hereabouts, but at such extremely low angles that the appearance may be due to the lenticular form of beds or accidents of denudation.

Thence to the Goor at Seroor the road descends gradually, passing hills more or less rounded in form, composed of the softer beds of the trap.

The hills immediately north-east of the Goor are much rounded and the bedding inconspicuous: it is, however, nearly, if not quite, horizontal.

Near the 24th milestone from Ahmednuggur the road comes up upon high ground. The beds around are well seen; and are nearly horizontal. Indeed, the apparent low dips may be due to the lenticular form of the beds. An instance of this is seen on a hill about one mile south of the road just where the latter attains the summit level. One of the strata composing the hill thins out rapidly, so that the terrace formed by its upper surface dips east, and that formed by its lower surface dips west.

Still there is here, as before, the appearance of a very low westerly dip. The country as far as Soopa is an undulating plain with scattered rocky flat-topped hills. The traps as usual consist of alternations of hard basaltic beds with softer ashy strata.

From Soopa eastwards the same horizontal stratification prevails. About the 11th milestone from Ahmednuggur there is an apparent low southerly dip. Thence the country falls gradually to the broad and nearly flat valley of the Sina river.

From Ahmednuggur the road runs north to the base of the flat-topped hills which enclose the Sina valley. In these hills the traps appear to be perfectly horizontal. Thirteen miles from Ahmednuggur at the Seeor Ghât the road suddenly descends a scarp 500 feet high to the nearly flat valley of the Godavery. On the side of the road towards the top

of the scarp a fine section of traps is exposed, and the following beds are seen in descending order. The thicknesses given are merely approximate:—

1. Compact basaltic trap weathering into rounded boulders, and divided by numerous irregular jointing planes of a yellow brown colour; thickness considerable; upper surface not seen ... ...
2. Soft ashy purplish amygdaloidal trap, about ... ... 20′
3. Hard crystalline compact basaltic trap, with but little jointing, containing agate and quartz in parts; this bed is softer and less compact, about ... ... 50′
4. Soft grey amygdaloid, containing horizontal layers of agate, and kernels of agate and of stilbite or heulandite. Some kernels also contain a black micaceous mineral; *none of the kernels are surrounded by green earth.* This bed has a thin layer of red bole on the top: about ... ... 15′
5. Very amygdaloidal soft grey trap, half composed of small nodules of agate and zeolite all covered with green earth; surface of bed irregular ... ... 20′ to 30′
6. Thin parting of red bole ... ... 3″ or 4″ to 1′
7. Amygdaloid similar to 5, but containing fewer nodules, and these also covered with green earth ... ... 10′ to 15′
8. Purplish very amygdaloidal bed. Kernels covered with green earth. The rock mixed here and there with large patches of felspar porphyry ?

From below this the section is less distinct, all the beds to the bottom of the Ghât being much decomposed at the surface: the majority are amygdaloids—felspar porphyry (basaltic trap with large tabular crystals of glassy felspar) occurring in places. The beds appear thin where seen along the hill side, generally 10 to 15 feet each. The upper hard bed appears to have preserved the hills and given them their flat top.

For some distance below the Ghât while traversing the gently undulating plain of the Godavery much trap appears at the surface; beyond that distance black soil alone is seen in general, the trap only cropping out in rises here and there. This is the case throughout as far as the Godavery. The cotton soils appear greyish on the higher parts of the country, darker in the hollows, and they are much mixed with sand and salts in the neighbourhood of the river.

On the banks of the Godavery near the villages of Moonghee and Pyton, there is a considerable thickness of brown clay above, generally abounding in kunkur, and evidently a river deposit. Below this is gravel, chiefly of fragments of agate and of a zeolite (apparently natrolite). In places this gravel is united by a calcareous cement into a concrete. The upper kunkuriferous clay is frequently obliquely laminated, the laminæ dipping, as a rule, though not invariably, down the stream. Trap rarely appears below Moonghee; above that village, between it and Pyton, it is seen in several places. The concrete sometimes, but rarely, occurs in the tributary streams.

Mammalian remains in gravels, &c.—In the concrete and gravel mammalian bones are met with, and hence, doubtless, the specimen of *Elephas (Namadicus)* mentioned by Dr. Falconer (Quart. Journ., Geol. Soc., Lond., Vol. XXI, p. 381, November, 1865) was obtained.*

Mr. Wynne found near Moonghee a fragment of some large bone, and, *in situ*, a chipped agate flake, the latter possibly of human origin. I found, *in situ*, a molar of *Bos*, and on the river sand, one or two other teeth probably washed out of the gravel. Bones appeared to be scarce just here, however. Shales frequently occur near the top of the gravel, and perhaps in the base of the clay; they were not observed below, but in this neighbourhood very few sections of the gravel are exposed.

* The history of this specimen is not detailed by Dr. Falconer. The cranium was found by General (at that time Major) Twemlow, then stationed at Aurungabad, who took it to England. This must have been 30 years ago at least. The same officer found mammalian bones in large quantities near Hingolee.

Many of the agates in the gravel have a peculiar dark semitransparent look, resembling flint. Such do not elsewhere prevail amongst the varieties occurring in the traps.

Large numbers of the agates in the gravels are fractured.

In the drift wood, twigs, grass and rubbish deposited at the edge of the river, I found the following land and fresh-water shells. The list may be useful, if the sub-recent and pleiocene deposits be hereafter searched for comparison.

Helix Tranquebarica, Fabr. (the Deccan variety, which is near the shell figured by Reeve in the Conc. Icon. as *H. vitellina*, Pffr.).
„ *atomus*, Fairbank, M.S. (a very minute species of the *Macrochlamys* type resembling *H. vitrinoides* or one of the European *Zonites* in form).
„ *crassicostata*, Benson. *H. fallaciosa*, Fér.
Bulimus pullus,* Gray, 2 or 3 varieties. *B. cœnopictus*,* Hutton. *B. Abyssinicus*, Rüpp. (a finely costulated var. *B. moussonianus ?*).
Pupa (or Carychium ?), sp.
Achatina Vadalica, Benson. *A. brevis*, Pffr. *A. balanus*,* Bens.
Planorbis compressus, Bens.: *P. sp.*,* small: *P. coromandelianus*, Fabr.
Melania tuberculata,* Lam.
Bythinia pulchella ? Bens. *B. sp.* (minute).
Paludina melanostoma.
Unio cœruleus ? Lea, rare: *U. favidens** ? Bens.
*Corbicula arata** ? Bens.: *Pisidium* sp.
Those marked thus* are most abundant.

The road from Moonghee to Jalna traverses for some distance the gently undulating plain, which does not end to the north abruptly in general, though at Chandalla and Bambeera a little escarpment is seen, formed by a hard bed of trap. It is apparently perfectly horizontal. The same horizontality is seen in the range of hills near Umbud and on the traps around Jalna. If there be any dip it must be a very low one indeed, to south or south-east.†

From Jalna to Loonar the traps appear horizontal. No change whatever takes place in them near Loonar. The beds on the edge of the singular crateriform hollow are the usual basalts and amygdaloids abounding in kernels of agate, carbonate of lime, zeolites, &c., coated with green earth as usual. *No dykes whatever were observed.* Ash certainly is met with, but it is the ordinary vesicular ash of the traps, full of zeolite, and such as may be found everywhere in the Deccan. The hollow is as nearly as possible circular, rather more than a mile in diameter. The sides nearly precipitous. A stream from a small spring which supplies Loonar with water has cut a shallow ravine down to the lake which occupies the depression. There is no outlet. The sides of the crater to the north and north-east are absolutely level with the surrounding country, while to the west, south-west, south and south-east, there is a raised rim never exceeding 100 feet in height, and frequently only 40 or 50 feet. In this low raised rim there is no trace of distinct ash-beds or lava flows; it is unquestionably composed of huge blocks of trap, precisely similar to those of the beds below irregularly piled together. The types of the ordinary Deccan traps are so peculiar that their identification is easy. The mass of materials forming the rim resembles those thrown out of an artificial hole in everything except the size of some of the fragments.

The trap beds dip away from the edge of the hollow generally, but irregularly, and appear to owe their dip entirely to disturbance.

There is thus a total absence of everything which in general characterizes a volcano. And yet without volcanic action it is inconceivable that such a hollow should have been formed. No process of aqueous denudation can explain it. The rim, too, appears formed from the fragments ejected from the crater. True, this rim cannot contain one thousandth part of the material removed, but the majority was probably reduced to fine powder by repeated ejections, scattered over the country, and removed by subsequent denudation.

† In Sheet 55 of the Indian Atlas, so far as it was traversed, the mapping appeared good, but the shading of the hills is greatly exaggerated. No one would imagine by looking at it that the great scarp represented as stretching away to the south of east from Loonar is only in reality about 100 feet high in general, and never, so far as I saw, much over 150 feet, if it is anywhere so much. Moreover, it rises gently and not abruptly. The country in general is comparatively level, low flat topped rises, and broad undulating plains, less cultivated than is the case to the westward. No hills of any height occur.

The hollow might be due to sinking, but in this case it is probable that the trap beds around the rim would dip towards the hollow rather than away from it, while the rim is simply unaccountable on such an hypothesis. It is certainly strange to find so well marked a crater without any trace of anything ejected from it. Such a crater might just as well have been found in sedimentary rocks.

Malcolmson's description (Trans. Geol. Soc., London, 2nd Ser., Vol. V, p. 562), is admirable in every way; he observes well that if denudation had removed any cone formed of scoriæ and lava, the crater itself could not have preserved its form uninjured.

Dr. Carter's description, (Journal Bombay Br. Royal Asiat. Soc., Vol. V, p. 324), copied from a manuscript by Dr. Bradley, is very incorrect. The latter found lava flows, or, as he terms them, lavic currents proceeding from the crater, greenstone dykes and scoriæ. I did not discover the two former. Scoriæ I certainly found, but they came from brick-kilns.

The water has a peculiar saline taste. It is so heavy that a slight breeze does not appear to ruffle it. It looks like a lake of oil. There is a slightly unpleasant smell caused by the decay of a green scum *(? confervæ)* which occurs on it. Malcolmson's analysis shows that the water contains no lime, yet there is a calcareous deposit on the rocks of the ravine by which water reaches the lake. The accumulation of salt must be due to the absence of an exit. All the salts carried in by streams accumulate, the water evaporates.*

The shore of the lake is of muddy sand. Around is a fringe of babul trees *(Acacia arabica)*, and beyond them tamarind and bhér *(Zizyphus jujuba)* and date palms. The sides are covered with jungle.

By aneroid measurement my camp at Loonar was about 313 feet above the lake. The rim might be in places 100 feet above my camp, so the whole depth can barely exceed 400 feet.

The salt of the lake is largely collected in the hot weather. A Parsee is said to have paid 11,000 Rupees to Government for three years' monopoly. The principal use is for the manufacture of glass bangles for women, for which purpose the salt is smelted with quartz (gár). The purer salt is used by washermen. There are said to be five kinds of salt, but they appear to be merely varieties of the same, differing in purity and state of aggregation.†

East of Loonar Lake the traps appear to be perfectly horizontal. One bed extends for a considerable distance near the villages of Devilgám and Lony, and beyond the last named village to Mudhee, and appears to be absolutely level throughout.

Towards Wakud on the Pain Gunga the beds may dip somewhat to the north; they seem to fall somewhat from Loonar and Lony towards the river, while there is a scarp to the south, but the dip, if it exists, is very low.

The Pain Gunga near Wakud and for many miles below is a deep sluggish stream, with earth banks covered with grass and exposing no section at the sides. Trap occasionally but rarely shows. Near Muslah a little gravel is cut through here and there.

From the Pain Gunga the road leads over an undulating plain, stony in places, to Bassim, and thence to Mungrool. Between Parudee and the latter place the road for five or six miles traverses a very stony plain, covered with trap boulders, the majority small, not above 2 to 4 inches in diameter, and unusually well rounded, not by rolling, but by weathering. The bed of trap from which they are derived (by weathering), and which forms the surface throughout, is compact, and very minutely crystalline, containing no olivine, nor any other mineral distinct from the mass, and, so far as I observed, neither zeolite nor agate nodules.

To the north this bed ends in a low scarp (not a great range, as represented on the map). It may consequently have a slight dip to the south, but if so, the inclination is so small as to be imperceptible.

From Mungrool the road taken‡ leads east through the Woon or south-east district of Berar. A scarp is descended about 4 miles east of Mungrool, and a second about

* This does not alone, however, account for the composition of the solid contents of the water, for which see Malcolmson, l. c.

† Alexander, Ed. Phil. Journ., 1824, Vol. XI, p. 308: Orlebar, Proceedings of Bombay Geogr. Soc. for February, 1839, p. 35: Buist. Ed. New Phil. Jour. 55, Vol. I, New Ser., 260: Newbold, Journal Royal Asiatic Society.

‡ From Mungrool I proceeded nearly due east to Mangali, and thence north to Nagpúr.

12 miles further on. The rocks appear perfectly horizontal, and these scarps which are not of great height may be merely steps in the descent from the high ground, and the upper traps of the Deccan plateau to the lower ground and inferior formations of Nagpúr. At the same time it is quite possible that the traps have a low dip to the west, but if so, it is, as usual, so slight as to be imperceptible.

The country continues to fall beyond Dharvi towards Larkeir. A little south-east of Larkeir the traps have a distinct low dip, about 2° to north or north-east. A similar low northerly dip is seen about the village of Both. There are low scarps to the south, and long slopes on the north side of the hills.

Near Kini, a few miles west of Yeotmahal, there are some small rounded hills of very compact laterite. It is highly ferruginous, and might doubtless be used as iron ore. It is generally concretionary in its structure (but not formed of minute concretions aggregated together like the Bengal laterite), and covered with the usual brown glaze. Some fragments show distinct stratification, and pass into ferruginous shale. The mass of the rock resembles the laterite of Mahableshwar, and like that contains yellow or white clay in small angular or rounded fragments.

East of Yeotmahal other knolls of laterite occur. They are about 100 to 150 feet high, but it is impossible to see how much consists of laterite and how much of trap. The laterite appears to be horizontal, but only isolated caps remain. It contains small rounded grains apparently of decomposed trap.

Yeotmahal stands high: there is a considerable ascent to it from each side. To the east the road continues to descend towards the Wurda valley and about Kalam emerges from low hills into a broad open plain. The traps along the sides of the hills appear horizontal as usual.

There is some peculiar compact and crystalline limestone near Ralagao and Antargao, apparently intertrappean, but so far as was observed unfossiliferous. Its character differed from all other intertrappean beds seen.

The boundary of the trap at the Wurda on Malcolmson's map (Trans. Geol. Soc., Lond., 2nd Ser., Vol. V) is incorrect. He makes the subjacent formations extend in a great way to the northward and westward. Really all is trap on the Wurda to below its junction with the Wunna.

No intertrappeans (unless the limestone of Ralagao belongs to that formation) had been met with throughout the Deccan or anywhere along the road until between the Wurda and Mángali. Near the village of Dodchi, 5 or 6 miles east-south-east of Pohna and to the west of the village, there is fine compact brownish-white limestone with fragmentary fossils and occasionally perfect Melanias *(M. quadrilineata?)*. East of the village a good section of limestone associated with fine white and yellow shales is seen in a stream with trap both above and below. In the underlying trap are fragments of the limestone enclosed. The amount of trap seen below is very small, and limestone may recur beneath, otherwise the former must be intrusive. It does not follow that the intrusion is more than local. The shales contain *Cyprides* in abundance, with fish scales and wings of insects. They dip slightly to the northwards.

In the Wunna close to its confluence with the Wurda a fossil vertebra of some large animal was pulled up. Probably the ossiferous gravel occurs here.

Trap occurs at Chikni; thence to Samli very little rock could be observed. At Dongurgaon, 2 or 3 miles south of Chikni, is a low ridge of hard siliceous rock, but whether it belongs to the gneiss series, or is one of the usual sedimentary rocks more hardened than elsewhere, it is impossible to say.

At Almoodi south of Samli trap occurs, probably an outlier. At Talligaon just north of Almoodi between Samli and Mángali close to a tank sandstones fine, hard and compact in general, containing bands of pebbles and conglomerates in places, occur with a north or north-east dip (towards Mángali). The sandstones are white and grey, with specks and patches of bright red. The pebbles in the conglomerate comprise vein quartz, quartzite, metamorphics of various kinds, red jasper (rarely) and a somewhat sandy rock having the appearance of silicified wood or coral. Beneath the conglomeratic beds are some fine red argillaceous sandstones.

Agate Knife found near Pyton, Upper Godavery.

From north of Samli to 200 or 300 yards north of the deserted village of Mángali all is trap. About Samli no rock is seen, nor are any sections seen south of the trap between Talligaon and Mángali. Coming south from the trap at the latter place the first sedimentary rocks seen are fine grey quartzose sandstone, conglomeratic in places, as compact as Vindhyan sandstone, much more so than Damudas usually are,* having a general resemblance to the beds at Talligaon.

Just south of these are the old quarries whence Mr. Hislop is said by the villagers to have obtained his fossils. The rock is a very fine deep red argillaceous sandstone, shaley in parts. Thin layers of a yellow colour are frequent, and these appear to be richer in fossils than the red portions. *Æstherias* (of two species apparently) abound, and some ill marked plant-remains also occur.

The surfaces of the slabs are frequently covered with irregular pits, and appear as if corroded by surface waters. This is curious, as argillaceous sandstone is not a rock easily dissolved by water, yet it seems difficult to account for the corrosion otherwise.

From Mángali to Hingunghat and thence to Nagpúr no rock except trap is seen. The country is mainly an open cultivated plain, thickly covered with cotton soil, a few scattered flat-topped hills occurring towards the south, and nearer to Nagpúr some well marked hill masses come in to the westward. The traps wherever seen are apparently perfectly horizontal.

On the road from Nagpúr to the Wurda on the way to Oomrawatee all is trap, perfectly horizontal to all appearance, except an inlier of *Damudas* near Bazargaon, (not examined), and some isolated caps of laterite near Koondallee.

July 1866.

On the Agate-flake found by Mr. Wynne, in the Pleiocene(?) deposits of the Upper Godavery, by T. Oldham, Esq., LL. D., &c., &c.

On the accompanying Plate (Plate 1) I have given full-sized figures of the agate-flake referred to above (p. 61) by Mr. Blanford—Mr. Blanford here says, 'possibly of human origin.' Further examination and comparison satisfied him of the true nature of this specimen. He said (Proceedings Asiatic Society, Bengal, October 1866), "I was at first very sceptical as to the genuineness of this flake, but a recent examination and comparison of it with some of the Jubbulpoor specimens have strongly inclined me to believe that it is really of human manufacture:" and he pointed out the similarity with one of those found near Jubbulpoor.

The flake here represented was found by Mr. A. B. Wynne while searching the banks of the Upper Godavery for fossil bones. It was discovered just below the village of Moongee, near Pyton. The river cliff here has a height of about 50 feet. And in a bed of uncompacted sub-calcareous conglomerate or concrete, gravelly and containing shells of species similar to those now living in the neighbourhood, the specimen was found imbedded. A brief but careful search was made in the neighbourhood for other specimens, but without success. Not more than 15 to 20 miles, however, of the river could at the time be visited.

The flake was found about 20 feet above the base of the cliff. Its general form and character will be understood from the Plate better than from a description. It is formed from a compact light coloured agate chip, which near the surface has become blackened, and in two parts the original smooth ferruginous (rolled?) surface of the agate mass remains. The flake is rudely triangular in section, one side being flat, while between the two edges, although not centrally, it rises on the other side into a ridge. The whole is slightly curved, and at one end the sharp edges are curved so as to form a slight reflexion of the whole flake, giving that end very much the form of the curved end of a carving knife for game. The other end of the flake has a lateral extension which may have served as a means of attachment to a handle. The sharp cutting edges are much blunted and hacked, obviously by use. The total length of the flake is $2\frac{1}{2}$ inches; its breadth, which is tolerably constant for its entire length, is $\frac{7}{10}$ inch.

* This appears to be universally the case near Nagpúr. The Damudas and Mángali beds are much harder and more compact than the corresponding rocks in Bengal and the Nerbudda valley. However, this remark is based on but a slight acquaintance with the Nagpúr beds.

The first notice of the discovery of this flake was given at the meeting of the Asiatic Society of Bengal on the 6th December 1865. The specimen had not then reached me, but judging from the description I had no doubt about its character, and the matter was brought forward as of "the highest interest." I then said: "Many of the members of the Society are perhaps not aware that, spreading over a large area, in the country drained by the upper waters of the Godavery and its affluents, there is a widely-spread deposit of clays and gravels containing remains of large mammalia, which are probably of the same kind as those which occur in the similar gravels and clays of the Nerbudda valley, and of which the Society possesses many specimens. From these gravels and in the valley of the Godavery near Pyton, an agate flake, bearing evident marks of having been artificially made, has been dug out recently by Mr. Wynne of the Geological Survey. This is a fact of *great importance*, and we must only hope that further research will tend to clear away any difficulties that now remain, and add to the history of these interesting relics of the early inhabitants of these countries," (p. 207). This important discovery of Mr. Wynne's was alluded to by Mr. H. F. Blanford in a letter quoted in the Geological Magazine (London) for February 1866 (where Mr. Wynne's name is erroneously printed Bynne), p. 93. And Mr. Wynne himself gave a more detailed account of the mode of its occurrence in the same Magazine (June 1866, p. 283). Mr. W. T. Blanford more recently (October 1866 and September 1867) has again alluded to this discovery of Mr. Wynne's as bearing on the early appearance of man in India.

This question of the antiquity of man in this country long since excited much interest. Almost the earliest speculations in which my lamented friend Hugh Falconer indulged when the Sewalik fauna was beginning to unfold its richness to him were on this point, and he, to the last, believed that there was good reason to suppose that several of the animals whose remains were found imbedded in the so called miocene deposits of the Sewaliks had been cotemporaries of man. Much more therefore would he have been prepared to admit the validity of proof tending to establish his existence at a more recent period.

Unfortunately as yet we have no specific determination of the animal remains from the Godavery valley excepting in one case *(Elephas Namadicus)*. Bones of oxen, &c., have been found, but have not been identified specifically. Still looking to the marked general resemblance both in mineral character and in mode of occurrence and distribution, and to the fact of the comparative proximity of the Godavery to the Nerbudda, there can, I think, be little doubt that these similar deposits in the two valleys are approximately of the same geological age. From the Nerbudda valley a large number of species and of genera have been determined, and to these deposits Falconer assigned the general age of 'pleiocene' in these cautious words, alluding at the time specially to the researches of the Geological Survey of India: "In designating the formation as pliocene which I have during many years, I have been guided by the indications of the mammalian fauna, as intermediate between the miocene of the Irrawaddi, Perim Island and the Sewalik Hills, and that of the existing period" (Quarterly Journal, Geological Society, London, XXI, p. 383). In the same masterly paper, Dr. Falconer pointed out that no trustworthy cases of the occurrence of very ancient human bones, or industrial objects, have yet been established from the section of the Jumna and Ganges, but that they may be looked for on a more careful and extended search, stating also that the ancient fossil Mammalia of the Gangetic valley belong to the pliocene fauna of the Nerbudda, "to which also it would appear certain that the deposit of the Godavery" (from which the flake now described was obtained) "also belong."

The vastly interesting results which these researches involve have for years past been most closely and keenly discussed in Europe and America. The antiquity of man is there one of the most eagerly investigated questions of modern science, while in this country, where so many reasons combine to indicate a greater probability of success, but little has been done. It will be useful to quote here the eloquent words of Dr. H. Falconer on this subject. After referring to the curious support which the discovery of the huge *Colossochelys* served to give to mythological tradition, and the inference that this animal may have lived down to an early epoch of the human period, he proceeds:

"It is not meant to be urged now, after a lapse of more than 20 years, that any serious claim can be preferred on the speculation put forward in the passages above cited. But it will perhaps be admitted that the mind of the observer from whom it emanated was then occupied with the subject of the possibility of the remote antiquity of man in India

on palæontological evidence. It is true that the expressed view is, that the *Colossochelys* may have lived down to an early epoch of the human period, and not that man had lived back to be a contemporary of the tortoise, now proved to have been miocene. But the two views are reciprocal; and the form of expression selected on the occasion was that which was least calculated to provoke ridicule, or to shock the strong prejudices on the subject which were then dominant among educated men.* And so firmly was not merely the possibility, but the probability of the case impressed upon our minds, that Captain Cautley and myself were constantly on the look-out for the turning up, in some shape or other, of evidences of man out of the strata of the Sewalik Hills, partly from considerations of a different order, to which I shall briefly allude.

"The cataclysmic speculations of Cuvier and the diluvial theory of Buckland were then exploded. The wide spread of the plains of India showed no signs of the unstratified superficial gravels, sands, and clays, which for a long time were confidently adduced as evidence that a great diluvial wave had suddenly passed over Europe and other continents, overwhelming terrestrial life, and leaving the marks of its course and violent action in those enormous deposits of transported debris. Every section along the Gangetic plain indicated that the superficial strata there were of local origin, and the result of tranquil sedimentary deposition. Viewed in the light of a strictly physical inquiry, the chief rational argument in support of the opinion that the advent of man upon the earth dates from a very modern epoch was first, the negative evidence in the non-occurrence of human relics, and next the fact that taking him in conjunction with the mammals with whom he is now associated, they appeared, as a group, to belong to a new order of things strikingly different from that of the immediately preceding period. The mammoths, wool-clad rhinoceros, the cave-lions, and spelæan hyænas, the Irish elk, &c., of the European fauna were all extinct, although the carcasses of some of them had been discovered, under favorable circumstances, in the most perfect state of preservation. Facts of corresponding import were yielded by a glance cast upon the latest palæontology of the American Continent. There also the huge extinct edentata, the mammoth, and the mastodon indicated a different order of life, especially from that now existing. But in India the problem presented itself under another aspect. There no break was visible in the tranquil succession of deposits, no interference of a general oceanic submergence, followed by incoherent beds of sand and gravel, no intercalation of glacial phenomena to disturb the previous system. The present physical order of things -modified only by alterations of level, by upheavement and depressions—could be traced back, in an unbroken chain, to the ossiferous strata of the valley of the Nerbudda and of the Sewalik Hills. Results in harmony with these indications were yielded by a retrospect cast upon the system of organized life. The *Mastodons*, the *Stegodons*, and the *Loxodon* Elephants were extinct, as were also the *Sivatherium*, the *Chalicotherium*, the three-toed *Hipparion-Horse*, the *Hexaprotodon*, the *Merycopotamus*, and other peculiar forms. But they were found associated in the same Sewalik deposits with species of true *Equus*, of *Camel* and of *Giraffe*, the two last being characteristic cotemporaries of man at the present time. The pliocene fauna of the Nerbudda valley produced, along with the miocene *Stegodon insignis* of the Sewalik Hills, an extinct Elephant *(E. Namadicus)*, the dental system of which is closely allied to that of the existing Indian species; a true *Hippopotamus*, and, not to mention others, a true Taurine Ox, *Bos Namadicus*, and a huge Buffalo, *B.* (*Bubalus*) *(Palæindicus)*, which is nearly approached by the living 'Arnee' of the forests of Assam, being the stock from which the domestic Buffalo of Oriental countries is supposed to have sprung. That the actual order of the present system of life had begun during the Sewalik period was indicated by the living Gharial Crocodile and *Emys tecta* being found associated with the extinct mammalian forms. And of the latter, some, like *Stegodon insignis*, accompanied by a species of *Hexaprotodon*, descended to the pliocene period of the Nerbudda fauna, to be associated with a true Taurine Ox and with a Buffalo which hardly appears to differ more from the living *Arnee* than does the ancient *Bison priscus* from the living Aurochs. Another fact chimed in with special force. Among the four or five species of Sewalik Quadrumana alluded to above, one was inferred by Sir Proby Cautley and myself, in 1837, to have been a large Ape, exceeding the size of the Orang-Outang, but of unknown

* M. M. Garrigou and Filhol recently (April 20th, 1863), requested the opening of a sealed packet, which they had deposited with the Academy of sciences, Paris, so long since as 1861. In this they had shewn the probability of man's existence in the miocene age, from observations made in the deposits of Sansan. The evidence consists of bones split longitudinally, &c.

immediate affinity. This opinion was founded upon a canine tooth of an old animal, which is figured and described in the Journal of the Asiatic Society of Bengal (Vol. VI, p. 359). Five years afterwards, in 1842, I instituted a close comparison between the fossil specimen and the corresponding tooth of three skulls of the Orang-Outang, contained in the Museum of the Asiatic Society in Calcutta, and found that their agreement was so close that I conjectured that the extinct Sewalik form had been a large Ape allied to *Pithecus satyrus*.

"A quadrumanous astragalus derived from the same strata approached in form and proportions so near to that of the existing Honuman Monkey, *Semnopithecus entellus* that the help of the callipers had to be put in requisition to enable us, in 1836, to discriminate them by differences not exceeding millimétres. The distinction between the fossil and the recent bone is hardly greater than that which might be expected to occur in any two individuals of the living species. Here, then, was clear evidence, physical and organic, that the present order of things had set in from a very remote period in India. Every condition was suited to the requirements of man. The lower animals which approach him nearest in physical structure were already numerous. The wild stocks from which he trains races to bear his yoke in domesticity were established. Why then, in the light of a natural enquiry, might not the human race have made its appearance at that time in the same region? Cuvier, notwithstanding his strong bias in favor of the modern appearance of the human race, admitted, in language which has often been overlooked in later discussions, that man may have lived before the last great revolutions which were the subject of his disquisition: 'Tout porte donc à croire que l'espèce humaine n'existait point dans les pays où se dècouvrent les os fossiles, à l'epoque des rèvolutions qui ont enfoui ces os; car il n'y aurait eu aucune raison pourqu'elle èchappât toute entière à des catastrophes aussi générales, et pour que ses restes ne se retrouvassent pas aujourd'hui comme ceux des autres animaux; mais je n'en veux pas conclure que l'homme n'existait du tout avant cette époque. Il pouvait habiter quelques contrées peu etendues, d'où il a repeuplè la terre après ces évènements terribles,' &c. The valley of the Ganges seemed to present the exceptional conditions here demanded; it was exempt from the protracted submergence under the ocean, the effects of which on Europe suggested the idea of cataclysmic revolutions. I dwell upon the subject now in the hope that, when the palæontological exploration of the Sewalik Hills and Nerbudda valley, or of other equivalent formations, is resumed, these remarks may attract attention in India, and that a keen look-out may be kept up for remains of the large fossil Ape above alluded to, and for traces of man, in some form of equally remote antiquity. For it is not under the hard conditions of the glacial period in Europe that the earliest relics of the human race upon the globe are to be sought. Like the Esquimaux, the Tchuktshes, and the Samoyedes on the shores of the Icy Sea at the present day, man must have been then and there an emigrant, placed under circumstances of vigorous and uncertain existence, unfavorable to the struggle of life and to the maintenance and spread of the species. It is rather in the great alluvial valleys of tropical or sub-tropical rivers like the Ganges, the Irrawaddi, and the Nile where we may expect to detect the vestiges of his earliest abode. It is there where the necessaries of life are produced by nature in the greatest variety and profusion, and obtained with the smallest effort; there where climate exacts the least protection against the vicissitudes of the weather; and there where the lower animals which approach nearest to man now exist, and where their fossil remains turn up in the greatest variety and abundance. The earliest date to which man has as yet been traced back in Europe is probably but as yesterday, in comparison with the epoch at which he made his appearance in more favored regions." *(a)*

Years since the officers of the Geological Survey engaged in Madras discovered chipped stone-implements identical in character and form with those so generally known from the Amiens and Sussex Gravels. These have been described by Messrs. Foote, King, Oldham, &c., but unfortunately there was nothing tending to determine exactly their age. They occurred abundantly in a lateritic conglomerate, or somewhat compacted gravel, near to, or on the surface; others, again, more nearly approaching in character the flake now described had been discovered in the vicinity of Jubbulpoor. These latter, as is this Moongee specimen, exactly represent the flakes so frequently found associated with human remains in Europe, under

(a). H. Falconer, Palæontological Memoirs and Notes, Vol. II, p. 576, and Quar. Jour. Geol. Soc., London Vol. XXI, 1865, p. 386.

circumstances indicating great antiquity. Unfortunately, however, very little information was obtained regarding the mode of occurrence or the antiquity of these specimens. And it therefore was of the highest interest to find absolutely in the bone-bearing beds of the Godavery some 30 feet below the surface at that place, and in a bed, not of soft easily movable silt or sand, but of hard compacted calcareous conglomerate, the flake of which drawings are now given.

It is, however, as yet the only case on record of such occurrence of works of human art *in these beds* in this country. And we would earnestly seek the co-operation of those who may be more permanently in the vicinity of these deposits to institute and maintain a search for others. Mere casual visitors have comparatively but slight chance of success in such researches.

September, 1868.

The boundary of the VINDHYAN SERIES in RAJPOOTANA, by H. B. MEDLICOTT, F. G. S., &c., &c.

The strata of the Vindhyan period have long since received a prominent place in the rock series of Hindustan. In the typical area between the Nerbudda and the Jumna, the Geological Survey had been for some time more or less accurately acquainted with the relation of the Vindhyans to the underlying rocks along the south-eastern and north-eastern boundary, when, in the cold season of 1865-66, I was sent to investigate their western extension towards the Arawali range in Rajpootana. The formation as a whole shows no effects of disturbance *ab extra*. Along the entire north-eastern boundary, wherever older rocks are exposed, the Vindhyans rest totally unconformably upon all, whether crystalline schists or unmetamorphic strata. The junction is normal and undisturbed, being simply exposed by denudation; and its position coincides more or less with an original limitation of the basin of deposition. Along the south-eastern boundary there is the same total unconformability with all underlying rocks; but here there is a margin of variable width in which the strata are more or less intensely disturbed; for the most part this has the character of simple elevation outside the boundary or of depression inside it; but the junction is often locally faulted. Here too, however, there are indications of an original limitation of the deposits corresponding with the actual boundary; several of the sub-groups thin out and disappear on approaching it. Besides the feature that has been noticed in the north and south extension of the Vindhyan groups there is an analogous feature in the east and west distribution; along the south boundary several of the groups are overlapped and so disappear from east to west; thus it is only in the eastern portion of the area that we find the important and peculiar strata which are known among us as the lower Vindhyans, and which are well exposed throughout the entire length of the Sone valley.

The examination of the third and western boundary of this area has not added anything to our general knowledge of the Vindhyan rocks. The boundary is as sharply defined as elsewhere; the groups that are seen are like their representatives 500 miles to eastwards, with which they are continuous; and even the features of the boundary are like what is seen in the Nerbudda valley. The lower Vindhyans do not appear anywhere along this junction; but the several groups of the upper Vindhyans—the Bundairs, the Rewahs and the Kymores—are well represented. The famous old fort of Chittorgurh stands close to the western boundary, upon a scarped hill of Bundair sandstone, an outlier of a plateau to the east; the limestone and shales of the same group being well exposed in the plains at its base. The same beds are also well seen to the north-east, about Parsoli and at Boondi, close to the boundary; and at several places the lower groups crop out along the boundary from beneath the Bundairs. Although here, as elsewhere throughout this series, there is a strong apparent likelihood for the deposition and preservation of fossil remains, none have been discovered.

To the west of Bagh the steep scarp of the Deccan trap bounding the Nerbudda valley on the north is rather the face of a ridge than of a plateau. There is a very considerable fall on the northern side, and the country is deeply undulating instead of formed of open plains as at a few miles distance to the east. In the valleys and low ground about Jubbooah the crystalline rocks are freely exposed. We here, in fact, come upon the western boundary of the Malwa plateau. It is a very irregular orographical feature, being purely determined

by denudation, and it is interesting to observe its very apparent relation to the distribution of the rocks. The river Mhye with its tributaries is the first of the streams flowing northward from the south edge of the plateau which has not to encounter the resistance of the horizontal Vindhyan strata; beneath the trap it only encounters the decomposable and variable rocks of the metamorphic series, and erosion has gone on unchecked. After a northernly course of many miles the Mhye bends westwards and southward into the gulph of Cambay.

The greater part of the plateau of Malwa is formed entirely by the great Deccan trap formation. In going northward along the table land from Indore through Rutlam, the Vindhyans first appear at Mundesor, about 140 miles from the Nerbudda; they gradually emerge from beneath the great expanse of trap to the east. In following a parallel course a little to the west, along the boundary of the table land, it is seen that the non-appearance of the Vindhyans to the south is not owing to their being concealed by the trap; for all along the boundary the crystalline rocks immediately underlie the volcanic rock; and an examination of the Vindhyans themselves shows that their boundary at Mundesor is a feature of very ancient date. It runs in a north-west by west line from Mundesor, and the Vindhyans rise into small plateaus in that direction, the strata being quite horizontal. Even on the high level signs of disturbance are traceable along the line of contact, but it is where the strata run out along this strike into the low ground that the structure is fully seen. Here the lower groups of the upper Vindhyans crop out with a rapidly increasing north-easterly underlie against the crystalline rocks; the lowest band being a conglomeritic sandstone. In the opposite direction the boundary at Mundesor strikes towards Hoshungabad and Burwai, the lowest point to which the Vindhyans reach in the Nerbudda valley.

About the point where the Mundesor line of boundary strikes the edge of the plateau, the boundary makes a sudden bend of half a right angle, running due north for 40 miles, passing about 20 miles west of Neemuch. This is the most westernly position of the Vindhyan boundary. With it there commences an immediate change in the character of the contact: the margin of disturbed rocks is several miles wide, marked by flat, symmetrical, anticlinal flexures, causing ridges along the outcrop of the sandstones with intervening valleys on the contorted shales.

These features are well seen where the Neemuch and Oodipoor road crosses. The actual line of junction is marked by no special feature, the contact taking place on the low ground with the Vindhyan shales, which seem to be about equally liable to erosion as the gneissose series. It seemed to me that the shales at the contact were those with which the limestone is associated and which I have considered to be of the Bundair group. There would thus be presumption in favor of a fault.

Close to Chittorgurh there is another abrupt bend in the direction of the boundary; from north and south it turns to the north-east. For some distance at least, in this new direction, the character of the junction is the same as that last described; the Nusserabad road north of Chittor crosses at the same level from the crushed Vindhyan shales, with limestone, on to the friable granitic rocks. The strike of the contortions in the shales has already become identical with the new direction of the boundary. The actual contact often runs in a slight depression of the surface, there being no vein-stone visible or any direct evidence for the supposed fault. Where I next examined this boundary near Parsoli, some 15 miles north-east of Chittor, although its strike and that of the strata continue steadily to north-east, the conditions of the junction have entirely changed, having again assumed the form noticed in the Mundesor reach. From the north-west one approaches upon granitic and schistose rocks up to the very base of a steep ridge of sandstone in which the dip is south-easterly. Beyond this ridge there is a steady longitudinal valley upon crushed shales, without limestone; then again another ridge of sandstone with the same south-easterly dip; just inside this ridge the village of Parsoli stands in an irregular open valley formed of the shales and limestones, the plateau-hills to the south-east being formed of the sandstone overlying the same. This is the most compact section I observed of the three groups of the upper Vindhyans.

At about 4 miles to north-east of Parsoli the regularity of the section terminates in the most obscure manner, involving a fresh change in the direction of the boundary and in the strike of the rocks. At Bumunia and Singoli the sandstone ridges come to a sudden termination along an east-west line, facing a low wide-spreading plain. The feature is

manifestly connected immediately with structural conditions of the rocks. At the end of the outermost ridge, that of the Kymore sandstone, I could trace a change in the dip from the steady south-east of the ridge to east-north-east, to north-east, and to north-north-east, there being here a little spur of sandstone tailing off to the west-north-west. Of the middle ridge of Rewah sandstone I could make nothing; at its present termination the south-east dip is still maintained. On the undulating high ground formed by the top band of sandstone, that of the Bundair group, the undulations which at Parsoli corresponded with the north-east strike, are rapidly replaced towards Singoli by a north-west strike, and the outermost ridges underlie towards the plains to the north. On the low ground for some distance in front of all the ridges, Vindhyan shales (I cannot say of what group) are the only beds seen; they are much crushed, but with a prevailing east-westerly strike. On a mere cursory survey and without any map of the ground my study of the sections could not be sufficiently detailed to offer any explanation of these complex stratigraphical features.

From Singoli the tracing of the exact line of junction is greatly obscured by a change in the nature of the older rocks in contact; instead of the easily distinguished granite, gneiss and schists, the prevailing rock here is an imperfectly cleaved clay-slate, often scarcely distinguishable from the crushed Vindhyan shales. Superficially the change is indicated by the abundant debris of quartz derived from the veins that freely traverse the slates, but are altogether wanting in the Vindhyan rocks. The run of the boundary here would seem to be much less regular than what we have seen to the south. Towards Boondi the junction is again somewhat better defined, at least locally. Boondi stands at the end of a valley formed on an anticlinal of the Bundair group (taking the limestone associated with the shales as a criterion of that group). The strike is about 15° north of east. On the north side of the valley is a massive ridge of quartzite sandstone, which must, at least in part, be formed of the Bundair rock. The slates are found close to the north base of the ridge. The difficulty of discriminating the series is increased in this vicinity by the occurrence of a limestone, not markedly different from that of the Vindhyans, among what I took to be the slates.

The crystalline metamorphic rocks underlying the Malwa trap on the west show much variety, and invite a closer examination than I could give. They are decidedly gneissose; and granitoid masses are frequent. There is one strong and persistent run of a coarse conglomerate. It is well exposed in the river at Tandla: the matrix, though coarsely foliated, is rather earthy, the pebbles are often large and subangular, not always elongated in the strike: whatever they may once have been they are now mostly granitoid. North of Tambèsera the same is well seen: the boulders in it are sometimes 2 and 4 feet in diameter; they are thinly and partially distributed in the matrix. There is a crystalline limestone largely developed alongside the conglomerate. I also noticed some earthy graphitic schists associated with it. At Talwara, 10 miles to west of Banswarra, a white granular limestone is quarried to some extent. A north-westerly strike prevails throughout these rocks.

Rocks of semi-metamorphic character were first observed north of Chittorgurh. Ribs of quartzite tail out from a considerable group of hills to the north to within half a mile of the Vindhyan boundary. They are associated with earthy ferruginous flaky slates or semi schists. They are in very irregular junction with a coarse, quartzose, friable granitoid rock, which largely prevails here in the metamorphic series; it is quite massive and amorphous. It is found in contact with the quartzite, and within a few yards is separated from it by many feet of the slates; yet I noticed no case of special intrusion or any signs of contact metamorphism. At Gungrar the quartzites have become very massive, apparently overlying the slates, and forming considerable hills. A limestone shows very subordinately in these slates. I was greatly struck here by the resemblance of the lithological and stratigraphical conditions to those of the slates and quartzites of the Rajgir hills in Behar. The plains south of Hameergurh are formed on these slates, the northernly strike having changed to a steady east-north-east direction; and thus they stretch away to the east, being the same as have been already noticed in contact with the Vindhyans from Singoli northwards.

Of rocks younger than the Vindhyans the Deccan trap is almost the only representative within the area I refer to. At one spot about a mile south of Jabbooah, near the north base of the great ridge of trap, there is a small remnant of the Bagh cretaceous deposits;

sandstone and bryozoan limestone, scarcely more than 10 feet in all, capping a low ridge of crystalline rocks for about a mile in length, and then itself covered by the trap. Although I examined the base of the trap at many places in the vicinity and all along for nearly a hundred miles to the north I found no other representative of the Bagh beds.

Of the trap itself a great variety occurs within the area I traversed. I did not notice a single instance of intrusive trap of this age. The trap is first met with on the Great Deccan road, at about half way between Sipri and Goonah; and from here its spread is unbroken, save by a few projecting ridges and points of the Vindhyan sandstones, and this only in the northern part of the area. Near Kotra I noticed large blocks of baked sandstone weathered out of a trap flow. I nowhere found large siliceous geodes so abundant as in the bottom flows at the boundary of the trap area. On the whole, porous vesicular trap highly charged with zeolitic matter largely predominates. In the road cuttings through the hills south of Goonah there are excellent sections exhibiting the distinct flows of rock. In several I noticed the gradual passage, within 8 or 10 feet, from a close-grained crystalline ball trap to a highly vesicular and earthy rock at the surface of the bed. At the base of a flow also, compact rock takes the place of the large spheroidal trap of the centre of the mass. In the region from Beora to Mehidpur a strong, dark, columnar basalt is constantly met with in the beds of the large rivers. In the western region north of Rutlam a porphyritic basalt is common. It is the hornstone-porphyry of Dangerfield's description.

Intertrappean beds were noticed at many places in the north-eastern part of the area; but always very local, thin and highly altered into a confused agglomeration of crystalline limestone, arragonite and silica. At the village of Bugleri, 3 miles north-west of Mundesor, I noticed at the base of a small scarp of Vindhyan sandstone a bed of breccia made up of Vindhyan debris. Although the fragments were not water-worn the bed seemed to me to be certainly water-laid; and it is overlaid by trap.

Laterite of various descriptions occurs at many places. The regular, primary form of this rock,-that so generally associated with the Great Deccan trap formation,-is found capping the hills south of Goonah; and, again, the plateau on which Augur stands is covered by about 50 feet of laterite, rocky and massive at top, and soft, earthy and ochreous at base, as is generally the case with this deposit.

Black cotton soil occurs frequently over large areas, but its connection with the trap seems very indirect. I frequently observed trap decomposing into an ordinary yellow kunkury clay, this being overlaid, with a sharp surface of junction, by a thick layer of black soil.

August, 1866.

METEORITES.—The Museum of the Geological Survey of India has been enriched, during the past quarter, by a magnificent specimen of the meteorite which fell at Menow, in Mechlenburg Strelitz, on the 7th of October, 1861 (?1862), and also by a perfect cast of the whole mass. This mass was purchased at the time by Baron Reichenbach, and has ever since remained almost intact in his collection. He would not have it cut, and specimens, therefore, excepting a few of very minute size, were unknown in other collections. More recently, Baron Reichenbach has been desirous of disposing of this splendid meteorite, and after sometime it passed into the hands of Mr. Wm. Nevill, now of Godalming, Surrey, whose valuable collection of meteorites is well known. This collection is now, I believe, the finest private collection in the world, and it would rank very high even among the series in Public or Government Institutions. To Mr. Nevill, I am indebted for the splendid specimen now here. It consists of about one-third of the whole mass, showing on all but the cut and polished plane the original crusted surface of the mass. This vitrified crust is coarser, more granular, and altogether less truly vitreous than usual. I have as yet only had the opportunity of seeing the polished surface of the cut stone, and it is not easy to distinguish the structure in this way. The sp. grav. is more than 4, showing the amount of metallic matter in the stone. But a more careful examination of it will be made.

To Mr. Nevill, I am also indebted for the extremely rare specimen of the stone which fell at Perth, Scotland, on the 17th May, 1830. Of this fall, only one specimen was known. This which belonged to Mr. Nevill (having been a part of the Lettsom collection purchased by him) was divided with the British Museum, and the fall was, therefore, only represented

in the collections of Mr. Nevill and of the British Museum. Mr. Nevill has now, with singular liberality, presented his almost unique specimen to the Geological Survey collection. The specimen is small, only weighing 6·5 grains.

In the previous number (p. 39), when noticing the addition of the specimen from Pultusk, I had only received the early intimation of the fall, when it was supposed that not more than three or four pieces had fallen. Subsequent research has shown that the number of separate stones, the majority of them being perfectly crusted on all sides, exceeded even a thousand!! A perfect shower of meteorites!

DONATIONS TO MUSEUM, &c.

A series of bones of various parts of the Solitaire *(Pezophaps solitaria*, Gmel.) from Rodriguez Island, by Edward Newton, Esq., Auditor General, Mauritius, through Geoff. Nevill, Esq.

Specimen of Meteorite which fell at Perth, Scotland, on the 17th of May 1830, by Wm. Nevill, Esq., Godalming.

Two specimens of roofing slates from Chamba quarries, by Captain J. P. Turton, 4th Goorkas.

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FROM 1st JULY 1868 TO 30TH SEPTEMBER 1868.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1869. [February.

The Valley of the Poorna River, West Berar; *by* A. B. Wynne, Esq., F. G. S., &c.

The Poorna valley between longitudes 76° and 78° east, is traversed by the 21st parallel of north latitude. It is about 124 miles in length from its upper or eastern end to where it passes into the larger valley of the Taptee; the main directions of both diverging at first so as to include an angle of about 50,° but afterwards becoming more nearly parallel or east and west. The width of the valley may be roughly estimated at from 30 to 40 miles on an average, but is in places greater.

Its boundaries are—on the south, the range of the Adjunta ghâts,—an abrupt scarp of the Deccan plateau produced, and gradually becoming less marked, to the eastward—some hilly and undulating ground forming the watershed in that direction between the Poorna and Wurdah valleys; and on the north, the lofty bold and varied escarpments of the Gawilghur range, which carry a high crest westwards near to where the Poorna river runs into the Taptee, the termination of the mountain range here sinking with some rapidity, though not being by any means abrupt.

The southern ranges pass imperceptibly into the usual steppe character of the Deccan, while the mountains on the north are a complex mass or group with a generally east and west extension, and such summit elevations as 3,595, 3,778, and 3,975 feet, declining gradually northward into the valley of the (upper) Taptee.*

These Gawilghur mountains are intersected by steep glens and wider valleys, sometimes presenting nearly vertical precipices of great but unmeasured height which may in places reach 1,000 to 1,200 feet. The glens and ravines wind intricately among the mountains, affording some very fine scenery, and as their streams seldom retain water for any considerable time, the wildness of this is increased by solitude.

The valley of the Poorna possesses but little variety of geological interest and is principally distinguished by monotonous repetitions of features observable in crossing the Deccan from the seaward to this locality, where each hill and ghât and undulating slope or plain exhibits similar kinds of nearly horizontal flows of gray amygdaloidal trap, with here and there a bed of harder texture of columnar structure, or of bright red bole, or alternations of these; the traps sometimes containing numerous zeolites.

In the river valleys, and where superficial 'rain-wash' has accumulated, a light brown 'kunkury' alluvium is associated with calcareous sub-recent conglomerate below and black cotton soil above, one being quite as occasional and accidental as the other, the conglomerate or concrete being perhaps the most persistent along the river courses, the brown alluvium or (P) "soda soil"† more universal and the cotton soil occurring, subject only to the rule that it is always uppermost.

Upon descending the escarpment of the Deccan into the valley of the Poorna its alluvial plain is entered, often at no great distance from the ghât, and stretching away as far as can be seen; only clear days permitting some of the nearest mountains upon the opposite side

* These heights are taken from a small photograph copy of a map of Gangra by J. Mulheran, Esq.

† This efflorescing brown alluvium is considered by Mr. Blanford different from the "soda soil" of Madras.

to become visible. Heights not being given upon the best maps obtainable, the elevation of this plain and its boundary ranges could not be ascertained even approximately in the absence of a barometer—which is to be regretted, as the main watershed of India separates the sources of the Poorna from those of the Wurdah, the water of the former being discharged eventually at Surat whilst those of the Wurdah are tributary to the Godaveri, which enters the sea below Rajahmundry on the opposite side of the peninsula.

The alluvium of this great plain, although of very considerable depth and occupying so large an area, is as completely isolated from that of the neighbouring rivers as such a deposit can be said to be. A section crossing the valley from the Adjunta ghâts, by Edulabad across the Poorna river, to the western termination of the Gawilghur range, would show the ordinary trap of the Deccan, forming the high ground at either end, and an undulating country between, which viewed from above or from a distance has a plain-like aspect, but frequently exposes the rocks of which it is formed; consisting of the usual traps, here and there covered only by slight detrital accumulations of the same kinds as those of the Deccan. Except on the very banks of the Poorna no considerable quantity of alluvial matter would be found, and this does not extend far from the river at either side. North and south through Mulkapoor a different section would be obtained. Here a wide space, chiefly on the south side of the Poorna, is occupied by fine brown calcareous alluvium with 'kunkur' and is connected by a narrow neck, at Peeprala, with the great alluvial deposit of this valley which in thickness may exceed 150 feet; and nothing else, save varieties of this, is to be seen in or near the river from Dadulgaon on its south bank eastwards up the stream nearly to the "sungum" or junction of the Phairlee river, which enters the Poorna near Kowsa, if we except two or three small exposures of trap in its bed near Peeprala Pulsoad and about three miles west of Burra Golagaon. The Poorna changes its course from the N. N. E. at the junction of the above-named tributary, and thence takes a westerly direction:—the alluvium on its south side seldom extending beyond an average of ten miles from the river and nearly coinciding along its southern boundary with the Nagpoor extension of the Great Indian Peninsula Railway—while on the north it reaches nearly to the base of the mountains. On the east its rather arbitrary and more or less indefinite boundary closely approaches the watershed east of Ellichpoor and bending southward traverses undulating country eventually reaching the flanks of the hills near Oomrawuttee.*

All round the margin of this alluvial tract is a belt of country that might or might not with propriety be included within it, although the surface deposits there do not conceal the underlying rock, the exposure of which was taken as the chief guide in determining the line of boundary. On the north and east, this tract of country is very stony, though nothing resembling an old beach is seen, and it may be supposed that streams descending from the mountains and hills have frequently travelled across this space, their courses subject to lateral deviation, covering the whole of it with the coarser fragments brought down by floods at a time perhaps when the water of a lake or the sea, occupied the basin of the finer alluvium and arrested the boulder-bearing velocity of these mountain streams.†

In every part of the alluvium calcareous conglomerate or concrete is of common occurrence. It occasionally contains fragments of bone or fossil teeth of ruminants, but although sought for, no large accumulation nor even a large fragment of these fossils, was observed. Yet enough was seen to show an identity of the conditions under which these deposits and those of the Nerbudda valley were formed. This sub-recent conglomerate‡ is very frequent in the stony tract above mentioned. It was everywhere searched for worked flints but without success, although one flake was found in a quite similar deposit, forming the right bank of the Godaveri at Pyton in the Deccan, at a considerable distance to the south.

Small land shells are not uncommon in the alluvium, some were preserved and transmitted to Calcutta, but in general they were too fragile for removal. They appeared to belong to existing species. Specimens of *Melania tuberculata; Paludina Bengalensis; Bithinia pulchella; Lymnæa—; Planorbis—; Unio* (?) *favidens: U.—?* have been recognized.

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* Pronounced Oom'rowtee.

† At one place in the stream near Dhanspoor the stony margin seemed to unite with the finer alluvium by alternations of coarse and fine strata two feet or so in thickness.

‡ The native name for this 'concrete' is "Kârruk."

A deposit of varying thickness (within three feet) and but small lateral extent, consisting of fine dazzlingly white sand finely laminated occurs in the alluvial bank of the Poorna at Paruth. It appears to be composed of comminuted or disintegrated crystals of felspars with a small admixture of clay. It did not appear to be formed of or to contain minute organisms, such as foraminifera, and was not elsewhere observed.

Much of this Poorna alluvium produces efflorescences of salts, of soda chiefly, and in many places the wells sunk in it are brackish or salt. Over a wide tract on each side of the Poorna river, north of Akola and thence eastward towards Oomrawuttee, wells are specially sunk for obtaining common salt from highly saturated brine.

Some of these salt wells near Dyhunda in the lands of Gunoree are from 120 to 130 feet in depth or probably more. They are sunk through yellow clay, then redder clay, and below this a coarse sand or fine gravel from which the water issues with great force. They are lined with wicker work in order to preserve the pottery vessels, in which the water is raised by hand, from breakage. The crystals of the salt are small and it is rather dirty, but during the "dhūp kâla" or hot season, it can be obtained whiter. The wells are numerous over the tract north of the river and some also occur to the south.

That the alluvium of the valley is of considerable depth may be perhaps inferred from the absence of numerous exposures of rock, as well as from the depth of nullahs and height of the river cliffs. The conglomerate, as usual, occurs in its lower portions, but was observed in some places west of Patulla at different heights in the sections exposed. Its constant or frequent occurrence beneath the rest of the alluvium would not prove its being contemporaneous in all places, as the trap rocks, upon which these deposits lie, cannot be presumed to have had a surface sufficiently even to have permitted this.

Whether the whole of this alluvium was deposited in a lake, or by the river travelling from side to side of the valley under other conditions than at present obtain, does not appear. A former estuarine state of things may be indicated by the salt-bearing gravels, or a large salt lake, but the even though interrupted surface of the alluvium is against the probability of its having been deposited by the Poorna under present conditions; while want of information as to the relative levels, obscures the possibility of determining whether the rocky country about Edulabad may not have formed a natural *bund* flooding the country occupied by the alluvium; certainly the stream through most of this is sluggish, but it seems to be a rather strong assumption, that no greater fall than the height of the river banks where it enters this rocky tract—perhaps on an average not more than 30 feet—takes place within so great a distance as extends between this and the upper end of the alluvium, about or S. W. of Oomrawuttee.

Good water is scarce in this district, in some places shallow 'jhieries'* alone can be depended upon for a supply, the wells being brackish and even the river gravels furnishing brackish water if pierced to any considerable depth. A succession of dry years seems to have greatly reduced the usual supplies of water, and very many of the villages among the hills to the north are deserted, it is said, because the streams which supplied them formerly do not now furnish sufficient water. Not improbably the diminution in the supply has been caused by the wholesale cutting down of the jungles which covered the country before the period of the English Raj.†

The hills and portion of the valley south of the Poorna river have been stated to consist of trap similar to that of the Deccan; all the usual varieties of amygdaloid, zeolitic, columnar, hard, gray, and softer, ashy-looking traps occur, their stratification being very perceptible, and always nearly horizontal.

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* This name is applied to small excavations in the sandy bed of a river reaching the water which trickles beneath the surface, and thus becomes naturally filtered.

† Want of water is much complained of at Chikulda. There seems to be no reason why the plateau to the east of the bungalows should not afford a sufficient catchment basin for the station. As the trappean strata of the hill dip N. by W. at 5°, if wells were sunk, the north side of the plateau would be the position to choose with most probability of success. Near the bungalows however the plateau, if such it can be called, is very narrow, and affords a much smaller catchment area, yet even here the hill must contain strata which retain water as it issues from the rocky beds of nullahs, and one well immediately beneath the northern edge of the plateau, and at a considerable height upon the mountain side, is stated never to go dry.

About the Gawilghur range on the north there is a constant dip at low angles in that direction, the lower part of the range being chiefly composed of amygdaloid and soft traps; and hard basaltic beds occurring in greatest quantity among the higher parts of the hills, where such bands may be seen to course along the sides of cliffs and mountains for several miles; a capping of the harder trap remaining here and there on top of an isolated peak or hill, while lower elevations around have less angular and more flowing outlines, being formed of the softer varieties of the trap.

Occasionally along the base of this range, the beds have been thrown into wide curves with very gentle inclinations, their axes dipping but slightly to the northward.

Intertrappean beds are said to occur among the Gawilghur hills; they were only detected in one place, and consisted of hard chert enclosing numerous shells: but though near, this is not properly speaking within the Poorna valley.

Perhaps the most interesting geological feature of this country is the occurrence of a great fault, with a down-throw to the south, which may be very considerable, as it shifts the trap downwards for some two or three hundred feet visible, added to an unknown thickness of the trap which is buried by it, so that trap, of what exact horizon cannot be stated, is brought against the underlying Mahadeva or Bâgh (Tanda)* sandstones. This fault crosses the country in an east and west direction, close to the foot of the Gawilghur range north of Ellichpoor, where the abrupt southern scarp of the range shows these sandstones, occupying the interiors of open curves in the trap like those just now mentioned. The difference of inclination between the sandstone and the traps is but slight, so that their unconformity is, as usual, not very strongly apparent, though it nevertheless exists; the line of contact where the overlying traps rest upon the sandstone, is frequently difficult to see when close by it, though from a distance the difference of coloring and the bold projections of the sandstone outcrop mark it well. The sandstones are chiefly soft or coarse white and even-grained rock, which would doubtless make a good building stone. A large mass of these occurs in the lower portion of the group exposed; above them are conglomerates, other sandstones of similar kind, purple and black shales and flagstones, variegated and white flagstones and shales, and then solid gray limestone with silicious or cherty nodules of peculiarly rugged aspect; these limestones in some places becoming so variegated as to form what if polished would doubtless be a handsome marble.

In this group of Mahadeva or Bâgh beds dips to the north of 10° and 15°, with others more nearly horizontal, may be sometimes seen; these becoming less as the sandstones finally disappear beneath the Gawilghur traps to the north of the cantonments of Ellichpoor. In the river at Nurrha, north-east of the latter place, the section is somewhat unusual. The ground here seems to have been intensely faulted, and instead of leaving the trap and passing over the fault on to sandstone at the base of the hills, trap is again found north of the general line of fault; then occur several large dykes of another intrusive trap different from that usually met with, between which are masses of the limestone, sometimes resting upon a conglomerate, and tilted in various directions at angles of 35° and 50.° Beyond this disturbed locality the next rock seen is sandstone, horizontal for some distance but soon overlaid and covered up from view by the unconformable trap.

In the flaggy portion of the Mahadeva or Bâgh group, impressions of large plants have been observed, and in the shales and some of the limestones numerous small univalve shells.

Fossils were known to have occurred north of Ellichpoor, as mentioned by Dr. Bradley. These sandstones were known to the late Rev. Mr. Hislop, but seem to have been erroneously considered inter-trappean. Lithologically they frequently recalled the appearance of the sub-trappean cretaceous rocks of Bâgh-Tanda and Rajpoor along the Hutnee river, &c., in the valley of the Nerbudda, and it was a disappointment not to find the same, or the same quantity of fossiliferous evidence here, the beds in both places being possibly, or probably, of the same age.

Laterite occurs on the new road from Ellichpoor to Oomrawuttee at a place called Bulgaon or Burgow, about six miles from the latter city. It is more properly a lateritic conglomerate of small pebbles cemented together by iron oxides. It lies horizontally, and has

* Bâgh-Tanda is the name generally used by people when speaking of Bâgh at a distance therefrom.

much the appearance of a re-composed rock, in many places quite incoherent, harder at the top and outsides than internally, and the pebbles are all red, bright purple or ferruginous, glazed outside and not recognizable as derived from any of the traps of the country, unless from their resemblance they might be taken to have come from one of the beds of red bole, which are not very uncommon; but then there is no reason why if so derived they should not be intermixed with other trap pebbles. This has all the appearance of a local deposit, does not crop out in some natural excavations near at the same level, and apparently passes away underneath the cotton soil, but being horizontal or nearly so shows for a considerable distance along a sluggish stream which occurs here, occasionally varying in structure so as to become a mottled white and purple rock of some strength.

In one place on the bank of this stream a little cliff shows the incoherent gravel resting upon a soft ferruginous bed, about 9 feet thick, with some lines like those of deposition. Beneath this are 5 or 6 feet of greenish-gray trappean mudstone, very splintery and breaking up into cubical forms so much that it is nearly impossible to obtain a fresh fracture; some harder parts seem calcareous, and have a fracture resembling that of compact limestone. The laterite may be traced for more than a mile in an east and west direction. Near Budja Kaira, on the larger river here, strong vesicular laterite undulates about horizontally, but does not continue down the stream.

Again at Reethpoor lying to the eastward from Oomrawuttee, there is a quantity of laterite in low swelling undulations—with the usual appearance of lateritic ground, a ferruginous more or less smooth surface and occasional hard projecting knobs, but no good sections of the rock.

At Chickulda (the hill station on top of the Gawilghur range frequented by people from Ellichpoor), the plateau upon which it stands and the surrounding summits have a strongly lateritic appearance such as may be seen at Matheran and other summits of the Western Ghâts.

These indications of laterite, occurring as they do in situations where the uppermost beds of the trap series might be supposed to occur, may indicate a similar or nearly the same lateritic horizon, which is known to occur among the uppermost, if not actually on the top of, the Deccan traps along the Western Ghâts. Otherwise they may be referrible to zones of ferruginous strata more specially lateritic than the layers of red boley trap referred to as occurring in this neighbourhood and on the Deccan plateau; but their limited development and isolated character hardly afford sufficient grounds to reason upon with much probability of arriving at trustworthy conclusions.

The cotton soil or black soil of the Poorna valley, although common enough, as is usual in these trappean districts, has no geological peculiarity here requiring attention. To its development, however, and the fertile nature of soils derived from the trap may be traced doubtless the name which this country has obtained as a cotton-producing district.

On the KUDDAPAH and KURNOOL FORMATIONS: *by* W. KING, Junr., B. A.

The rocks forming the greater parts of the Kuddapah and Kurnool districts in the Madras Presidency have been long known through previous explorers under the names of "Diamond Sandstone," "Clay-slate Formation," &c. They extend over such an immense area, and are found to be so complex in their stratigraphy and so diversified in their relations, particularly among the lower and older groups, that their systematic survey is not yet quite completed, though some years have already been spent in their examination. Sufficient, however, is now known of them to warrant the giving a short sketch of this interesting series of rocks.

The series consists of great thicknesses of quartzites (altered sandstones), slates, trap-flows and their associates, and limestones; and these are found to constitute two (if not more) great and distinct formations. To the older, being so typically and largely exhibited in the Kuddapah district,* the name KUDDAPAH FORMATION has been assigned; while the newer KURNOOL FORMATION derives its appellation from the adjoining district over which it is so very well seen.

* Kuddapah town itself is on shales and limestones of one of the groups in the newer formation.

The area of these rocks, from the Kistnah river down to Naggery Nose,* their southernmost extremity, is about 13,500 square miles. The greatest thickness of each formation, as at present known, is:—KURNOOLS, 1,200 feet; KUDDAPAHS, 21,000 feet.

The most interesting feature about these formations is that they are most probably representatives of the great VINDHYAN series of Indian rocks. This conclusion has been arrived at from careful comparisons of typical rock-specimens from either series, and of the recorded observations made during the surveys of each. The VINDHYANS have now been traced as far south as the Godavery river, where it traverses the district bearing its name; and here they are so lithologically and stratigraphically like the KUDDAPAHS and KURNOOLS on the Kistnah river, not very far south, that there hardly remains a doubt as to the identity of the one with the other.

The history of the KUDDAPAHS is still to be thoroughly worked out; and on this account, the present sketch will be more directly confined to a description of the KURNOOLS. There are, however, some well-marked and clearly made out features of the KUDDAPAHS which may in the mean time be adverted to.

Both formations agree in this, that they are largely made up of quartzites, while limestones are sparingly developed in one and extensively in the other; but the KUDDAPAHS are distinct in showing strong groups of clay-slates, with one of which it may be necessary eventually to include the trap-flows and their associates referred to above.

Supposing at present that all the quartzites, slates, &c., not included in the following description of the KURNOOLS, may be considered as of the KUDDAPAH FORMATION, it is then possible to give an idea of their locality in the great area of country occupied by this formation.

The Goolcheroo hill-ranges south of Kuddapah, and their extension south-eastward down to Triputty and the Naggery hills, are made up of quartzite sandstones and conglomerates; while rocks of the same kind with bands of slate go to form the long range of the Eastern Ghats or Yellacondas lying between the Kuddapah and Nellore districts. The country south-east of Kuddapah, that is Ontamitta, Chitwail, Poolumpet, &c., within these mountain ranges, and that due north of it:—Nullamullays, Budwail and Cumbum, up to the Kistnah river, are also made up of like rocks of the same formation. The Gundicottah range of hills, north-west of Kuddapah, is likewise of these old quartzites, and the parallel ridges and valleys between that range and the Bellary district to the west, with their extensions right up to Jaggarnat-Conda (hill), a few miles south of Kurnool, are of quartzites, slates and traps.

These older rocks are interesting as being traversed, at rare intervals, by veins and strings of copper and lead ores, accounts of which have from time to time been given by writers on the resources of Kurnool and Kuddapah. Copper ore occurs very sparingly; in fact, there are only traces of it, but the sulphide of lead is more abundant. The workings for both were abandoned years ago; a state of things perhaps due to the difficulties in the way of living at, and working the mines, rather than to a failure in the ore. Traces of these ores are also known in the older crystallines or gneiss, of the remainder of the districts.

With such a brief account of what is at present known of them, the KUDDAPAHS may be left for future description.

KURNOOLS.

This formation unfolds itself as a double series of groups of limestones and quartzites; the lowest beds of all being quartzites, as thus, in descending order:—

1.	Limestone group ...	... { a. Calcareous shales. b. Limestones.
2.	Quartzite group ...	... { a. Pinnacled beds. b. Plateau beds.
3.	Limestone group ...	... { a. Non-calcareous shales. b. Limestones.
4.	Quartzite group ...	... { a. Massive beds. b. Beds (containing diamond gangue).

* A peak of the Naggery range, about 40 miles W. N. W. of Madras.

These four groups are quite distinct, though conformable; they generally overlap each other in some part of the field, and they lie, for the most part, very much as they were originally deposited, viz., in great flat basins with edges slightly turned up,* or in very flat undulations, from which, however, the upper limestones are always denuded, leaving the quartzites exposed.

1st Group, Khoondair Limestones.

The uppermost group lies nearly all over the wide Khoond-air (river) valley which stretches northwards from Kuddapah town, and over most of the Kuddapah basin or southern extremity of this valley. There is a small outlier under the fort of Kurnool; while more of the same rocks cover the eastern extremity of the Raichoor Doáb. Again, a considerable detached area of these beds, with the other groups, occurs in the Palnád, or western taluqa of the Kistnah district.

The rock coming to the surface,† especially in the Khoond-air valley, is not, however, always limestones; more generally, there are reddish-purple calcareous shales (occasionally cleaved), and these constitute the upper member of the group. For instance, the shales occur all up the middle, and very strongly at either end, of this great valley. They gradually shade down into the typical limestones of the group, which are dark-gray, more or less earthy, sub-crystalline beds; sometimes very massive and thick, oftener flaggy or easily split up into flags of 1—3 inches in thickness. The limestones are also occasionally more crystalline and compact, and cleaved to a certain extent, where folding or crushing of the beds has taken place, as along the eastern side of the Khoond valley. They of course show most along the skirts of the valley, as near Kuddapah, Podatoor, Dhoor, Chagalmurry, Sirwél, and so on up to the banks of the Kistnah.

2nd Group, Paneum Quartzites.

Along the western side of the Khoond valley, the country rises very gently in a series of low long-sloping hills, with a few plateaus and undulations, which finally present an irregular scarp towards the Bellary district. These are the Gundicottah, Ramwarum and Paneum hills, whose surfaces, with the exception of the Gundicottah range, are made up of quartzites of the second group, which thus rises up from under the limestones of the Khoond valley.

This is the only side of this part of the country over which these quartzites occur; they do not appear on the western side of the valley, for the group thinned out altogether in that direction, as well as to the north and south; the sections among the turned up strata on this side showing the upper limestone group lying on the lower one without any intervening quartzites, as is the case in the sections on the western side.

Altered sandstones of the same group show rather strongly in the Kistnah district; where they are again, through the denudation of the upper limestones, the superficial beds of the low hills in the south-west corner of the Palnád.

The quartzites are of two kinds, quite distinct enough as features in the landscape, but hardly sufficiently so to be referred to as separate members of a group. The upper variety is a thick-bedded, massive, compact, white sandstone, much vitrified, but granular, and showing a very peculiar style of weathering into massive buttresses and pinnacles. The strata are generally horizontal, or at a very low angle, and the steep-sided ravines and scarps denuded in these are often fringed with strangely picturesque masses of rock, or the slopes below the scarps are strewn with great fallen masses of the same beds. The high-road from Kurnool to Nundial passes over a plateau of those white quartzites, and the quaintly worn masses immediately remind one of some rocky coast from whence the rushing and tumbling waters have long since retired.

Coarse sandstones and grits, with pebble beds, of dark colors, and in thinner strata are generally found subjacent to the thick, white, pinnacled quartzites, and are often alone without the covering of the upper beds. In such last cases, the remaining beds now form the summits of a number of flat-topped hills fringing the Koilkoontla and Banaganpilly sides of the Khoond valley.

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* The subjacent Kuddapahs are, on the contrary, turned up on end, convoluted, crushed, and faulted in the most varied way.

† The Khoond valley is very extensively covered with cotton soil.

3RD GROUP, JUMMULMUDDAGOO LIMESTONES.

Wherever the above group of quartzites has been cut through, it is seen to be resting quite conformably on a thick series of shales and limestones; occasionally the shales thin out and nearly disappear altogether, and then the quartzites look to be resting directly on gray limestones.

These constitute the second limestone group among the KURNOOLS, and they are generally easily distinguishable from those of the Khoond valley. The shales are generally of a buff color and are never calcareous, while the purple shales of the upper group are always more or less so; and again the limestones are as a rule more crystalline and compact. There are, it is true, just as earthy and flaggy beds to be found in the upper as in the lower group, but such beds are less frequent in the latter, and they are arranged in definite succession. There is generally a three-fold series, thus:—at the bottom, compact, sub-crystalline gray, and some purplish beds, with a thin series of peculiar limestone breccias; in the middle, thick, compact-splintery dark-gray and blueish beds; and thirdly, pale and dark-gray compact, sub-crystalline and sub-earthy, often flaggy, beds.

The more crystalline and compact beds weather in a peculiar coralloid manner; the worn surfaces being so radiately furrowed, pitted, and concentrically terraced, that the rock seems to be made up of two or three different forms of coral; but close examination has failed to show any organic structure. This coralloid appearance is characteristic of any great show of these lower limestones, though the same feature is also seen every now and then in the upper group.

This generally more crystalline set of limestones is seen at intervals, along the eastern side of the Khoond valley, in a narrow belt of outcrop at or near the western base of the Nullamullays. Again, on the western side of the same valley in Koilkoontla and Banaganpilly, and in the valley between the low Nosoom ridge and the Gundicottah hills, and so further south, in the western part of the Kuddapah basin, where the Nerjee quarries* have been opened up in the thin and compact beds of the group.

In the steep western slopes of the Gundicottah, Ramwarum, and Paneum ranges of hills, these limestones again come to light and form a narrow continuous terrace below the vertical scarps of upper quartzites, all the way from the tops of the hills east of Tadpurthee (Bellary district), up to within 24 miles south-south-east from Kurnool, when it spreads out in wide sheets between the lower and gentler undulating hills which are here sinking down to the flat country of Kurnool, itself built on a further out-stretch of these same beds.

Here, in Kurnool, the group has thinned out a great deal, but still there are the three varieties of limestones in their proper order: the canal being cut in thin flaggy upper beds; the more crystalline strata cropping out between the canal and the village of Calloor; and the thin grey compact sub-crystallines, though altered much by local igneous action, showing close under the western bastions of the town. Thence, with the exception of some slight denudation in the Toongabudra and Kistnah, these limestones extend northwards to a few miles beyond the latter river, in the Hydrabad territory.

In the Palnâd there is the limestone again in great force. It here presents identical characters with those in Kurnool and Kuddapah, except that it is more extensively cleaved; and that the white and buff non-calcareous shales are only seen to a small extent.

4TH GROUP, BANAGANPILLY QUARTZITES.

Lowest of all of these strata comes another quartzite group which is interesting as including the beds from which only diamonds are known to have been extracted in the districts under description.

Hence, if the old nomenclature of "diamond sandstone," or "diamond formation" was to be employed in a classification of Madras rocks, it would have to be applied to the KURNOOLS, or one of the groups included in that formation. There is no case known of diamonds having been found in quartzites of the KUDDAPAHS, or in fact in any other group of

* These quarries were opened, and are now extensively worked by E. W. Barnett, Esq., who has used the stone whenever practicable on the Madras Railway, and for the new Madras University and other public buildings in the Presidency.

quartzites but the one now described. It is not, however, advisable to employ a name to distinguish a formation, which is derived from what is evidently only an accidental attribute of the rocks; while it is not certain that the diamond sandstones of Punna in Central India, which belong to the VINDHYAN SERIES, are on the same geological horizon as the diamond-bearing beds in the KURNOOLS.

This group of quartzites is a generally thin series of coarse sands, grits, and pebble beds, of dark colors; the sandstones being in thick beds, while the grits, &c., are generally thin and sometimes flaggy. The pebble beds are full of small fragments of chert of various colors which are evidently derived from the slates and trappean beds of the KUDDAPAHS, on the up-turned edges of which they now rest.

The relations and constitution of the group were first made out at Banaganpilly in the Kurnool district, where the long sloping hill which rises to the west of the town is faced with the quartzites.* From this point the strata were traced to the west, on either side of the Puspulla valley, as another narrow terrace of nearly horizontal beds of not much thickness, below and continuous with the terrace of limestones of the second group, already referred to as lying below the western scarps of the Ramwarum and Paneum hills. Indeed, these lowest quartzites form the toe of these western slopes.

The thin-bedded pebbly strata which are generally the lowest in the group seem to be the holders of the gangue, or shaly seams, in which the diamonds are found, but it is only at rare intervals in the exposed area of these pebble-beds that workings have been opened, which is partly accounted for by the fact that these seams of sandy and pebbly shales are only of local occurrence in the quartzites. The selection of working sites seems mainly to have been guided by chance, as the finding of a diamond by a cooly or shepherd, and the selection has been a lucky one in only some cases, for there are localities where extensive workings have evidently been carried on for centuries; while others have soon been deserted. The diamonds found at present are very small and not of much value, nor do the returns seem to have been any better for many years. The workings are of two kinds; mines excavated in the strata, or pits sunk at various points in the recent deposits of débris, shingle, and gravel, derived from the denudation of the quartzites.† The Banaganpilly workings are mainly mines, while the now deserted pits at Chennoor near Kuddapah were in recent gravels.

In the Palnad,‡ there are again a set of altered sandstones answering to this group, and there too among these beds are frequent traces of old diamond workings.

The lowest group of the Kurnool formation is always found to be resting unconformably on other quartzites, slates, and limestones; and where it is overlapped by the superincumbent limestones, these in their turn are found covering the older rocks in the same way; in fact, there is not the smallest doubt but that the four groups now described constitute a distinct formation separable by a great interval of time from the subjacent strata, or the KUDDAPAH.

Both formations are totally devoid of any fossil remains, at least not a trace of evidence of organic life has been found in their strata, and in this they are like the VINDHYANS which are as indicative of a period when there was no life. No more likely series of rocks for containing such remains could be imagined; and one is tempted again and again to examine favourable localities, but always with no other result than some deceptive concretions, or worm-like tracks, or the most perfect surface of ripplings in the sandstones.

Neither can it be that fossil remains which may have once existed can have been so completely obliterated by the metamorphic influence to which these rocks have been exposed, as to have left no trace behind; for whenever we have the originally sedimentary contrition of the rock apparently completely baked out of sight, as it were,—as in the case of pebble beds and the coarsest conglomerates, which, until they are weathered, are as uniformly granular quartzites as one could wish to see—, the various weathering influences have again revealed the original constitution.

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* The Banaganpilly diamond mines are sunk and worked on the slope of this hill.

† These débris-deposits are often quite outside the area of KUDDAPAHS and KURNOOLS, and hence we occasionally hear of diamonds being found in the neighbourhood of granite, or gneiss, when they are supposed to be derived from the latter rocks.

‡ It may be as well to notice that the so-called Juggiapett coal-field is a north-easterly extension of the Palnád area, and the Juggiapett rocks are KURNOOLS and KUDDAPAHS which are not at all of a coal-bearing character.

There are deceptive appearances of organic structure, such as, minute concentrically laminated globular bodies, in some of the KUDDAPAH rocks; the coralloid character of the Kurnool limestones; minute *Cypris*-like bodies in the upper limestones; the dendritric crystallizations of the oxide of manganese in quartzites, limestones, and slates; and lastly the cavities of clay-galls so frequent in the sandstones; but these of course are all referrible to other than organic origin.

GEOLOGICAL SKETCH OF THE SHILLONG PLATEAU: *by* H. B. MEDLICOTT, F. G. S., Geol. Survey of India.

The main features of the geology of the Shillong plateau, on the north-eastern frontier of Bengal, have been known for some time: cretaceous, nummulitic, and younger strata, resting horizontally upon metamorphic rocks of various types, at an elevation of 4,000 to 5,000 feet, and doubtfully related to extensive masses of trappean eruptive rocks. A brief opportunity has recently occurred of visiting the hitherto geologically unexplored western portion of the plateau in the Garo region; and also of re-examining the central portion, in the Khasia district, *at a season when field work was possible.* A brief abstract of the results is here given in anticipation of the more detailed description.

Regarding the supra nummulitic rocks, which are very poorly exposed in the central region, little fresh information has been gained. From the sandstone of Nongkalong on the western limits of the Khasia district, where it rests upon nummulitic limestone, Captain Godwin-Austen has made a collection of fossils upon which Dr. Stoliczka remarks that "none of the species, so far as recognizable, appear to be identical with those known from the nummulitic beds of the same district."

The nummulitic formation presents a total change in the character of the deposits from east to west: from being purely sandy and calcareous, they become almost entirely argillaceous.

The doubtful horizon between the nummulitic and cretaceous formations has been worked out. The former does not overlap the latter; the northern outliers, so far as known, are all of the cretaceous deposits.

The local order of the cretaceous deposits at Cherrapoonji is described.

Many of the fossils collected have been identified by Dr. Stoliczka with forms occurring in the Ootatoor and Arrialoor groups of the upper cretaceous rocks of South India. In the small collection obtained, there were recognisable eleven forms of Cephalopoda, twenty-seven of Gastropoda, eleven of Lamellibranchiata, three of Brachiopoda, and four Echinoidea.

A very extensive formation of stratified eruptive rocks is exposed, unconformably overlaid by the cretaceous strata and resting in natural junction against a steep face of the metamorphic rocks along the south base of the plateau. It is fully 3,000 feet thick. No inter-trappean sedimentary rocks, nor any infra-trappean younger than the metamorphics, having been found, it is impossible to assign the age of this eruptive formation. It is proposed to call it the Sylhet Trap.

Totally distinct from this is the Khasia Trap, so massively developed in the interior of the hills, associated with the younger metamorphics. It is probably hypo-synchronous with these, *i. e.*, introduced (?formed) at the time of their main disturbance and metamorphism.

The granite occurring, both in large masses and in dykes, through the upper metamorphics is younger than the Khasia Trap.

The separation of the Shillong series (the upper metamorphics) from the Gneissic series, is conjecturally indicated.

The peculiar position of the plateau, between two great regions of disturbance, and the close relation of the stratigraphical features with the south-eastern of these mountain-regions are discussed as illustrative of current opinions upon crust-movements.

The occurrence of a sharply defined terrace of older alluvium round the west base of the Garo hills, and corresponding with the well known Madhoopoor jungle deposits in the plains to the south, is noticed with reference to the changes that have affected the delta of the great rivers.

October 1868.

On the occurrence of Gold in the district of Singbhúm, &c., by Val. Ball, Esq., Geological Survey of India.

The existence of gold in the districts of the south-west frontier of Bengal and in the neighbouring tributary states has long been known. It is found not only in the sands of many rivers and streams, but in some instances it has been mined for in the alluvial and other superficial deposits.

Colonel Haughton in his interesting memorandum 'On the geological structure and mineral resources of the Singhbhúm Division,* has given an account of the gold washing, and enumerated several localities where gold mining had been, or was, at the time of his visits, carried on. He also quotes from a letter from Mr. Robinson in which that gentleman states the results of his attempts to establish gold-mining under European superintendence.

At Rohobe in Oodipur where operations were commenced and shewed some prospect of being fairly remunerative, the climate proved so "hot and unhealthy" that it was found that no European could live there, and the works were given up.

Colonel Haughton says that "the metal was found some years ago in considerable lumps "in the Sona Nuddee of Sonapet in Tamar on the northern extremity of Singhbhúm, "and much is still found there."

I have invariably found that the washers have traditions of nuggets having been found at intervals.

The cases of the gold having been found *in situ* are undoubtedly rare. Colonel Haughton speaks of it occurring in *(in situ?)* "a little north of Assuntitlea in Khursowa," but further on he states "I have not heard of any instance in which the metal has been found attached to a stone, so that the former statement must only mean to imply that it is mined for in superficial deposits." Dr. Emil Stœhr states† that traces of gold were found in the copper ores of Singbhúm.

A Mr. Emerson was specially employed by the Singbhúm Copper Company to investigate the gold resources of the country. He is said to have crushed a quantity of quartz and to have found traces of gold in it; but his operations do not appear to have been sufficiently successful to encourage him to continue.

When in Chaibassa last April, I was shewn a small nugget of gold in a quartz matrix. It was said to have been obtained in the Kappergudee Ghat near Kalkapur in Dholbhúm.

It is not within the scope of the present paper to give a complete resumé of all that is recorded on the subject, but rather to give an account of what has actually come under my own observation in those portions of the districts which have been examined geologically.

During the season of 1866-67, Mr. Ormsby and myself fancied we were able to connect the occurrence of gold in the streams with the existence of certain submetamorphic rocks (magnesium and mica schists, slates and quartzites) which were then for the first time met with in Mânbhúm.

Being anxious to put this connection to as rigid a test as circumstances would admit of, and wishing to define, if possible, the exact boundaries within which gold certainly exists and may be reasonably looked for, I with some difficulty persuaded two gold washers (man

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* J. A. S. B. XXIII, p. 103, 1854.

† Einige Bemerkungen über den District Singhbhum in Bengalen. Viertel Jahrs'schrift der Naturforschenden Gesellschaft. Zurich, 5th year, Part 4, 1860.

and wife) to accompany me during my examination of the remaining portion of the district of Mânbhúm. They remained with me for upwards of three months, washing daily at such places as pointed out.

One of the most interesting results is, that the existence of gold in the metamorphic as well as the sub-metamorphic rocks has been satisfactorily proved. This, from various reasons, I was not prepared to expect. Colonel Haughton, who speaks of the granitic gneissose rocks as *igneous*, states that gold is never found in the streams traversing them. Again, the Natives, so far as my experience goes, do not wash in the sands, &c., lying on the metamorphic rocks, although they do not connect the existence of gold in the sands with the vicinity of any particular rock.

In Mânbhúm, the experience of generations of washers has enabled them to define the boundaries within which washing is remunerative; and this boundary, it is interesting to observe, corresponds on the north exactly with that of the sub-metamorphic rocks.* This coincidence I ascertained in the following manner. On my arrival at Dulmi (which is situated on the faulted boundary of these two groups of rocks) when marching northwards from the lower part of Pattrum, the gold-washer asked to be allowed to return to his own country (Dhalbhúm), stating that none of his race ever went north of Dulmi. I induced him however to stop, and while we remained north of the fault the washings were carried on in the granitic gneiss area with comparatively poor, but not exactly barren, results. On the day I crossed the fault south of Sindaree, when returning southwards, the gold-washer said that we should after that find gold more regularly and in greater quantities than we had done since we came north at Dulmi.

During the whole time, a record was kept of the daily results and of the nature of the rocks in which the washings were made. The following abstract will suffice for comparison of the productiveness of the two formations:—

Sub-metamorphics.

	January.	February.	March.	April.	Total.
Number of days on which washings were made	31	9	18	8	66
Unsuccessful days	2	3	2	2	9 = 3·6 per cent.
Gold in grains	17·68	4·65	7·6	2·45	32·38
Daily average in grains ...	·57	·516	·4	·3	Daily average for whole period = ·46 grains.

Metamorphics.

	January.	February.	March.	April.	Total.
Number of days on which washings were made	.....	20	13	.....	33
Unsuccessful days	.....	13	9	.....	22 = 66 per cent.
Total gold in grains	.....	4·78	·7	.....	5·48
Daily average	.....	·23	·05	.....	Daily average for whole period $= \frac{5{\cdot}48}{33} = {\cdot}16$.

* A line drawn across the southern part of Mânbhúm from Simlapal on the east through Burrabazar to a little north of Echagurh on the west, roughly indicates the position of the line of boundary between the two formations.

Comparing these results by the number of successful days first, we may say, that for gold producing, the submetamorphic rocks are to the metamorphics as (100—13·6=)86·4 to (100—66=)34=2·5 : 1; comparing by daily average, the proportions become ·46 : ·16=q. p. 3 : 1.

We may therefore conclude that the submetamorphics are between two and half and three times as productive of gold as the metamorphics, so that as the gold washers only find a subsistence from washing in the submetamorphic area, it is obvious that it would not pay them to work in the metamorphics.

The greatest amount found on one day was 2·2 grains, but the daily averages given above should not be taken as indicative of the amount of gold to be found by a regular system of working where the washers would of course be set at favorable spots, and would not have to spend a considerable portion of their time daily, as was the case of the men I employed, in making marches before they reached the scene of their labours.*

Various papers in the Asiatic Society's Journal describe the methods of gold-washing practised in different parts of India. The instruments used, though essentially the same in principle throughout, have local peculiarities of shape, &c., and the manner of manipulation also varies.

At Heera Khund† the same instrument and manipulation serve for the separation of both diamonds and gold. In fact the diamonds are found in the middle of the process, the iron sand with specks of gold being the final residue.

In Mânbhúm and Singbhúm the instruments used are perhaps more simple than those used in any other place. The dish measures 28″ by 18″, it is hollowed somewhat eccentrically to a maximum depth of about 2½ inches. A scraper formed of a flattened iron-hook set in a handle, serves to collect the auriferious sand and gravel which accumulates in the angles of the rocks in the beds of streams. The dish when filled is placed in shallow water, and the operator working with his hands soon separates and throws aside all the coarser gravel and stones, while the agitation of the water serves to carry away all the mud and lighter portions.

The dish is then balanced on the palm of the left hand and oscillated to and fro with the right; this serves to throw off the greater portion of the remaining gravel, and the process is completed by a circular motion, which is communicated to the water in the hollow of the dish, by which even the smallest particles of foreign matter are separated, and the final result is a residue of black iron-sand in which the specks of gold are readily apparent.

The gold-washers belong to the lowest and poorest races in the country, Gassees according to Colonel Haughton, but some of those which I met with were a race of kumars, called Dokras. Their numbers have been greatly reduced by the famine; without exception they are all in the power of the Mahajuns, for whom they work at a low rate, and are never able to free themselves of the claims which the Mahajuns make on account of advances.

The daily earnings of the gold-washers are small, but might no doubt be increased, if it were not that they are always satisfied when enough gold has been found for procuring the day's subsistence.

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* It is conceivable that the fact of the greater quantity of gold being found in the superficial deposits within the submetamorphic area might be atttributable to something in the configuration or elevation of the ground conducive to the greater accumulation of gold within that area. I could not however discover anything of this kind; the fall to south is gradual throughout both formations.

The origin of the gold which is annually found in the rivers at present is, I believe, twofold. A portion being directly derived from the rocks and the remainder resulting from the re-assortment of detritus which is the remanet of sub-aerial action.

In both formations, the evidences of extensive sub-aerial action are numerous and prominent, and it is obvious that nature has been carrying on gold washing operations in the valleys, since denudation first commenced to scoop them out, leaving barriers of intervening ranges of hills formed of the hardest rocks between them.

† J. A. S. B. VIII. 1057, 1839.

Colonel Haughton says—"The Gassees can always reckon on earning from three to four pice per day, and I am assured that a vigorous man often gets as much as twelve annas, which, as the ordinary rate of field labour is about one pice, must be considered a very large sum."*

Mr. Robinson found in a trial which he made at Rohobe in Oodipur, that men to whom he paid one anna could produce for him from three to four annas worth of gold.

Colonel Dalton states that the washers themselves regard it as a very poor trade, simply yielding they say *pét bur* (bellyful).

Dr. Stœhr in his paper on Singhbhúm states that he found the average daily earning to be about 25 centimes (rather more than an anna and a half).

The men I met with stated that they could earn about an anna a day and occasionally three or four annas.

Taking into consideration the manner in which the gold is distributed through the superficial deposits of these districts, it would seem that the system of hydraulic mining, at present practised in California, is the one which would be most likely to be successful.

In a recently published account† of that system we learn that there is a company in California which supplies water to the miners at such a moderate rate that "350 miner's inches of water, with a head of 160 feet, will remove and wash 4,000 tons of gravel per diem, leaving a small profit on the working of stuff affording gold to the value of only three half pence per ton."

In parts of the districts under consideration it would be hopeless to expect to obtain a constant and sufficient supply of water with the necessary head-way: but there must be many places at the bases of the plateaux which rise towards the west, where the conditions would be peculiarly favourable. During the rains the number of such places would of course be vastly increased.

The simplest idea of this process, which seems so nearly to approach to perfection in California, is not, however, altogether unknown to the natives. Mr. Robinson says‡—"Another plan and a very remarkable one in which the people collect the gold is by drawing up small watercourses before the rains, so as to make places for a deposit of soil carried down by the water; this soil is cleared out several times and in it is found a large deposit of gold."

In the shallow diggings the hydraulic system would not of course be applicable, but even in them an increased field would undoubtedly result from supplanting the native's dish by the Californian pan, rocker, long-tom and sluice.

September, 1868.

MEMORANDUM ON THE WELLS NOW BEING SUNK AT THE EUROPEAN PENITENTIARY, AND AT THE SITE FOR THE CENTRAL JAIL, HAZAREEBAGH, *by* H. B. MEDLICOTT, F. G. S., GEOLOGICAL SURVEY OF INDIA.

1. All the rocks of Hazareebagh are of the most extreme metamorphic type, and are besides very irregularly arranged. It will, therefore, be at once understood that a question of water-supply, in which these rocks are concerned, is altogether beyond those simpler cases where a study of the sections might enable a Geologist to give an approximate positive judgment upon the source of water in any given position. The independent method being thus not applicable, I had to trust to the discussion of existing local experience, and the comparison of this with the special cases proposed, with the following results.

2. Hazareebagh is on an undulating upland. There is nowhere any strictly level ground; but the tops of the ridges are generally very flat, and the slopes very gentle. It

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* J. A. S. B., 1854, p. 109.

† Quar. Journal of Science, XIX, July 1868.

‡ J. A. S. B., 1854, p. 108.

is only in the immediate neighbourhood of the main stream-channels that rougher and steeper ground occurs, and also where rocks come to, or near to, the surface, whether on the slopes, or on the ridges. But even in this latter case, the summits of such ridges are very approximately on the same level as those where no rock is to be seen; I regret that available information does not enable me to give figures. Over large areas, as in and about the Station and Cantonments, no rock whatever is exposed. From the few glimpses I was able to get in the upper part of unlined wells or in ditches, it would appear that such areas are formed of a dark stiff sandy clay, tinted with iron, and mottled with concentrated granules of the same in varying proportions. The greatest thickness I was able to observe of this stratum was 14 feet in a partially dug well, where the water level had not yet been reached; but, no doubt, it locally attains greater dimensions. I could not fully satisfy myself, from an inspection of this clay, whether it is purely derived from the decomposition in place of the subjacent rock, or whether it be in some manner alluvial, a point that would bear importantly upon the under-ground distribution of the water. I incline to the former view; but, if correct, the rocks must be there unusually free from the quartz-veins which occur so abundantly in the exposed rock sections, and which veins would remain in position and unaffected in the clay. This stratum forms a cold and retentive under-clay: the upper two feet or so of a paler colour, where de- and re-composition has further advanced, forms a slightly improved sub-soil, yielding at the surface a very poor soil. Where the iron and the sand are not in excess, the under-clay forms an excellent brick-clay; the upper layer being fit for tiles. Below this clay, I am told, there comes suddenly an unknown thickness of incoherent sandy or gravelly material, in which the water runs freely; but from the very apocryphal descriptions I have received, I am quite unable to say whether this be a diluvial deposit, or merely disintegrated rock in place; what has been conjectured regarding the clay may show that I incline to the latter view: the evidence of any old heaps or of well-clearings is in favor of it. The greatly preponderating rock of the region is a finely granular hornblendic gneiss. From a list of measurements taken in 42 wells within Cantonments, and a partially contoured plan, both furnished to me by the Executive Engineer, I have made the annexed tabular statement, from which a few inferences may be gleaned. In none of these wells, that I could hear of, was anything like *rock* met with.

3. It is remarked on the list that "those measured in the evening have often been largely drawn upon, as No. 14 on the south side of the Plunge-bath. Early measurements for all would have been better, even if it had to be done on consecutive days; it would seem, however, that the discrepancies thus introduced may balance each other in the averages of the several groups; but the data being thus not comparable, and there being no collateral information, one is left without a clue to an explanation of what may be only apparent anomalies; such as Nos. 26 and 27, deep wells, exhausted, while much shallower wells in the same neighbourhood hold several feet of water. In all such statistics, the original depths to which the wells were sunk should be the measure given; this ought to be in a permanent record and with it some attempt, however rough, to describe the materials cut through. All should, moreover, be easily referrible to the level of the lowest drainage point of the region as a datum line.

4. The table, contrary to what might have been expected, shows no decided advantage in the supply to wells at a lower level.

5. There is a very marked advantage shown, as was of course to be expected, in an increase to the depth of the wells; there is at least 6 inches gained in the daily supply for every foot in depth below a certain point. I say *daily* supply, for I do not think that the depth of a well would affect its permanent level: thus Nos. 2 and 3 are within 70 yards of each other, neither was much in use; and although No. 3 is deeper by 8 feet 6 inches, there is only 1 foot 3 inches difference in the water level, and even this is in favor of the shallower well. From every consideration it is manifest to me that to have an unfailing supply of the best water in Cantonments, it is only necessary to sink a few feet lower than has been the practice, and, I might add, to adopt some less primitive mode of drawing water than that of hauling in buckets. Where there are only a few feet of water, this mode of raising makes it turbid and unfit for immediate use. Serious difficulty seems to have been felt in attempting to carry the wells even to their present depth; but I cannot find that any proper means have been tried to overcome this difficulty, such as the use of some method of shoring up the sides while the work is being carried on in friable, watery ground, and at the same time some means of unwatering more effectual than the obstructive one of baling and hauling.

6. Several figures in the list show how safely the water is stored below; how slowly, but surely, the supply recovers when drawn upon. These measurements were taken on the 5th of June, after a long season of drought. Dr. J. M. Coates, Superintendent of Jails, has kindly given me a statement of the rain-falls for the preceding months:—January, 0·26; February, 0·97; March, 0·64; April, 0·0; May, 1·54; up to 5th June, 0·59. The scarcity was much felt, but it was not an extreme case. I am told that worse seasons have been experienced, still there were 13 and 20 feet of water in wells Nos. 2 and 3 at a depth from the surface of 26 and 27 feet. In other cases, as Nos. 6 and 14, a fair daily supply was renewed nightly. The stratum of clay can be but very slightly permeable to water, and can contribute little; all the evidence goes to show that the water is lodged in the disintegrated upper portions of the under-lying gneiss. The depth to which this decomposition takes place is variable according to the variety of the rock in different spots; but it is generally very considerable, and in every case I would take that as the depth to which a well may be sunk with advantage. The moderate permeability of this rotten rock, as shown by the facts just quoted, suggests an alternative to the deep sinking which has been recommended as the best safeguard against scarcity: it would seem that wells may be sunk within 80 to 100 yards of each other without seriously affecting the daily supply in each within the limits of ordinary demand.

7. In connection with the question here discussed, I would bring to notice an allied one of equal importance. In the 13 days following the 6th June there fell 14·43" of rain, and all the wells were filled to within a foot of, or were quite up to, the surface. This is their condition for months throughout the rainy season, after which they slowly subside to their minimum at the end of the ensuing hot season. Such a state of things will seem strange after what has been said of the configuration of the ground, that the surface drainage is ample in every direction; and that at no great distance the rocks outcrop in valleys much below the general level of the country, unless from artificial causes there is no surface lodgement of water. It may seem stranger that it should be allowed to remain so. I have lately heard doubts expressed as to the reputed healthiness of Hazareebaugh. Without in the least wishing to endorse such an opinion, against which there is much presumptive evidence, I may remark that, according to received notions, it seems like neglecting a means of improved healthiness to allow the water to be so near the surface. It may be said, and I am not prepared to deny the assertion, that so long as the water is even a few inches under ground, it is innocuous; that it is only when allowed to stagnate on the surface that it becomes injurious; if it be so, most of the ground would require no treatment, but there would remain much to be done. When I passed through Hazareebaugh in the middle of November 1866, after we had many days of hot sunny weather, I noticed soft sludgy ground in many places, even within a short stone's-throw of the barracks. At half-way down the slopes of the shallow hollows the water does ooze out, creating this boggy ground, so long as the general water level remains above the level of the channel. Surely this would come within the limits of the conditions to which the autumnal unhealthiness is attributed all over India. But here, not as in the cities of the plains, the remedy is easy; the most complete facilities exist for drainage of any required degree. Of drainage, such as is usually understood in India, Hazareebagh has had its fair share: the natural water channels and the cuts along the roadside, or elsewhere, are kept clear, but in such a sub-soil as that here the effect of this is imperceptible. Drainage to be effectual should be such "thorough drainage" as a farmer would apply to similar land in Scotland, if he wanted to bring it under tillage.

8. The Civil Station adjoins Cantonments immediately on the north-west, the ground being apparently slightly higher. Here, about the Zillah Jail, and in the grounds of the house occupied by the Superintendent of Jails, I saw some sections in unlined wells somewhat different from what would seem to be the rule in Cantonments, in so far as that the clay, which is of precisely the same character as elsewhere, is much less thick, not more than 6 to 10 feet. The rock does not appear at the surface. Even here I could not satisfy myself upon the mode of origin of the clay; there seems to be generally at the base a foot or so, in which coarse quartz debris is abundant and irregularly scattered. Here, however, it is certain that the water-yielding rock is the porous rotten gneiss, in which the wells are dug without any difficulty. It is often so loose as to crumble away and fall in.

9. We may now come to the main object of our investigation. The European Penitentiary stands about three-fourths of a mile to north-north-east of Cantonments, and separated from them by a broad valley, some 40 feet deep, passing up to westwards, in which

direction the ridges are confluent. The site for the Central Jail is some few score yards beyond the Penitentiary, on another minor branch of the same system of ridges. In both localities rock crops out freely in many places, and it might have been anticipated from the beginning that the well question would assume a very different aspect from that of any case within local experience. It were useless to moralise upon so common an occurrence as want of foresight, or to indicate its source in this particular instance.

10. In the Penitentiary well there is no clay at top. After about 3 feet of coarse quartz gravel, mixed with red sandy earth, they come upon a run of largely crystallized granite (pegmatite) very irregularly associated with hornblendic gneiss. At first this mass was not difficult to be cut, although not nearly so soft as the rotten rock already spoken of, but it rapidly became harder, and at about 20 feet blasting had to be resorted to. All effects of decomposition from surface atmospheric influence having ceased, the stone showed its true characters of intense hardness and complete impermeability. The arrangement of the bedding, if, indeed, it be true bedding, in this short shaft is exceedingly irregular, at one spot apparently dipping to the north, and at another to the west. In the hard rock at base there are some well marked joint planes showing large flat surfaces nearly vertical, but these joints do not seem to be available for the percolation of water; the few leakages that occur are from points in the indefinite cracks that traverse the stone discontinuously without any system, and generally where there is a film or layer of partially disintegrated rock. Near the base of the shaft another vein of granite like that at top, but thinner, traverses the gneiss irregularly at a low average angle, but here it is firmly united with the containing rock, the same even surface of fracture passing indiscriminately through both. I waited for several days to have this well emptied, but the water was still knee-deep at my last examination. I do not consider that I have lost any evidence of importance.

11. From the accounts I have received, there would seem to be some prospect of immediate success. I am informed by Dr. Coates that a few days before the work closed at the end of the hot season, he made a rough measurement of the leakage water, and found it to be about 40 gallons per hour, nearly 1,000 per day. I confess that this surprises me much: the excavation then was at about the level the water stood at when I saw it last, and the leakage did not seem to me any thing like so much, although the time of year was so much more favorable, and the well had just been emptied by double gangs of men working day and night. Subsequent to that measurement, the last few blasts put into the rock disclosed one or more layers much softer than any met with for some yards above, and from which water flowed in much greater abundance than from any of the higher points. Unfortunately the rains put a stop to the work before this ground could be fully proved. The only symptoms I could detect of these sources was that, in walking about through the water, I felt at two or three spots a very appreciable warmth under my feet. The first thing to be done now is fully to test this ground. Five or 6 feet more of cutting ought to prove what it is worth. But a large margin ought to be left above any measurement made now for the diminution that may be expected in the dry season.

12. There can, of course, be no doubt of ultimate success: accumulated drippings will at last yield the required supply. But this must remain matter of experiment. No one but a diviner would venture to predict at what point success would be attained in rocks like these. There is, however, an evident choice as to the direction in which these contributions are to be sought. That word "spring" has a great deal to answer for: most men seem to think that water comes from the bowels of the earth, whereas in 99 out of 100 apparent cases the source is from above. The only available, and the only known, source of water here is the one already pointed out, the porous mass of disintegrated rock at the out-crop under the clay. This being the case, I would decidedly recommend, in the event of the next few feet in depth not giving the required supply, that the vertical shaft be changed for a nearly horizontal drift. The chances are almost all in favor of this plan, and there is here the ultimate certainty of tapping the source itself in the most effectual manner from below. In the vertical shaft there is no doubt the chance of contributions from every side, while in the drift we must select the most likely direction, but I am in favor of this attempt. There are two elements for consideration, the structure of the rocks, and the lie of the surface. From what has been seen of the rocks in the Penitentiary well, there is little or no room for choice; they have no definite arrangement. The most frequent run of the rocks in this neighbourhood is about north-north-west, and so the most likely line to cut them would be at right angles to that direction. The *primâ facie* view of the second condition would

suggest to make straight for the nearest point of the slope of the ridge, but it must be modified in this case. I have carefully examined the line of the surface, and should consider that course to be unsafe; the slope to the south is too near and too rapid. The ground from which a supply is to be expected lies to the west and west-south-west. I would recommend that the drift be cut to west-30°-south, with a rise of 1 in 20. This direction, too, would approximately suit the probable run of the strata.

13. There is at least one advantage in having the well in solid rock; it may be left with its present full width, and only cased for 20 feet or so from the surface. I would recommend that this be done at once; and that the pump, by which it is to be hoped the future water-supply is to be raised, be put in position now. In such a well, too, the work can be continued at any time as well as at first, should a season's trial prove the supply to be insufficient. I would not, however, let this be an excuse for an incomplete job at first; the failure would, of course, occur in a season of extreme drought, and might be seriously felt. But, indeed, the energy of Dr. Coates has provided an excellent resource for a time of such need, by converting the unsightly and doubtfully salubrious ravine in front of the Penitentiary into a most picturesque lake of deep water. A very little care on the part of the authorities can prevent any possibility of its becoming unwholesome.

14. The case of the Central Jail well is quite analogous to that of the Penitentiary, but a little more puzzling. Here too, however, I would recommend the prosecution of the work. I believe that success can be secured at a much less cost than would be entailed by abandoning the site upon which preparation and work has been already so far expended. At top there were 6 to 8 feet of red gravelly earth, resting on the edges of the strata, which are thoroughly disintegrated for 3 to 4 feet passing down into much firmer rock. Unlike in other wells the beds here have a steady dip of 40° to north-35°-west. At a depth of 30 feet on the rise, and 38 on the fall, an intensely hard rock was encountered, in which the work now stands at 40 feet. This well also had just been unwatered; and considering this, and the time of year, the leakage appeared to me to be very trifling. The last rock cut in this well is exceedingly unpromising; the large surface of it now exposed does not show a single crack or crevice. It breaks with sharp edges and large conchoidal fracture: it is a fine grained mixture of hornblende quartz and felspar thoroughly crystallized; superficially it might be described as a granitic diorite; but geologically it must come under the genus gneiss, as it seems to be strictly in the bedding, and to be simply an exaggerated form of the fine foliated hornblendic gneiss of the district. A correct knowledge of this rock would greatly help a decision regarding the well; but very little can be discovered; there is no out crop of it to be found. On the other side of the Penitentiary, at the edge of the upper lake, an exactly similar rock is exposed for fully 10 yards across its strike. Thus in the well shaft there is a prospect of having to cut through an indefinite thickness of perfectly barren rock, and of the most difficult nature. The same obstacle affects the consideration of a drift. In this position, also, the condition of the surface is of dominant importance on account of the rapid fall in certain directions. The most likely direction for a drift to intercept an abundant supply of water would be about due south, but this would take it into the same rock, and even for a greater thickness than in the shaft, the cut being oblique both to the strike and the dip; here, however, there would be the prospect of its becoming softer at every step. I have no doubt of this being the safest course. The lower the inclination of the drift, the better the chance. I would not advise a greater slope than would ensure the flow of water to the shaft. By cutting the drift to northward, it would run towards a convex bend of the ridge, and success would not be so secure; but the obnoxious rock (at least this bed of it) would be avoided.

15. There is one well in a position to be compared with these. The well for the Police Barrack stands nearly centrally on the ridge of which the new buildings occupy prolongations: it is 470 yards to west-18°-north from the Penitentiary well (the distances are taken from a plan lent to me by Colonel Dawson) and 1 foot 9 inches higher; the same well is 700 yards to south-42°-west from the Central Jail well, and 4 feet 6 inches above it. It is 30 feet deep. I have had very different accounts of this well: like all the others, it fills to the brim in the rains, and some say that it has a constant supply, the demand upon it not being very great; while others declare that it fails; that in the hot weather people living along side it fetch water from a considerable distance in the hollow. Some measurements of these three wells are given in Table II. The water in the two new wells on the 10th October was probably below what they had contained at their fullest; but even that

quantity shows that on the 19th June, when every other well in the place was at its full, these were still at least 10 and 6 feet below their minimum height, an indication of the slow and circuitous percolation by which they are fed.

I have made this report rather long, but I thought it best to omit nothing that might give information.

23rd November 1868.

TABLE I.

Table of depths of Water and of Wells in Cantonments as measured on the 5th June 1868, *just before commencement of the rains, grouped according to levels of sites.*

Number of Well.	OVER 88′ CONTOUR.		BETWEEN 88′ AND 84′		BETWEEN 84′ AND 80′		UNDER 80′		REMARKS.
	Depth		Depth		Depth		Depth		
	Of Water.	Of Well.	Of Water.	Of Well.	Of Water.	Of Well.	Of Water.	Of Well.	
1	7·6	37·0	...	...	...	...	...	...	
2	13·0	38·9	...	...	...	...	...	...	Within 210 feet of No. 3.
3	20·1	47·3	...	...	...	...	...	...	These two wells were little used.
4	...	...	7·5	32·6	...	...	...	...	
5	...	...	5·1	35·3	...	...	...	...	
6	...	...	...	...	1·3	32·5	...	...	Much used.
7	...	...	...	...	1·4	19·8	...	...	
8	...	...	...	...	3·0	17·75	...	...	
9	7·0	37·3	...	...	...	...	...	...	
10	9·1	40·3	...	...	...	...	...	...	
11	...	...	2·9	35·5	...	...	...	...	
12	...	...	...	...	5·0	34·5	...	...	
13	...	...	3·3	32·5	...	...	...	...	
14	...	...	2·0	38·0	...	...	...	...	Much used.
15	...	...	...	...	...	...	6·9	30·25	
16	...	...	7·0	35·5	...	...	...	...	
17	...	...	7·7	31·1	...	...	...	...	
18	...	...	...	...	...	...	1·8	20·5	
19	...	...	3·0	30·0	...	...	...	...	
20	...	...	1·5	39·5	...	...	...	...	
21	...	...	...	...	...	...	7·5	36·6	
22	...	...	...	...	...	...	5·2	31·8	
23	...	...	...	...	...	...	5·5	32·5	
24	...	...	...	...	...	...	2·0	25·0	
25	...	...	...	...	...	...	3·25	27·25	
26	...	...	...	...	...	...	0·3	34·25	
27	...	...	...	...	...	...	0·3	31·75	
28	...	...	...	...	...	...	2·5	33·5	
29	...	...	...	...	...	...	4·5	33·5	
30	...	...	3·0	25·0	...	...	...	...	
31	...	...	...	...	...	...	1·4	19·0	
32	...	...	...	...	...	...	4·3	24·3	
33	1·0	29·0	...	...	...	...	...	...	
34	6·2	38·2	...	...	...	...	...	...	
35	2·3	24·2	...	...	...	...	...	...	
36	6·4	32·4	...	...	...	...	...	...	
37	9·2	40·2	...	...	...	...	...	...	The four last are within a radius
38	4·6	35·6	...	...	...	...	...	...	of 180 feet.
39	6·0	28·5	...	...	...	...	...	...	
40	0·0	21·0	...	...	...	...	...	...	Within 80 feet of No. 39.
41	7·2	32·2	...	...	..	...	...	...	
42	0·0	29·0	...	...	...	...	...	...	The five last are within a radius
	79·5	442·8	43·0	304·0	10·7	104·55	45·45	379·70	Of 256 feet.
Mean of 13	6·1	34·0	...	...	...	...	...	...	Nos. 3 and 40 are omitted as
„ of 10	...	...	4·3	30·4	...	...	...	...	exceptional.
„ of 4	...	...	...	...	2·7	26·1	...	...	
„ of 13	...	...	...	...	...	...	3·5	29·2	

TABLE II.

Table of measurements in the new Jail Wells.

	Depth of Well.	Depth of Water on 19th June.	Depth of Water on 10th October.
	feet.	feet. inches.	feet. inches.
A. Police Well	30	28 0	23 6
B. Penitentiary, 1'—9" below A.	56	39 0	43 6
C. Central Jail, 4'—6" " "	39	21 6	31 0

METEORITES.—To the collection of Meteorites in the Geological Museum, there have been two valuable additions during the past three months. One of these, a specimen of the very interesting fall which occurred on the 11th July 1868, at Ornars (Doubs), in France, has been presented by M. Jules Marcou, Paris. It is a remarkable stone of a dark-grey colour, oolitic or sub-oolitic in texture, very friable, so as even to crumble under the action of the fingers. Iron is present in extremely small particles. It is very slightly magnetic. In fact, the fall represents a state intermediate between the ferruginous and the non-ferruginous falls, sp. gr. 3·599 (in fragments). It yielded to Pisani by analysis no less than 75·10 per cent. of Peridot. To the kindness of my good friend M. Marcou I am indebted for this interesting specimen.

The second fall occurred in India, near Mooltan, on the 17th October. The fall took place at a spot about 12 miles east of Lodran. "About 2 P. M. a loud report was heard "in the sky to the westward, and immediately a cloud of dust rose from the ground. On "going to the spot the aerolite was found. The sky was quite clear at the time." This is the account given by Captain Bond, District Superintendent of Police.

A portion only of the mass was obtained and forwarded. It is a very beautiful stone, consisting of a large proportion of bright yellowish green olivine, the crystals of which are imbedded in a kind of crystalline net-work of brilliant iron. The stone is at present being analyzed, and the result will be given hereafter.—T. O.

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GOVERNMENT OF INDIA.

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MAP.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1869. [May.

Annual Report of the Geological Survey of India and of the Museum of Geology, Calcutta, for the year 1868.

In reporting the progress and doings of the Geological Survey of India during the year 1868, I shall take each branch of our labors in the same order as I have for the most part observed on former occasions.

Mr. W. T. Blanford has, during the whole of the year just past, been engaged with the Abyssinian Field-force, and since its return in arranging and examining the large collections he made during the expedition. Mr. Ormsby was compelled to leave for Europe early in the year, having suffered from exposure to the tropical sun. And Mr. Charles Oldham left on furlough in November. On the other hand, Mr. Tween returned to his duty in charge of the Museum here. Mr. Foote resumed his labors in Madras, and Mr. Theobald in Burmah. On the whole our numbers have been, during the past year, less reduced than usual in consequence of ill-health.

At the commencement of the year, I proceeded to the Madras Presidency to make enquiry on the spot into the facts regarding the asserted occurrence of coal close to the town of Juggiapett, or Battavole, near the Kistna River. For years it had been persistently repeated that coal had actually been raised in that neighbourhood, and this statement was maintained notwithstanding the fact that very many persons, deeply interested in the result and most anxious to confirm the discovery if possible, had visited the localities, but had entirely failed to find any trace of evidence that coal existed or was likely to exist. Its occurrence in this place would have been of such high importance, that I was desirous of visiting the place as soon as practicable; I had also received from the Madras Government an urgent request to enquire into the facts. This request had reached me at a time when field-work was not practicable, but I had promised to go there as soon as possible. I left Calcutta, therefore, early in January; and accompanied by the original propounder of the discovery, I visited carefully every locality which he indicated, and went generally over the district. I regret to state that I found no trace of the coal-bearing rocks; no signs of coal, or of any of its usual accompaniments, nor was I able to see a single spot where anything, in the slightest degree leading to the conclusion that coal did exist there, could be found. On the contrary, all these rocks are an unbroken and uninterrupted continuation of similar rocks which cover an enormous area in the districts of Kurnool, Kuddapah, and Guntoor to the south, and which, thoroughly exposed as they are in their many folds, contortions, and disturbances throughout this area, must have exhibited any beds of coal or coal-shale which possibly existed. But, neither in the Juggiapett country, nor over the many hundred square miles to the south, over which similar rocks extend and which have all been carefully examined, has any trace of such deposits been noticed. I was, therefore, compelled to believe that the statement of coal having been found at or near Juggiapett was either based upon an intentional deception practised on the original observer, or was a delusion.

From the vicinity of Juggiapett, I proceeded southward, devoting some time to carefully testing the accuracy of the geological mapping of a considerable area which had been previously examined by Mr. C. Oldham and Mr. King, and returned to Calcutta.

Towards the close of the year (December), I proceeded to Attok to examine the rocks under the River Indus, through which a tunnel drift had been carried, with a view to determine the practicability of enlarging this drift into a regular roadway. I had wished to accomplish this work earlier in the season, but as the tunnel was full of water, and was not pumped out until December, I was obliged to defer it. Having already reported in some detail on this question, I need not here enter into the facts, further than to state, there appeared nothing either in the structure or in the composition of the rock-masses to prevent the immediate enlargement of the drift with perfect safety, provided proper precautions were adopted, and the work were done at once. But that these precautions would render the cost of the tunnel, when completed, quite as great as that of a first class bridge, and that even then the accommodation to the traffic would certainly not be as great as that afforded by a bridge.

Subsequently, at the request of the Government of the Punjab, I examined with some care the range of hills near Futtyjung, extending southward from Cheerat, and in which petroleum had been obtained. I saw everything to lead to the conclusion that petroleum would be found over a large area in these orbitolite limestone rocks, although probably not in any very great quantities in one place. The best position for trials seemed fairly indicated, and these I noted. The probability would seem to be that limited reservoirs of this oil will be found at no great depth from the surface, although I am not very sanguine that they will prove very extensive in any one locality. Similar rocks occur again in a rudely parallel range to the east, and here also traces of earth-oil are seen; and it would appear very probable that supplies will be found extending over a large area in this part of the Punjab.

An examination of the Dhurmsala district, and also of the Goorgaon district near Delhi, was requested, with a view to determine the extent of deposits of kaolin said to occur in each. Looking, however, to the inaccessibility of both and their distance from any markets, which must prevent the economizing of this clay to any large extent; and also to the fact that, so far as any local demand existed, it was of no importance to determine at the present the *extent* of these deposits, their existence being known, I felt compelled to think this enquiry was of vastly less importance than others. And that, so far as any question of extent or amount of such deposits was concerned, a very much more satisfactory answer could be given after the whole districts had been gone over than after a rapid visit to one or two isolated localities. No mistake can be greater than to imagine that a geologist can, by a sort of intuition, arrive at a knowledge of facts bearing on such questions. This can only be acquired by a continuous and detailed investigation necessarily demanding time.

Bengal and Upper Provinces.—During the early part of the year just closed, Mr. Medlicott was engaged in the investigation of the western and southern flanks of the Garo Hills. So long since as 1842, Mr. Bedford, who had surveyed parts of this area, announced the occurrence of coal in the hills bordering the Bramahpootra River at the western extremity of the Garo Hills, near to a village called Harigaon, and other outcrops had been noticed further to the east in the Sumesurri River. The peculiarly favorable situation of these places, within easy reach of a great river, and in districts where fuel was otherwise not readily procurable, rendered it of high importance that the facts should be ascertained. It was also known that the rocks which accompany coal in the Khasia Hills extended to the west, and there was, therefore, a probability that the coal might also be found to extend in the same direction. It had long been hoped that a topographical survey of these hills would afford the means of recording carefully the geological observations, but as there appeared little likelihood of these hopes being realized within any reasonable time, and as meanwhile the question of the eastern and northern extension of the Eastern Bengal Railway was urgent, it was determined to examine the area, in such a general way as might be sufficient, without entering into minute detail, to solve the question satisfactorily of the probable amount and character of the coal which occurred there. Mr. Medlicott's report on the results of his examination having been published (*Records of the Geological Survey of India*, Part 1,1868, p. 11), it is unnecessary to enter into any detail here. It will be sufficient to state that he has shown that the spurious coal of the Garo Hills is geologically distinct from most of that known in the Khasia Hills; that, in all cases, this coal occurs near to the base of the whole stratified series within a few yards of the underlying crystalline rocks; while the coal itself is very poor, in one place mainly a resinous shale, in another, a thick bed of dark stiff clay with insignificant strings of lignite through it. Where in greatest quantity, it is described as a thick band of shale in the midst of which

occurs the coal-seam: it is a good deal crushed, altogether about three feet thick, but very unequally carbonaceous, being locally split by strings of clay and sand; and contains but few thin strings of coaly substance. The mass of what would be extracted as coal is a highly resinous batt or shale, full of small nests and strings of a kind of amber; it gives a woody sound when struck, is very tough, and breaks with a large conchoidal fracture. It was obvious that whatever little use might be made of such deposits, if required on the spot, they were practically of no value as a source of fuel for general purposes. It is most seriously to be regretted that the statements upon which expectations of coal had been founded should have proved to be so fallacious.

Having completed the cursory examination of these rocks, Mr. Medlicott devoted some time to a more careful examination of the Khasia Hills, for which portions of the topographical survey maps were ready. These very interesting hills had never before been visited by any of the officers of the survey at a time when it was possible to examine the lower parts of their steep slopes; and consequently, as pointed out long since, much remained to be done, before we could suppose that we possessed any true knowledge of their structure. Further, the full determination of the cretaceous age of the sandstones, &c., under Cherra Poonjee, (*Quar. Jour. Geol. Soc. London*, 1863, p. 524, Oldham, on cretaceous rocks in E. Bengal) which, in my own early description, in consequence of their apparent continuity and conformity, (the fossils collected having been lost at sea) had been grouped with the tertiary rocks above, rendered it necessary to carry out this separation in detail. Mr. Medlicott has been able to do much towards this, and in tracing out these rocks has been led to several very valuable conclusions, a brief summary of which has already appeared in the Records of the Survey. As soon as the topographical survey of these hills is completed, I hope to be able to have them examined in detail.

Later in the season, Mr. Medlicott having arranged for the several duties assigned to the assistants under his charge, was requested to take up the very important geological question of the extent and relations of the several series of sandstones, &c., associated in Bengal with the coal, as compared with those in Central India. With this object, making a rapid traverse of the Ranigunj field, and passing westwardly by the Hazareebagh fields, he has carried out the section across to Jubbulpore, and with very valuable results, which will tend much to a clearer understanding of the different groups or formations. In a new country, where the general relations of the rocks is quite unknown, it becomes necessary for each observer to form for himself a classification of the rocks he examines, grouping them into series or formations, and often giving to these sub-divisions local names. But as the examination of the country advances, it not unfrequently happens that such classification is proved to be of purely local type, and it is essential either to increase the sub-divisions or to bring several together into one larger group. Mr. Medlicott's traverse of this wide extent of country will go far, I believe, to remove, in several cases, the limited amount of confusion which had unavoidably arisen from the fact that previously the officers of the survey had been working at distant and isolated points.

Mr. Willson has completed the detailed examination of the district of Saugor in the Central Provinces, which he has connected with those of Dumoh and Jubbulpur to the east. Unfortunately the want of maps of the country lying to the west of Saugor district has prevented the extension of our examinations in that direction, as I was very desirous of doing, in order to join on the geological lines to those we have been for some time past steadily carrying southwards through the Gwalior and Rajpootana territories. The district of Saugor is mainly composed of trappean rocks, which are, in this parallel, the most northerly portion of the Great Deccan area of these ancient volcanic rocks. These rest upon Vindhyan rocks for the greater portion of their boundary.

Mr. Mallet has, during the early part of the year, completed the examination of the crystalline rocks of Bundlecund—being a continuation of his work of the previous year—so far as the area occupied by these rocks is comprised on sheet 70 of the Indian Atlas. The further explorations of this year have rather induced Mr. Mallet to abandon the idea of separating these rocks into two series as was suggested in 1866-67. The evidence, however, is even yet scanty, and not conclusive. And it must remain for more careful investigation when better maps, on a larger scale, of the Bijawur area become available. The maps, at present procurable, are too imperfect to admit of any close or searching examination and record.

During the recess, Mr. Mallet completed a full report on the Vindhyan rocks, so far as that widely spread formation is known in northern India up to the present. A general map has been compiled to illustrate this. This report has been sent to press. At the commencement of the working season in October 1868, Mr. Mallet proceeded to take up the detailed examination of the eastern part of the Sone Valley, and is still engaged in that area. I have already intimated to Mr. Mallet the necessity for greater activity in the field, for looking both to the nature of the work done, and of the country in which he was engaged I felt disappointed that a larger area had not been satisfactorily examined.

Carrying on the geological examination of the Gwalior and adjoining territories, Mr. Hackett was principally engaged near to the Byana hills bordering on Jeypur. The geology of this area has proved intricate and interesting. The sections are unfortunately not good, being cut up by intervening flats of alluvium which conceal the rocks. Rock masses of a peculiar character have been found to intervene between the Vindhyan series, and the metamorphic schists, which may approximately be taken to represent the Lower Vindhyan and the Gwalior series. These are possibly the same rocks as those which stretch away towards Ulwur, and if so, this will give a clue to the geology of the Aravali country. The country around Byana is, as I have already said, rather intricate in structure, and tedious therefore to work out, but I am not satisfied that a larger area might not have been completed during the season. Towards the close of the year, Mr. Hackett resumed his labours in the same or the adjoining country, but has been stopped by a want of maps. He has since been engaged further to the south in tracing out the boundary of the Vindhyan and trappean rocks to the east of the parallel of Neemuch, &c.

Mr. Hughes in the early part of the year was engaged in re-mapping the small coal-fields which occur detached near Kuroun in the district of Beerbhoom, and in revising with better maps, the Kurhurbaree coal-field. It has been difficult to obtain any very satisfactory information regarding this field, for the old pits which were some years since worked by the East Indian Railway Company are now full of water, and there are few other workings in operation. Any description, therefore, now given must be revised when the field is more opened out. At the close of the year, Mr. Hughes was engaged in the examination of the Palamow coal-field in Chota Nagpore. This might, Mr. Hughes thinks, be called in preference the Daltongunj field. It proves very small in area, not more than about 30 square miles, and there appear to be only two seams which can be worked, of which only one could at present be profitably extracted. This varies considerably in thickness. At Rajbera, where it was formerly worked by the Bengal Coal Company, it is eleven feet. It is of moderately good quality. The rocks of the field belong entirely to the Talcheer and the Barakar groups. The lithological character of the latter differs considerably from that of the typical rocks in the Ranigunj field, being as it were intermediate between the Barakar and the Ranigunj groups.

Mr. Ball has been carrying on the geological examination of the districts of Singhbhum and adjoining tributary states. He has been able to examine the copper-yielding rocks for a distance of nearly 80 miles; has noted some additional details with reference to the mode of occurrence of gold; and describes cases of excessive local metamorphism of the younger rocks, reducing them to such a crystalline condition as to be entirely undistinguishable lithologically from the old metamorphic rocks. Such cases are deserving of very careful examination.

Mr. Ormsby had, in the early part of the year, examined a considerable area of the metamorphic rocks in Chota Nagpore and Hazareebagh, but was unfortunately obliged to leave for Europe in consequence of ill-health before the close of the season.

Having very frequently had occasion to represent the importance of deputing a special officer of the Survey to the examination of the mines of India, and to the careful collection of statistics regarding the quantity and value of minerals raised and brought to market, I was glad to find that a gentleman, selected for this purpose, had been ordered to join the department at the beginning of the year. Mr. Mark Fryar, thus nominated as Mining Geologist in connection with the Geological Survey of India, joined his appointment in this country on the 1st of May 1868. After a little time in Calcutta, Mr. Fryar was deputed to the Ranigunj coal-field, there to make himself acquainted with the coal-bearing rocks of India, and the method of mining adopted in this, the most valuable, coal-field in India. It was necessary that he should acquire a knowledge of the rocks as locally developed, which would be useful in other localities, and indeed perfectly essential before he could safely take

up any enquiry in a new and undeveloped district. Mr. Fryar also, later in the season, visited the Kurhurbaree coal-field, when Mr. Theo. Hughes pointed out to him the several groups and their characteristic lithological characters. Towards the close of the year Mr. Fryar was deputed to the Nerbudda valley, and to pass thence southward by Chindwarra to Nagpore and Chanda, where Government had sanctioned the full and detailed examination by actual sinkings and borings of the extent and character of the coal known to exist there. For this purpose boring rods of best construction and borers have been despatched from England, and the work will be taken in hands at as early a date as possible. Mr. Fryar has submitted brief reports on the coal found at Lameta Ghât, Jubbulpore, and on the workings at the Nerbudda Coal and Iron Co.'s colliery at Mopani. The localities must again be visited by some one knowing the Indian rocks.

I hope that the necessary appliances for boring, &c., which have been sent for, will reach this country before it be too late to do any thing this working season. Once commenced, the investigations will be carried on systematically, so as to ascertain exactly the full extent of area over which the coal beds extend and the thickness and nature of the coal itself. The country is much covered with alluvial deposits, and excepting by actual trials it will be impossible to say what the extent of the coal-fields may be, while the importance of the locality taken in connection with the supply of fuel on the Nagpore branch of the Great Indian Peninsula Railway and for other purposes, cannot be over-estimated.

It has not been found possible, with the reduced number of our staff, during the present season to place any one of the officers of the survey in this part of the country, with a view to trace out the extension of the coal-bearing rocks to the south from Chanda, if they do so extend. It is probable that the further extension will be traced, although the evidence seems tolerably conclusive that there is a continuous diminution in thickness of these rocks as they pass to the south; and it is highly probable that they will be found not to extend much further than they have been already traced. We know that they have entirely disappeared, at about seventy miles in that direction, and steps will be taken at the earliest possible date to have the intermediate country examined. Reports of the occurrence of coal have frequently been circulated, and recently it is stated to be in some quantity near Domagoodium: but these reports have not as yet been confirmed.

When proceeding to the Ranigunj field, I specially directed Mr. Fryar's attention to the very high importance of inducing, if possible, the colliery proprietors to economize the large amount of waste and dust coal which at present is allowed to take fire and burn away to no useful purpose at the pits. The peculiar structure of Indian coal renders the proportion of this waste, produced in hewing, larger than in coal of a more homogeneous and richer character, while the very much greater brittleness of the strings of rich jetty coal as compared with that of the tougher laminæ of earthy matter also adds to the proportion of the better fuel, which is lost in the waste. I urged on Mr. Fryar to induce some of the proprietors to make trial of washing and compressing this waste and dust so as to form bricks or cakes of fuel, and mentioned to him the success which had attended some experiments made by myself, on the use of common rice water as a medium for agglutinating the mass. Several trials were made and many bricks produced from washed waste, and, as I believe, good promise of success was established. The system has not, however, as yet recommended itself to the proprietors; they believe that the expense and cost would not be repaid by the result, and they have therefore not taken any steps to carry the trials further.

In the experiments I had myself made years since, and in those which were made by Mr. Fryar during the past year, no sufficient pressure was available. And in consequence, although the rice-water appeared to act very successfully, there was much too large a quantity of it taken up. The result of this was the comparatively open and uncompressed texture of the bricks, and when put on the fire they smouldered away rather than burnt. The only pressure used was that of a very inferior brick machine, nor was anything like proper attention paid to washing the dust before moulding.

I am quite confident that a very large amount of most valuable fuel could be with profit economized in this field, all, or almost all, of which is at present allowed entirely to go to waste. I do not anticipate that it will ever be profitable, under the peculiar circumstances of Indian fields, to adopt the suggestions thrown out by some who have never seen these fields, of reducing all the coal extracted to fine powder by crushing, then washing, moulding

and baking into symmetrical blocks. But I am satisfied that much may be made out of the dust and dead-small coal, now wasted. The peculiar conditions of the field render it compulsory that all this should be brought to bank so that the only expenses to be incurred are in the actual manufacture. It would surely be more profitable to reduce a larger portion of this waste into the state of good useful fuel than to allow it to take fire and burn itself to a heap of ashes.

Mr. Fryar's attention was also given to the utilization of the small coal and dust for the production of coke, and with considerable success.

During the past year, a circular was addressed to the proprietors of collieries from this office, urging on their consideration the vast importance of maintaining proper under-ground plans, pointing out very briefly the advantages to be derived from such. And I was much gratified to find from the replies received from every one of the large proprietors that they not only saw the advantages to be gained, but were determined to secure them. Careful plans are now being made of most of the mines in the Ranigunj field; plans of the workings in the Kurhurbaree field will be commenced as soon as the workings there commence under the East Indian Railway Company, and will be maintained. In the Nerbudda plans are kept. I look upon this as a most gratifying progress for a year or two. The largest coal proprietors in the Ranigunj field have not only engaged a qualified mining surveyor, but they have ordered all their assistants to pass an examination in the use of the surveying compass, &c., and have secured attention to this study by giving an increase of Rs. 50 per month to the salaries of those who may pass. The same Company has also given an excellent example of progress by ordering one of their own servants, and who, by their permission only, is also examiner of steam-ship boilers under the Government of Bengal (Mr. Walker), to proceed each half-year to their works to examine carefully and report upon, in detail, the condition, work, duty, and capabilities of every one of their steam engines; this report to be submitted previously to each half-yearly meeting of the Company.

MADRAS.—In Madras Presidency, Mr. Foote was absent on medical certificate during the greater part of the year. He only returned late in October. The remainder of the party, Mr. C. Oldham and Mr. King, commenced the season's work north of Ghooty, and marching up to Kurnool, surveyed, as they passed along, a sufficient breadth of country outside of the boundary line of the Kuddapah rocks, to ascertain the non-existence of any outliers of those rocks in that neighbourhood, and to obtain a good general idea of the character of that area of metamorphic rocks. It proved to be chiefly an area of granitoid gneiss, with a few trap-dykes, and some runs of fault-breccia; the prevalent directions of these being west-north-west, with variation to north-west, and east-north-east, with a variation to north-east.

From Kurnool, the Surveyors passed across the hills to the east, by the Muntaval pass. Mr. King separated from Mr. Oldham at Doopaud, from which he moved northwards, carrying on his examination in connection with the survey of the previous season. Mr. Oldham proceeded to the Kistna district to join the Superintendent.

Mr. King rejoined Mr. Oldham in the middle of February, and working first through the Vinuconda taluq, they then passed into the Palnad, and carried their geological lines up to the Kistna River. Parts of this country are very difficult of access, wide areas quite uninhabited, without roads and without any means of obtaining needful supplies. Much of the geological structure is also intricate, and the district is at the same time very unhealthy. The temperature during the past year was unusually high in April and May, and repeated attacks of fever prevented the officers of the survey from carrying on their examination with their usual vigour. They continued, however, at work until the beginning of June, when Mr. King was compelled to proceed to station. Mr. Oldham went northwards and crossed the Kistna, hoping to be able to complete a detailed survey of the Juggiapett country. A part of this only could be accomplished, for the early and heavy break of the monsoon compelled him also to leave the field about the middle of June.

During the autumn Mr. Oldham delivered at the Civil Engineering College in Madras a course of lectures on Geology. These were attended, and with marked regularity, by a larger number of the general public than on previous occasions, while the engineering class was also very attentive and interested in the subject.

When I left the neighbourhood of Juggiapett early in the year, as already referred to, I had hoped that there would have been time to accomplish a detailed survey of that small area, taken in connexion with the adjoining country, before the close of the season. As I have just stated, the early and very severe setting in of the monsoon prevented this. I regret this the more, from the reiterated statements which have been made as to the existence of coal in that vicinity. Mr. C. Oldham, in regretting that he was compelled to give up the attempt to finish the work at that time, says—'I was, however, able to trace out the succession of the beds there for a considerable distance, and I had the opportunity of examining with somewhat more detail than we were able to do, during our visit early in the year, the way in which the rocks lie, and to convince myself (in entire accordance with your own conclusions) that, certainly over the part of the area which I was able to survey, in which are some of the localities where coal had been reported, not only does none appear, but that the occurrence of any thing like a workable seam of coal, unseen, is impossible. The rocks are singularly well exposed and their succession very clearly seen. The general succession of rocks seen in the Juggiapett area is, in ascending order, quartzite slate, limestone, schistose slates, and over these upper slates, in the hills to the south, comes apparently another set of quartzites.' The two lower groups, Mr. C. Oldham is inclined to refer to the Kuddapah series of rocks; and the limestone with the slates above it to the newer Kurnool group. There is apparently unconformity between the two series here, as in many other places. The Kurnool rocks cover a large area in the Palnad, and the two limestones with associated shales, are seen separated by quartzite, (the 'Paneum' quartzite of the survey); this is locally of considerable thickness and forms a very well marked bed, but elsewhere it thins out to a couple of feet or even disappears altogether. The lower limestone of the Palnad is apparently identical with that which covers so very large an area near Juggiapett, although the actual continuity of the two still remains to be traced. Much of the limestone would form a very durable and excellent building material, and several of the beds would yield a handsome ornamental marble, being veined in different colours, chiefly buff and pink.

Chipped stone implements were traced up to the Kistna district. On the Muntaval pass, one was extracted from hard solid laterite.

From Bezwara, Mr. C. Oldham visited a small area of sandstone at Tunglamoody, about 14 miles south-south-east of Bezwara. These sandstones there form a rising ground or hillock of no great extent. They are quarried for use in the adjacent country, where many temples have been built of them. No fossils were traceable, but from the general character of the rocks, Mr. Oldham considers them as belonging to the same group as the plant sandstones further to the south, to some of which they bear a great resemblance. Further, while marching back to Madras from Guntoor, he noticed similar sandstones and some porcellanic shales in several places near to Yinkolu, and south of that along the road: and at Razpoody a considerable amount of them is exposed, chiefly a greyish and yellowish shaly sandstone. These beds are quarried to some extent for local building purposes. The great resemblance lithologically of these rocks (shaly sandstones, and porcelain-like shales) to those in the neighbourhood of Sripermatoor, in the Madras district, is striking. Mr. C. Oldham thinks all these belong to the same series, and thus we have, at a distance of 450 miles from where we first found them in the Trichinopoly district, remains of a series of deposits once continuous, and the connection of which is now only indicated by the many detached areas of the same beds, which have been traced by the survey in the South Arcot, North Arcot, Madras, and Nellore districts.

Bombay.—The Bombay party of the survey has been during the whole year under the charge of Mr. A. B. Wynne, Mr. Blanford being, during all the time, absent with the Abyssinian Field-force. The party was engaged in the examination of Cutch, of which area about one-half has been very carefully completed. The reported occurrence of coal, said to be in workable quantity, was one reason which demanded a careful investigation of the rocks and their relations. But the principal interest connected with the investigation of Cutch centered in the fossils, which occur there in considerable abundance. Along with others, very well preserved remains of peculiar plants occurred, easily recognizable, and giving a very marked *facies* to the flora of these rocks. This was characterized by the predominance of various forms of Cycadeæ. These same forms of Cycadeæ had been found in abundance in Bengal, at the opposite side of the Indian peninsula, and in many places near to Madras, far to the south. In the Rajmahal Hills no associated beds occur from which the true geological horizon

of these plant-bearing rocks could be made out, while in Madras presidency also, although the succession clearly established that these rocks were not younger than the cretaceous formation there developed, there was (equally as in Bengal) no possibility of fixing their lower limit in geological time. In Cutch these plant-bearing beds, on the contrary, were said to occur associated with rocks rich in marine fossils, well preserved, and the geological epoch of which was well marked and readily determinable. But although undoubtedly associated with the marine fossiliferous beds, the mode of this association was still uncertain. Captain Grant, the original describer of the province, left it doubtful; while Mr. W. Blanford, during a cursory visit to part of Cutch, was led to believe that the plant-bearing rocks were actually intercalated with the others. The facts, as resulting from Mr. Wynne's very careful and detailed examination, appear to be that a very few and very imperfect remains of plants do occur in layers distinctly intercalated with the truly marine beds, and have probably been drifted into these localities from shores adjoining the seas in which the mollusca, now found fossilized in these beds, then existed. But as a whole the beds in which the well-marked *Palæozamiæ* occur are decidedly younger than those containing the truly Jurassic *Ammonites* and other characteristic fossils; and that they constitute an upper zone, but belonging to the Jurassic period. These very important results will be illustrated in detail in Mr. Wynne's reports.

Mr. Fedden has been engaged with Mr. Wynne in this careful examination of Cutch, and has more especially devoted himself to the portion of the province occupied by the tertiary rocks.

Very extensive and valuable collections of fossils have been made by this party of the survey, and transmitted to the Museum.

BURMAH.—Mr. W. Theobald, Junr., having returned from absence of leave, resumed the examination of British Burmah towards the close of the year. The time which elapsed up to the end of the year has been too brief to admit of any great progress. The country under examination has been that portion of the Prome district which stretches between the Eastern or Pegu Yoma and the Irrawaddi, and lies to the north of the Toung Raweng stream. This will, when finished, complete the whole of the Prome district east of the Irrawaddi. I confidently hope that we shall now be able to complete the examination of all British Burmah soon. The results at best are unsatisfactory from the absence of any good sections; and any attempt at classification of the rocks can only be of the largest kind. The whole country is too much covered to admit of any great detail.

PUBLICATIONS.—During the year under report, we have commenced the issue at stated intervals of a new series of publications called the "RECORDS OF THE GEOLOGICAL SURVEY OF INDIA." These are printed in smaller type and on thinner paper (for free transmission by post) than the more detailed Memoirs, but of the same size, so that they can on completion of a volume be bound with these. It is contemplated to issue a number every three months, making four numbers or parts in the year. It was impossible, however, to commence the issue until after several months of last year had passed, and therefore, for 1868, only three numbers appeared. In explanation of the object with which this series has been commenced, I may quote here from the brief Prefatory Notice which accompanied the first part. 'This series will contain a notice of the current work of the survey up to date; a list of contributions to the Museum or Library; a list, and occasionally an analysis, of such books published elsewhere, as bear upon Indian Geology; and, generally, of all facts illustrating the immediate object of our researches, which may from time to time come to our knowledge.'

The three numbers issued in 1868 have contained papers on very varied subjects; coal, gold, copper, fossils, and several local descriptive papers, which have proved of much interest to local officers; also lists of all additions to Library, &c., during the year.

I am happy to say this new series of publications, although necessarily issued with very few illustrations, has already attracted much interest, and I think will prove very useful.

Of the MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA, a very valuable part has been issued, containing a full report on the geology of the lower parts of the Nerbudda and Taptee Valleys by Mr. W. T. Blanford. The delay involved in the preparation of the necessary illustrations for this paper caused it to appear later than I had hoped. In the same part is also a detailed description of the structure and anatomy of the very curious little frogs long

known to be found in some thin papery shales near Bombay. To these Professor Owen had in 1847 given the name of *Rana pusilla*. More careful investigation, and more perfect specimens, show that these strange little frogs belonged to the existing genus *Oxyglossus*.

Mr. Blanford's report includes all the country lying between the parts already described by Mr. J. G. Medlicott (see Vol. II, *Memoirs Geol. Survey of India)* and the Gulf of Cambay, and thus completes a geological section right across the peninsula to the neighbourhood of Bombay.

This part completes Volume VI of the MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA.

Of the figures and descriptions of Indian fossils, included in the Palæontologia Indica, the second half of the description of the Cretaceous Gastropoda was issued in October. This contained four fasciculi, and being ready at that time, I was enabled to issue it in advance, so as to carry the publication up to October of the present year. The danger of loss, the facility of destruction or injury, and the delay in transmission, of the smaller fasciculi, render it preferable to issue the whole series due for a year at once, if this be ready.

The description of the Gastropoda, concluded in these parts, was carried out to the close with the full detail to which I specially alluded in my last report.

Much progress has been made in the preparation of the needful plates for the illustration of the Bivalves, the group which will be published next.

At the request of several local officers we have, during the year, furnished brief geological descriptions of their districts, which they needed for statistical accounts, descriptive reports, &c., &c.

LIBRARY.—During the twelve months of 1868, we have added to our library 1,766 volumes, or parts of volumes, of books. Of this total 508 were presented or received in exchange for the publications of the Geological Survey from Societies and other institutions. We continue to maintain our catalogue of these books up to date, and in the new series of our quarterly publications (THE RECORDS) a complete list is given, in each part, of those received during the preceding three months. It is hoped that this announcement being sent to the several Societies from whom the presentations have been received will suffice as an acknowledgment, and will thus obviate the necessity of separate communications.

We are quite as seriously inconvenienced in our Library arrangements, by the want of sufficient space, as in the Museum. The books are necessarily placed in double rows and often far too crowded in their cases. This renders it impracticable to be as careful of them as might be, and also seriously interferes with facility of consultation or reference. To give fair room for all we would require at least double the number of cases and shelves we have at command.

To this report is appended as usual a list of the Societies and Public Institutions from which the Geological Survey of India has received donations or exchange of publications during the year 1868.

In my last report I stated that the literature of Geology, Mineralogy, Palæontology, &c., had of late years so vastly increased that it was impossible to maintain our library effectively from the small sum annually appropriated to such purposes and I am happy to be able to state that an increase to this sum has since then been sanctioned.

MUSEUM.—Up to the close of the year we had not received all the series of fossils procured during 1867 in Europe, in connection with the purchase of the Klipstein collection. But few now remain to be received, and I hope to be in possession of all at an early date.

During the year, I had the advantage of the aid of Mr. Geoff. Nevill in arranging, preparing, and cataloguing these fossils as opportunity offered for opening and examining them. In many cases, the want of space has rendered it necessary merely to open, examine, check, and pack up again, box after box, as we have not space in which even to arrange, much less exhibit, our collections. Three additional rooms have been given up to the museum, and this will afford a certain amount of relief, when we have been able to procure cases. During the year more than 6,000 specimens have been catalogued.

We have returned to the Central Museum, Madras, the Cretaceous Gastropoda which they had been good enough to lend us for examination and description, and we have added to the

list as complete a series of duplicates of this group of fossils as our collections could afford. I think local museums should especially, and in preference to any more general illustrations, seek to render their collections specially rich and illustrative of local Natural History, and my desire has been to place in the Madras Museum the best series of duplicates which could be selected from the very interesting and valuable collections of Trichinopoly fossils made during our geological examination of that district in the Madras Presidency. With a similar object, I also sent to the Museum at Rajamundry as complete a series as our collections would afford of the interesting tertiary fossils found close to that town, carefully named, and with accurate references; so that those interested might have some good data for comparison, if they had the opportunity of adding to these local collections. We have also during the year examined and named for several persons specimens and small collections.

From the officers of the survey working in Cutch, the collections have received very large additions; among which are many good specimens. The other parties of the survey have not been engaged in richly fossiliferous districts. Mr. Medlicott has brought a small series from the Khasia Hills, and a few have been received from Burmah.

METEORITES.—To the noble collection of meteorites in our Museum have been added during 1868 specimens of the fall of Pultusk, 30th January, 1868: of Klein Menow, 7th of October, 1861: of Perth, 17th May, 1830; of Ornans (Doubs), 11th July, 1868; and of Lodran near Mooltan, 17th of October, 1868, being five in all. Of one of these (Klein Menow) our collection contained a minute fragment before, but we have now obtained a very splendid specimen. The others are all new to our series. For the very rare specimen from Perth, I am indebted to the friendly kindness of Mr. Wm. Nevill, Godalming, Surrey, from whom also I procured the Klein Menow specimen. To my good friend M. Jules Marcou, Paris, I owe the specimen of Ornans, while the contribution of that from Pultusk was among the latest communications received from the able Director of the Imperial Mineral Cabinet at Vienna, Dr. M. Hörnes, since deceased. This was only one among a very numerous and long-continued series of friendly communications, in which I have ever experienced the most hearty and graciously rendered support and co-operation from the Austrian Geologists, and from none more warmly than from the greatly regretted Hörnes.

A small map is as usual appended, showing roughly the areas of which the geological examination has been completed, or is now in progress, in connection with the survey.

THOMAS OLDHAM,
Supdt. of Geological Survey of India, and
Director of Geological Museum, Calcutta.

GEOL. SURVEY OFFICE;
CALCUTTA, *March* 1869.

List of Societies and other Public Institutions, &c., from which Publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1868.

LONDON.—Royal Society.
„ Royal Institution.
„ Royal Asiatic Society.
„ Geological Society.
„ Geological Survey of Great Britain and Ireland.
„ Royal School of Mines.
„ Royal Society of Arts.
„ Royal Geographical Society.

DUBLIN.—Royal Society.
„ Royal Geological Society.
EDINBURGH.—Royal Society.
GLASGOW.—Geological Society.
CORNWALL.—Royal Geological Society.
VIENNA.—Kais. Hof Mineralien Kabinet.
K. K. Geologischen Reichs-Anstalt.
Kais. Akad. der Wissenschaften.
DRESDEN.—Naturwiss. Gesellschaft, Isis.
BERLIN.—Deutschen Geologischen Gesellschaft.
BRESLAU.—Schlesischen Gesellschaft für Vaterland. Kultur.
MUNICH.—Kön. Bayerischen Akad. der Wissensh.
MOSCOW.—Société Impériale des Naturalistes.
SWEDEN.—Bureau de la recherche Géologique.
NORWAY.—Royal University of Christiania.
PARIS.—Comm. des Annales des Mines.
„ Société Géologique de France.
DIJON.—Acad. des Sciences.
CAEN.—Société Linnéenne de Normandie.
BELGIUM.—Academie Royale des Sciences, Bruxelles.
NEUCHATEL.—Société des Sciences Naturellés.
LAUSANNE.—Société Vaudoise des Sciences Naturellés.
ZURICH.—Naturforschenden Gesellschaft.
TURIN.—Royal Academy.
GOETTINGEN.—Königl. Gesellschaft Wissenschaften.
GERMANY.—Leop. Carolino Acad. of Sciences.
COPENHAGEN.—Danish Academy.
PHILADELPHIA.—Franklin Institute.
„ American Philosophical Society.
„ Academy of Natural Sciences.
BOSTON.—Society of Natural History.
AMHERST, MASS.—Museum of Compar. Zoology.
SALEM.—Essex Institute.
WASHINGTON.—Smithsonian Institute.
NEW HAVEN.—Connecticut Acad. of Arts and Sciences.
TORONTO.—Canadian Institute.
VICTORIA.—Geological Survey.
„ Office of Mines.
CALCUTTA.—Asiatic Society of Bengal.
„ Agri-Horticultural Society.
„ Indian Annals of Medical Science.
BOMBAY.—Branch of Royal Asiatic Society.
ROORKEE.—Thomason College of Civil Engineering.
Governments of India, Madras, Bombay, Bengal, North-Western Provinces, Chief Commrs., Oude, Central Provinces, Burmah.
Great Trigonometrical Survey of India.

NOTE *on* PANGSHURA TECTA, *and two other species of* CHELONIA, *from the newer tertiary deposits of the Nerbudda Valley*, by FERD. STOLICZKA, PH. D., *Palæontologist, Geol. Surv. of India.*

While engaged in the examination of the tertiary (? pleiocene) deposits of the valley of the Nerbudda river in 1858, Mr. W. Theobald, Junior, obtained, among other fossils, a few remains of CHELONIA which are of great interest as throwing light upon the then existing representatives of this reptilian order.

Mr. Theobald described these deposits at some length in a paper "On the tertiary and alluvial deposits of the central portion of the Nerbudda valley" (Memoirs, Geol. Surv., India, Vol. II, p. 279). He distinguishes two groups of beds, an upper and a lower. To both of these a large number of the fossils is common, but Mr. Theobald is inclined to think that those of the upper group may have been, partially at least, derived from the denudation of the lower group. The beds of this lower group are more fossiliferous than the others, but they can only be examined where they are exposed in the banks of the Nerbudda river itself, and in those of a few of the larger tributaries. The same author also gives a list of land and fresh-water shells found in these beds. Many of the species noted are still met with recent, and some appear to be identical with those determined by Prof. Ed. Forbes from the Sevalik strata (see Falconer's Palæont. Mem., Vol. I, p. 389). Of the vertebrate fossils also, several species are common to both the Nerbudda and Sevalik strata. Still some peculiarities in the Bovine and Pachyderm types have been pointed out, which seem to show that the deposits of the Nerbudda valley are younger than those of the Sevalik hills. On this point it is difficult to arrive at any definite conclusion from the examination of the fossils alone. The comparatively larger number of Bovines in the Nerbudda beds, as contrasted with the Pachyderms, the absence of Mastodons, &c., may be due to local causes. And further, the number of fossils as yet known from the Nerbudda is small, while from the Sevaliks, which have been examined more in detail, we have a large number of well determined species. The only question is, whether all the fossils which have been described from the Sevaliks really belong to one series of beds only, or whether they do not in reality represent somewhat distinct horizons (the Nahun series, the upper and lower Sevaliks, &c.) It is certain that no particular attention was paid to these divisions when the earlier collections were made. Much is therefore still left to be worked out, both in the Nerbudda and in the Sub-Himalayan country.

In the present note I shall direct attention only to the Chelonian remains from the Nerbudda valley. Mr. W. Theobald, in his report quoted above, repeatedly states that Chelonian remains occur throughout the lower group, but that they are rare as compared with those of the Mammalia (see pp. 289, 290, 292). Besides these remains of Chelonia I am not aware that any other reptilian remains have been met with in the Nerbudda beds, although Saurians and others most probably existed within that area, as they do now, and as they did already during the time, and in the area, of the Sevalik deposits.

These Chelonian remains are referrible to three species; one, which is sufficiently preserved, has been identified with the recent *Pangshura tecta*, and, of the three other fragments, one appears to belong to a recent *Batagur*, and the other two to a *Trionyx*.

I shall give first a short description of these remains, and then add a few words respecting the conclusions resulting from this examination.

PANGSHURA TECTA, *Bell*, sp., Plate I, Figs. 1, 2.

Emys tectum, Bell, Monog. Testudinarum.
„ *tecta*, Gray, Illustrations of Indian Zoology.
„ *Namadicus*, Theobald, 1860, Mem. Geol. Surv., India, Vol. II, p. 295.
Pangshura tecta, Günther, 1864, Reptiles of India, p. 33.
Emys tecta, Falconer's Pal. Memoirs, 1868, Vol. I, p. 388.

The shell of *Pangshura tecta** has an elongated oval form. The centre of the back is elevated, more or less distinctly carinate, the sides are rather flattened and slope at an angle of about 45°, which increase up to 50° towards both ends. The carapace is anteriorly

* I have adopted here the change in the specific name, *tecta*, as being more in accordance with the general system of nomenclature, although Bell said that Gray had misquoted the name *tecta* instead of *tectum*, the roof of a house, which was intended to express the general form.

about equal to, or a little shorter than, the sternum, and slightly emarginated; posteriorly it is obtusely rounded, and at the marginal shields more or less distinctly serrated.

In the specimen figured on Plate I,—which was discovered by Mr. W. Theobald at Moar Domar in the Nerbudda valley,—the carapace agrees in every respect with that of the recent species, as will be shown by giving the necessary details of its structure. To facilitate a careful comparison, I have also given a drawing of one-half of the dorsal and ventral views of the carapace of a small specimen, procured living in the neighbourhood of Calcutta. These drawings are intended to illustrate not only the epidermoid but also the osseous shields. Proper attention is seldom given to the latter in zoological works, although in palæontological researches they are of greater importance than the former.

The fossil figured is not perfect, the posterior portion of the carapace not having been found; but the rest of the shell is quite sufficiently preserved to admit of careful comparison for specific identification. The general form of this fossil is, as already stated, exactly the same as that of recent specimens.

Epidermoid plates.—The nuchal shield is very small, narrower anteriorly than posteriorly. All the five vertebrals are obtusely carinated in the middle, and the first three become successively more and more elevated at the posterior end. The first vertebral is pentagonal with an obtuse projecting angle in front, slightly emarginated at the sides, narrow and truncate behind. The second vertebral is about the same size as the first, also pentagonal, truncate at both ends, considerably narrower posteriorly than anteriorly, laterally, at one-third of the length from the front edge, widest and angular. The third vertebral is the smallest, but the highest of all, pentagonal, truncate in front, angular at the sides, after which considerably produced posteriorly, becoming gradually narrower and terminating with an obtuse point. The fourth vertebral is bell shaped, very much prolonged, joining the third with an obtuse point, then becoming gradually wider until it reaches about three-fifths of its length, after which it narrows again, terminating with a truncate side, about one-half of the greatest width of the shield. Of the fifth vertebral only the anterior portion is preserved, showing it to be truncate in front and quickly widening posteriorly. The sides were probably obtusely pointed and the posterior termination truncate, broader than the anterior, as in recent specimens. In these the sides of the fifth vertebral are sometimes pointed, sometimes distinctly truncated. Costal or lateral plates are five, all being transversally elongated and of a more or less irregular pentagonal shape. They entirely agree with those of living specimens, as is equally the case with the marginal shields, which are eleven in number on either side. The serration of the posterior marginal shields remains to be properly recorded if better preserved specimens should be discovered, for neither is it distinctly traceable in the figure given by Dr. Murchison in Falconer's Pal. Memoirs.

On the ventral side we have first to notice a pair of small, triangular, posteriorly pointed gular shields. To these follows a pair of larger, subquadrangular post-gulars; then a pair of rather high pectorals, next to which are the abdominals, being the largest, and then the other shields of normal size. The axillaries are comparatively small, posteriorly pointed, the inguinals large anteriorly, on the external side obliquely truncate. The longitudinal ridge which connects each axillary with its corresponding inguinal is very distinct, sharp and slightly longer than in most recent specimens. The plastrum is distinctly concave, probably a little more so than in male specimens, as usually met with about Calcutta.

Osseous plates.—The distribution of the osseous plates, as is well known, does not agree with that of the epidermoid shields. There is a very large nuchal plate and a very small caudal, the latter not being preserved in our specimen. There are ten small vertebrals, the last (the largest) not being seen in the fossil, but the other nine perfectly agree in their relative proportions and in their relations to the epidermoid shield with those of live specimens. The costal shields are eight; the first is the broadest, with reference to the longitudinal diameter of the carapace; all the others are very narrow. The number of marginals is eleven on each side.

On the plastrum we have a pair of subquadrangular gular shields, to which follows a pair of very large pectorals, these four shields enclosing in the middle a single, suboval post-gular; there is besides a pair of very large abdominals and one pair of smaller anals. The axials and inguinals are not separated from the pectorals and abdominals respectively.

No portions of the internal skeleton, as the extremities, &c., have been found preserved.

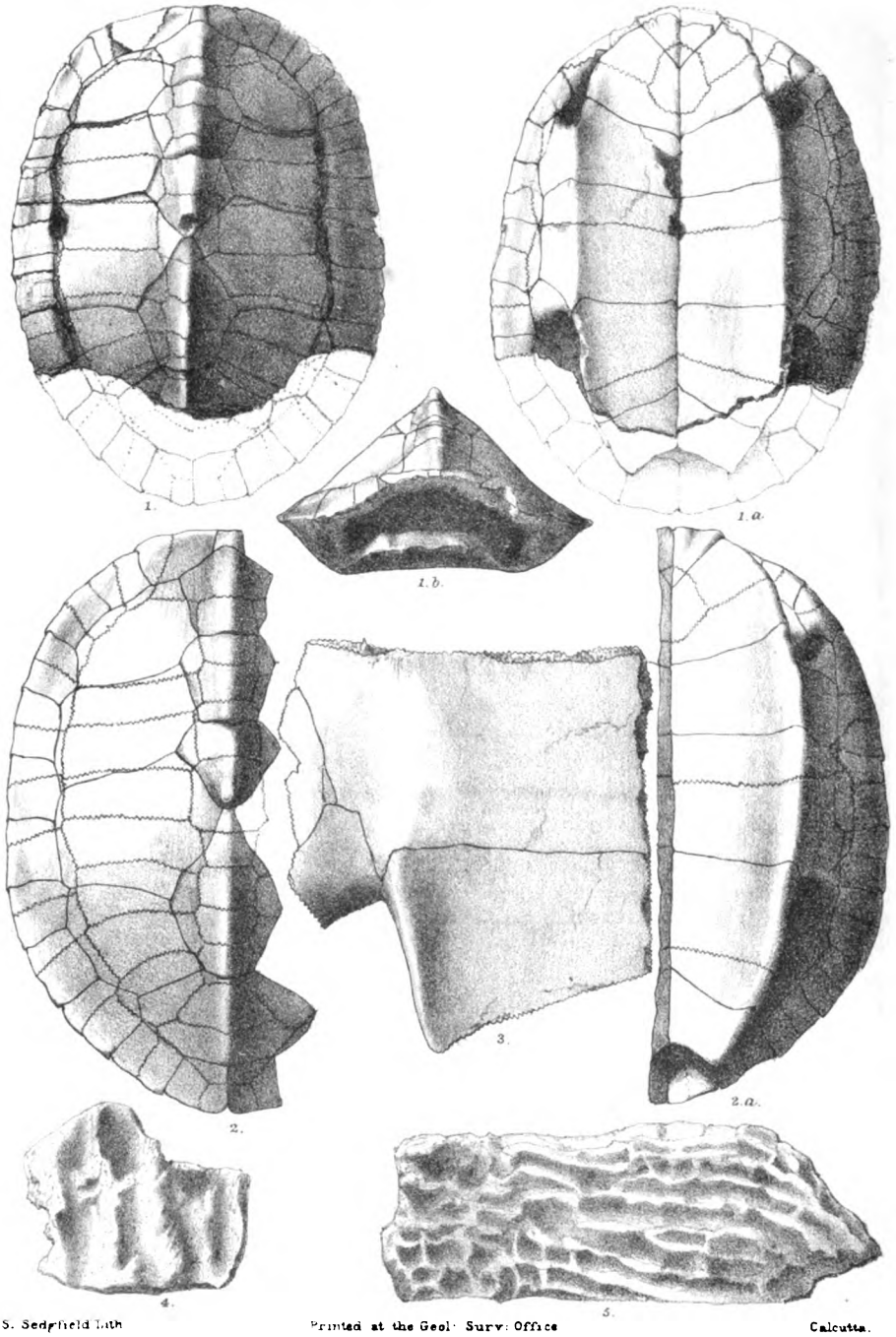
The epidermoid plates in *Pangsh. tecta*, and other allied species, are subject to a great deal of variation, which is especially considerable in the form of the vertebral plates, occasionally so much so that they cease to be of great specific importance. The most variable are the first and the fifth vertebral plates. In the Indian Museum there exists a remarkably large specimen of *Pangsh. tecta* from Cachar. Its first vertebral is pentagonal, the second quadrangular, third rather large, of regular form, fourth very large, bell shaped, the fifth is three-fifths of the length of the former, of almost equal width throughout, truncate in front, sub-angular laterally, and obliquely pointed posteriorly, while, as a rule, it is truncate behind (see fig. 2, pl. 1). There are twelve marginals on each side, instead of eleven, the tenth being divided by a furrow in continuation of the suture which separates the fifth costal from the fifth vertebral. The caudals are very small.

Comparing the epidermoid shields of some of the specimens of *P. tecta* with those of *Pangsh. tentoria*, it is by no means easy to point out any very remarkable distinctions, but the latter species can be always recognised by its broad, depressed back, the sides of the carapace being distinctly convex, and the general form of the shell more elongated. (See Theobald's Catalogue of Reptiles, etc., Jour. Asiat. Soc., Bengal, Extra No. 146, 1868, p. 14). Günther's figure of *Pangsh. tentoria* is by no means characteristic, being almost undistinguishable from that of *P. tecta*.

The costal shields are, on the contrary, much more constant, and they do not appear to vary essentially in allied species and genera. In all the species of *Pangshura* which I have examined they were arranged quite identically.

Mr. Theobald proposed for the specimen here figured the new specific name "*Namadicus*," while Dr. Falconer, in an essay already written in 1844 (see Falconer's Pal. Mem., Vol. I, 1868, p. 382), had identified another specimen found in the Sevalik strata with the recent species. The examination of the Nerbudda specimen has strongly confirmed Dr. Falconer's investigations; that celebrated naturalist summing up his results in the words, "that we are not justified in constituting a difference where we do not find it." Judging from all the solid parts of the carapace, it cannot, I think, be reasonably questioned that the Nerbudda and the Sevalik fossils, as described by Dr. Falconer, are both of the same species, and identical with recent specimens of that species. It might, of course, be said by some naturalists that the fossil specimens may have been, for instance, quite differently coloured, and this would be sufficient to constitute a specific distinction. Such hypotheses cannot, however, be admitted as having any value in pointing out specific distinctions of fossils.

I have no doubt that the specimen from which Dr. Falconer's description was taken is a true *Pangsh. tecta*, but it seems very doubtful that it was the identical specimen figured by Dr. Murchison on Plate 32 in Falconer's Pal. Mem., Vol. I. I have little doubt that this last one is also a *Pangsh. tecta*, but it can scarcely be the identical specimen which Dr. Falconer described. Dr. Murchison (in a note on page 382) pronounces the figured specimen to be the original of Dr. Falconer's description, but when writing the explanation to the plate some of the differences must have struck him, and here he leaves the identity of the specimen doubtful. On page 383 Dr. Falconer says, with reference to the first vertebral, (of the epidermoid coat), "the exact form is not distinctly seen, though it seems to converge less * * *." In the figure two-thirds of the first vertebral are broken off, and no convergence is perceptible. Farther, the author says, "the outline of the fourth scute is not distinguishable in the fossil, and the fifth one is wanting." In Dr. Murchison's figure the fifth shield appears perfectly preserved. With regard to the fourth vertebral scute there is an error in Dr. Murchison's figure. The draughtsman has in place of the outline of the epidermal shield marked the outlines of three osseous plates, and of these he does not seem to have given the outlines quite correctly. The fourth epidermoid vertebral scute extends over three complete osseous vertebrals and an additional one-half, or nearly that, on either end (see pl. I, fig. 2). It is important to point out this distinction, though every one, looking at Dr. Murchison's figure, will readily notice that some mistake of that kind must have occurred. For no *Emys* or *Pangshura* possesses seven scutes in the epidermoid covering, and if intended as a representation of osseous shields, the number is, as I have already stated, too small. In spite of this discrepancy and the somewhat strongly bi-tuberculated second vertebral scute, I can hardly think that the specimen figured by Dr. Murchison belongs to any other species than *Pangsh. tecta*.



S. Sedgfield Lith. Printed at the Geol. Surv. Office Calcutta.

BATAGUR SP., *conf.* DHONGOKA, *Gray*. Pl. I, Fig. 3.

Günther's Reptiles of India, Ray Soc., 1864, p. 42.

One right abdominal osseous shield has been found in the conglomeratic beds near the village Omeria. This abdominal osseous shield is 108 m.m. long and 94 m.m. broad in the region of the inguinal process. Its form, the flat surface and the outlines of the junction of the abdominal and præ-anal shields, of the inguinal and of the adjoining marginal on the external side, entirely agree with the form of the same shields of the recent *Batagur dhongoka*. Further materials are, however, necessary to show whether this supposed identification be correct.

The species occurs at present throughout India, especially in the larger rivers, and it is found up to the present time in the Nerbudda. Judging from the size of the fossil shield, the specimen to which it belonged must have been about one foot long; specimens much larger than this are met with alive now in India.

TRIONYX SP., *conf.* GANGETICUS, *Cuvier*, Pl. 1, Figs. 4—5.

Günther's Reptiles of India, Ray Soc., 1864, p. 47.

The two fragments which are referrible to the above species consist of the largest portion of the left lower inguinal plate, and a fragment of one of the bony (sternal) processes with broad longitudinal furrows. The rugose surface of the inguinal plate entirely agrees with that of *Trionyx gangeticus*, and this is the only reason which can at present be brought in support of the presumed identification of the fossil with the recent form. The thickness of the plate shows it to have belonged to a large specimen. These two fragments were also met with in the conglomeratic bed near Omeria. *Trionyx gangeticus* is found at the present time living in most of the large Indian rivers, especially in the Ganges and its tributaries.

We have thus up to the present three species of Chelonia upon record from the newer tertiary fluviatile deposits of the Nerbudda valley. These all belong to forms which live in fresh water, and so far agree with Mr. Theobald's conclusions, derived chiefly from a consideration of the shell-fauna, that there are no traces of any estuary or brackish-water deposits. Of these three Chelonia we may accept with the highest probability the identity of *Pangshura tecta* with the existing species, and the great similarity of the other two to existing species is also unquestionable. The Chelonia, probably unnoticed by man, appear to have changed far less in the lapse of time than the Mammalia. The *Pangshura tecta*, and probably two other species (not yet known to occur in the Sevaliks proper), have then continued to exist unaltered, from the time of the *Sivatherium*, *Mastodon*, various *Elephants*, *Hippopotamus*, *Colossochelys* and others, down to the present time. The changes in the conditions of climate, &c., may not have been great, and if the species of reptiles survived these changes man surely would have been able to do the same, had he existed at that early date. That he did so exist, and that he was a contemporary of the *Colossochelys*, as Dr. H. Falconer suggested long since, we have no reason to doubt, although as yet we may not be able to adduce any direct proof of the fact.

EXPLANATION OF PLATE I.

Figs. 1, 1a, 1b; dorsal, ventral and front views—half the natural size—of the carapace of a fossil specimen of *Pangsh. tecta* from newer tertiary conglomeratic beds near the village Moar Domar in the Nerbudda valley.

Figs. 2 & 2a; dorsal and ventral views of half the carapace of a recent specimen of the same species; (natural size).

Fig. 3 ... Ventral view of a right abdominal osseous shield of a species closely allied to, or identical with, *Batagur dhongoka*, Gray, from the same beds as Fig. 1; (half of natural size).

Fig. 4 ... Portion of the sternal process of a species closely allied to, or identical with, *Trionyx gangeticus*, from the same beds as the last; (half of natural size).

Fig. 5 ... View of a fragment of the inguinal plate of the same species as the last, and from the same locality; (natural size).

Sketch of the Metamorphic rocks of Bengal, by H. B. Medlicott, A. B., F. G. S., *Depy. Supt., Geol. Survey of India.*

From the descriptions of the earliest geological observers in India it has been known that large areas are occupied by metamorphic and submetamorphic rocks. It might not appear from its publications that the Geological Survey had given to these formations their due share of attention. But such an inference would be far from correct: coloured maps of large districts might long since have been published, with a general description of the lithology and of the superficial stratigraphical features; and specious analogies might have been drawn with the 'fundamental' rocks of other countries; but any such accounts would be illusive without some definite judgment upon the structure and relations of the several rock-groups. The following notice is a brief abstract of observations made by me during two seasons (1862-63, 1863-64) spent on these rocks, from the watershed of the peninsula near Jubbulpur, in an east-north-east direction, to Monghyr on the Ganges, a direct distance of more than 400 miles. Those who have any knowledge of the difficulties attending the investigation of such rocks will at once understand that my explanations can be only tentative.

The broad promontory round which the Ganges turns at Rajmahal is the termination of a great expanse of gneissic rocks. Here, throughout its eastern extremity, for nearly 100 miles, the gneiss is covered and bounded by the Rajmahal Trap, with its associated plant beds (jurassic), locally underlaid by other members of our Indian Stratified Series; and various outliers, of irregular shape and size, of these latter deposits, comprising our best known coal-fields, are scattered over the area to the west; but from the Rajmahal boundary the gneiss is continuous for 400 miles to the west-south-west to where it passes under the Great Deccan Trap (supra cretaceous) of the Mundla plateau. From the south extremity of the Rajmahal Trap the general boundary of the metamorphic area extends to the south-south-west. Across the middle of the area a straight line might be drawn for more than 150 miles from north to south, continuously on crystalline rocks.

Throughout the greater portion of the northern boundary (the region to which my observations more especially refer), and with few exceptions wherever rock is more exposed, the gneiss is in contact with submetamorphic rocks—slates, schists and quartzites. The exceptions are where, only very locally, the Lower Vindhyans lap on to the gneiss, and where the crystalline rocks themselves extend through and beyond the otherwise regular and continuous run of the schists. This latter case is a most important one; it occurs in about the middle of the region, and is connected with an interruption of nearly 80 miles in the run of the schists, dividing them into two separate areas, and introducing all the doubts and difficulties of identification. In the western area the submetamorphics are continuous along the south side of the Sone valley and into the Nerbudda valley, and are throughout the whole extent bounded on the north by the great Vindhyan range, the strata of which rest totally unconformably upon the schists. In the eastern area, in Behar, the slate series appears in detached groups of hills more or less isolated in the deposits of the Gangetic plain; the principal of these hills are those of Rajgir, Kurrukpur, Ghiddour, Bheowa, and Mahabur. There is perhaps a presumption that the analogous rocks in the two divisions of this great zone are closely related, but many circumstances combine to complicate the question of identification: in the western area the rocks are principally argillaceous, and the metamorphic products of such; while in the east, quartzose deposits largely predominate. Again, this break of continuity is coincident with the eastern extremity of the immense spread of the Vindhyan rocks, and thus, through a general analogy of composition, the possibility was at first suggested (the crystalline rocks not being necessarily all of one period) that the quartzites of Rajgir, &c., might be altered Vindhyans. This supposition may, I think, be quite set aside: the Lower Vindhyans near their eastern limit rest quite unaffected upon the granitics; and the most peculiar and characteristic beds of the Lower Vindhyan series are most extensively developed in this position, yet there are no rocks among the submetamorphics of Rajgir that would even approximately represent them specifically. There is, on the other hand, no inherent difficulty to the general equivalence of the submetamorphic series in the two regions, in the fact of there being much difference of composition at so considerable a distance. It need hardly be stated that only the leading relations of the rocks are to be noticed: no fossils have as yet been discovered in any of them, and no detailed work has as yet been attempted.

The superficial relation of position—a great spread of crystalline, fringed by submetamorphic rocks—is already variously suggestive: the rival leading questions would be—to what extent are the crystallines granitic and intrusive, thus determining the present limit of the schists? or, if the crystallines are in the main gneissic and themselves metamorphic, how far may the present limitation of the submetamorphic series as a fringing deposit be an original feature? No satisfactorily one-sided answer can be given: the facies of the crystalline rocks is emphatically gneissic (metamorphic); there is also ample evidence of granitic intrusion in the rocks of both series; yet, owing to theoretical scruples, and to deficiency of data, the residual phenomena are so numerous that no approximately final judgment can be put forward even as to the main relative ages. It is time, however, that our difficulties should be ventilated. The lie of this great band of slaty rocks, on the south of the Gangetic valley, and followed up, as it is, by the next succeeding deposits of the Vindhyan series, suggests at first sight inferences as to the possible substratum of the great alluvial formation, as to the inducing conditions for the great area of erosion or of depression, and as to possible relations to the rocks on the north of the plains, in the Himalayan region. But, whatever independent interest these large structural features may retain, such speculations as those mentioned are in a great measure negatived by the appearance to the north of the Vindhyans in Bundelkund of a large area of thorough gneissic rocks; and again, in Behar, in the small group of the Barabar hills, well to the north of the Rajgir range, we find very massive gneiss of most ancient aspect.

I must here briefly recall to notice some observations I made in 1856-57 in a neighbouring part of India (published in the 2nd Vol. of our Memoirs) as bearing upon the question before us. To the north-west of the Sone valley, and separated from it by the long eastern prolongation of the Vindhyan formation, there is the large area of crystalline rocks of Bundelkund; it is bounded on three sides by the Vindhyans and on the fourth by the Gangetic plains. Along the south-east border of that area there appears a strip of semimetamorphic rocks—quartzites, limestone* and slaty strata, with contemporaneous trap, rising from beneath the Vindhyans. I described them as the Bijawur formation. They are in many places seen to rest abruptly upon a flatly denuded surface of the gniess of that area. The bottom rocks in this position are peculiar quartzites, often compact and brecciated, and massive cherty limestone; but along portions of the boundary the usual Bijawur strata are underlaid, with at least approximate parallelism, by very non-descript gneissoid strata. The demarcation between these and the true gneiss is, naturally, very obscure; and it was not then possible to work it out; but there are locally some intercalated beds of quartzite-sandstone that effectually betray the stratigraphical affinities of these indeterminate strata to be towards the Bijawur rocks, and totally distinct from the true gneiss, to which they seem in the relation of an ancient superficial covering. We shall see that probable representatives of the Bijawur rocks occur both in the Sone valley and in Behar; and that thus we may at least get a hint as to the relative ages of the gneiss of the two areas.

A large part of the submetamorphic area of the Sone valley is occupied by rocks that would well represent the Bijawurs—ferruginous slaty schist with quartzite, limestone, and much contemporaneous trap. They are much more disturbed than in Bijawur; it is even probable that they are affected by certain granitic intrusions. The uncertainty upon this and upon other unsettled points regarding their relation to the main crystalline area to the south is largely owing to the presence of another older series of slaty rocks in the Sone area. The Bijawur deposits are known to be somewhat fickle, but unless they are so beyond all possible conjecture, there can be little doubt of the existence of this older series. In some of the best sections, notably in that of the Rehund, there is a clear transition from the coarse felspathic gneiss, through well marked stages of crystalline metamorphism, into a series of fine clay-slates, with plenty of intrusive greenstone, but in which none of the characteristic Bijawur rocks can be recognised. Where decided Bijawur rocks come in contact with the gneiss there is no such intimate relation between the two. Now that maps of this ground are available there is some prospect of our being able to unravel these obscure questions.

The hills formed of the submetamorphic rocks in Behar appear generally as precipitous ridges of quartzite, either singly or massed together in groups. Even in the

* The limestone of Dergoan, which I had doubtfully described as an outlier of the Lower Vindhyan limestone has since been shown by Mr. F. R. Mallet to belong to the Bijawur series.

latter case the inner vallies are so deeply eroded that it is often difficult to get a sight of the softer rocks contiguous with the hard quartzite. The Rajgir group is the most removed from the main crystalline area; the rocks are less altered than elsewhere; and it presents the best chance of discovering the normal order of succession of the strata. It cannot, however, be said that the strata here are less disturbed than elsewhere; although, on the whole, the strike of the ridges and of the rocks is very constant to north-east by east, the state of contortion could not well be aggravated short of presenting a great brecciated agglomeration. There are some sections in which there seem to be several hundred feet of quartzite in regular succession. At some points also the fine slaty schists present a very wide outcrop without any admixture of quartzite. Except very locally at the contact of the two there is no appearance of interstratification. It will presently be seen how essential it is to the geology of this whole region to ascertain the true order of succession of these two bands of strata. Some of my colleagues have considered the quartzite to be the bottom group; the supposition would alleviate some of our difficulties, and there are no doubt cases in which the schist now overlies the quartzite; but a close examination of the ground does not permit me to adopt this view; I consider that there is here but one great band of quartzite normally underlaid by a considerable thickness of argillaceous strata. There is only one spot at which these Rajgir rocks are seen in contact with others: along the whole south-east face of the range (at least at the several points at which I crossed it) nothing is seen immediately external to the quartzites; at about a mile from the base on this side there is one small outcrop of massive granitoid gneiss. On the north-west side the schists are very generally exposed; and at about the middle they form a wide fringe of low hills, on the outer margin of which, near Ghunsura, there is one good contact-section of the schists with a strong mass of granite. The relation is unmistakably one of intrusion; there are small protrusions and ramifying offshoots from the granite into the sedimentary rocks, and enclosing angular fragments of them. The general effect on the schists is very noteworthy: there is little of what is usually considered as hypogene metamorphism; the line of contact is sharply defined, and the schists tend rather to assume a homogeneous, trappoid aspect, than a foliated, quartzose, granitic one; the granite of the intrusions has lost much of its quartz. Elsewhere to the west, at Sapineri, Putturkati near Gya, and Muhair, and in other isolated outcrops, these re-actions are exhibited on a much larger scale; idols and utensils are extensively wrought from the soft serpentinous rock of the converted schists; and some of the granite dykes yield a fine kaolin, the only considerable use made of which is to adulterate lime.

To the south-east of the Rajgir hills the Bheowa range stands on the border of the crystalline area; and further south, across the narrow valley of the Sukri, rises the fine hill-mass of Mahabur, well in among the crystallines, and overlooking all the high land to the south. One cannot resist identifying the great quartzites of these ranges with those of Rajgir; and at Mahabur we again find a thick underlying series of fine schists. There are, however, considerable changes to be taken into account: all the rocks are more metamorphic than those of Rajgir; the quartzites are frequently full of small innate mica; and the schists are fine mica-schists, garnetiferous, and often with much globular felspar, but still the very kind of metamorphic rock that one might expect from the slaty schists of Rajgir; and they are very markedly distinct from any variety commonly associated with the gneiss. Round the base of Mahabur I did not succeed in finding a section showing even an approximate contact with the surrounding rocks; but on the north flank of the Bheowa ridge there is a fair example of what the general relation of the two series in this region may be. At the north end of the Hurkur pass there are several fine domes of granite; they are excellent instances of a form of rock that is of frequent occurrence all over the gneiss area; a more or less faint foliation is generally traceable in it, and it never shows any attempt to throw out dykes; it would seem nevertheless highly probable that it is in some manner intrusive; the partial foliation (as Mr. Scrope has maintained) being due to traction in the viscid mass. The case before us is about the best evidence that could now be given in favor of such intrusion: one of these domes occurs close up to the ridge of quartzite, and the two rocks show distinct re-actions at the contact; the granite has lost its usual coarse porphyritic texture; the quartzite is more than usually charged with mica, and has a steep underlie from the granite; at the lower levels traces of the schists were observed. If the supposition that forces itself so strongly upon our judgment be correct, that these several hill-masses are remains of a once continuous formation of argillaceous, succeeded by quartzose, deposits, there could be no doubt left of the truly

intrusive character of these sub-gneissoid granitic masses. On the same supposition the features of these Behar rocks, as thus far described, would fall well into harmony with generally received notions upon the process of hypogene action,—that these southern portions of the formation, being contiguous to the main region of hypogene activity, have undergone general metamorphism; while that portion at a distance from the centre exhibits special and partial intrusion, with a corresponding degree of metamorphism.

I must now attempt to exhibit those rock-features of the district which can scarcely be brought within, or which would seem anomalous in, the partial view that has been represented. The former are encountered in the sub-metamorphic rocks, and the latter in the gneiss, although it seems possible to bring them under one explanation. At about twenty miles to north-east by east, exactly in the run of the Rajgir range, and having the same strike, are the small hills of Sheikhpura. They also are principally formed of quartzites in considerable thickness. Some of these could not be distinguished from those of Rajgir; many beds are tinted red, a feature not noticed in the Rajgir rock; and on the southern ridge there are schists distinctly intercalated with the quartzite. But the fact most irreconcileable with the view taken of the Rajgir series is that these Sheikhpura quartzites are certainly bottom-rocks. Along the whole face of the ridge over the town they are admirably exposed in contact with a coarse granitoid rock of very doubtful aspect. It is so thoroughly decomposed and so massive that one might readily fail to detect its true character. The quartzite, too, is steeply inclined against it, the beds in contact being of abnormal texture, and in a manner amalgamated with the surface of the rotten pseudo-crystalline rock. The section, however, at once reminded me forcibly of those I had seen eight years previously at the base of the Bijawur series in Bundelkund. This conjecture made at Sheikhpura was fully confirmed ten miles further on in the same direction, where some small hills appear on the banks of the Kiul close to the railway station of Luckieserai. The northern hill is formed of a coarse conglomerate, large and small sub-angular pieces of quartzites (I noticed none of crystalline rocks) in a matrix of gneissose schist; the dip is 50° to south. The southern hill, only about 80 yards distant, is principally formed of an amorphous pseudo-granitic rock; but in it also strings of abraded detritus can be detected. On the south side this mass is overlaid by quartzites of precisely the same description and in the same manner as in the section at Sheikhpura. This section at Luckieserai most strikingly ressembles some in Bundelkund, 400 miles to westward; and the rocks are so peculiar that whatever else is doubtful in the Behar region, I am disposed to regard it as fixed that the Luckieserai beds are strictly geological representatives of the Lower (or rather, Infra) Bijawurs. Now, the question is, can these belong to the same formation as the Rajgirs? There are several suppositions possible: I may have mistaken the true order of the rocks of Rajgir, but this I am least inclined to admit; or, the real bottom rocks may not appear anywhere in the Rajgir sections, the junction at Ghunsura having cut through them; or, both may be bottom-rocks in their separate localities—how far are we at liberty to impose any fixed order upon the deposits, especially as the Bijawurs, which are in a manner our standard of comparison, are known to be most changeable on the same apparent horizon. As if to close this last mode of escape, or to push it to the uttermost, there occurs at Bichua, within two miles to the north-east of Luckieserai, a considerable hill, much larger than those just noticed, composed entirely of fine ferruginous schists, exactly like those of Rajgir or of Muhair; it is quite isolated in the alluvium. There still remains to be tried the supposition we found necessary in the Sone Valley—the presence of two distinct series, but more or less resembling each other in general metamorphic condition. To apply this supposition in the Behar region brings us into difficulties with the gneiss of the main crystalline area: in the Sone district the Bijawur representatives would certainly be the *younger* of the two series there present; and in Behar, too, from what has been so far stated, we should start with the same view; but here we find that the series which we have independently assimilated to the Bijawurs identifies itself most closely with at least one common form of the great gneiss of Bengal.

The Kurrukpur hills form the largest of the Behar groups. The general features are very similar to those already noticed; steep ridges of quartzite rising from the low ground on all sides. Schists occur abundantly within the range. The contortion of the strata is excessive, just as in the Rajgirs. Gneiss appears close to the base on the east and south sides; and on the west and north granitic crystallines occur within short distances. The Ghiddour range lies to the south-west of the Kurruckpurs, between

them and the Bheowa ridge; here also the general appearance is similar to that of the other principal hill groups.

Upon these general considerations of similarity of structure, position, and to a great extent of composition, one would not hesitate to suppose the rocks of all these eastern groups to belong to the same formation as the Rajgirs &c.; it is the conflicting evidence of the bottom-rocks, as already noticed, that would suggest a doubt—in the best sections I have seen at the base of the Kurruckpur and Ghiddour hills, the rocks near the great quartzites resemble those of Luckieserai. Although it would still be possible that there are two series of equal magnitude, and so closely resembling, yet quite distinct, the presumable unlikelihood of such being the case would quite outweigh all the difficulties to their complete identification; and it is only on the supposition of the sections to which I allude proving deceptive that I would venture to suppose there being any separation at all among these rocks, further than what may exist between the groups described in Bijawur to which I would then consider them parallel. The case I would explain is well exhibited at the east end of the Ghiddour range: for some distance a low flanking ridge follows the curve, and close to the base, of the great cliff of quartzite; it is principally formed of a coarse schist-conglomerate, sub-angular pieces (some are six inches across) of quartzites undistinguishable from those of the cliff, even to the peculiar innate mica; still the rock is thoroughly metamorphic, with the pebbles firmly soldered to the matrix. The underlie of this rock here is 30° to 50° westwards, thus apparently underlying the rocks of the range above. At the south-east angle, however, instead of following the run of the range westwards, it trends away to south and south-east, with very low dips, and completely identifies itself with the similarly arranged gneiss, schist and subordinate quartzite that cover so much of the low ground. I have little doubt in identifying these rocks with those at Luckieserai; and it appears to me more than doubtful that they truly underlie the Ghiddour quartzites. There is ample evidence on record of younger, apparently passing under older, deposits; and without involving the inversion of either. On the strength of their much more advanced type of metamorphism, these gneissic rocks at the base of the Kurruckpur and Ghiddour ranges have been considered altogether more ancient than the rocks of the hills; but if the suggestion now made be confirmed, that order will have to be completely reversed.

The same conjecture occurred to me from an independent point of view in the neighbourhood of Mahabur. Within about a mile of the east end of this ridge, right in the axis of its strike, we find these associated layers of tough mica-schist, hornblende-schist, gneiss, and subordinate quartzite, covering considerable areas at low undulating angles of disturbance. I was quite unable to conceive how such rocks could have been where they are at the time when the great quartzites were so intensely plicated, and the schists below them received their steady cleavage. The foliation of the Mahabur schists is cleavage-foliation; that of those other rocks is strictly lamination-foliation. This mechanical objection is at least as valid as the chemical one to which it is opposed, and which would determine the relative ages by relative metamorphism. But, indeed, there is little to choose between on this score here, for the Mahabur schists are often gneissose, containing much felspar.

In connection with this question of relative ages, it is necessary to notice the structure of the ranges as related to their distribution. Their isolated positions are not simply due to denudation: it is certain that the matter removed from between them at their present common level consisted in great part of crystalline rock. Uniform as is the general strike of the ridges, the termination of the ranges does not present a serrated front; the quartzites of the outer longitudinal ridges are bent round in a sharp regular curve, forming a continuous ridge of equal or greater elevation at the curve, with a precipitous external face, and generally an equally regular converging internal underlie. This feature is more especially well marked on the eastern aspect. In the larger groups there are internal features of the same kind; the contortion presenting a two-fold system of corrugation, one of which (the east-west one) greatly predominates, producing the marked longitudinal outline of the ranges. The cleavage and its foliation in the schists have been observed to follow these same curves. It was partly upon this evidence in the Rajgir group—that one can walk from any one ridge to any other without crossing a band of the schists which appear so freely in the enclosed valleys—that I inferred the supraposition of the quartzites. The drainage of these internal valleys does not take place endways, but by narrow gaps cut through the longitudinal ridges of quartzite. Outside the hills granitic rocks are sometimes seen in front of these abrupt terminations of the quartzite ranges. Thus it would seem as if the existing masses of the sub-metamorphic rocks had occupied areas of locally greater

depression at the time of the first great granitic invasion; and that to this we may owe their ultimate preservation as hill ranges. The feature is well exhibited in Mahabur: the axis of the range would strike up a reach of the Sukri, and on each side of the river there is an elongated oval of granitoid rock, as of denuded domes. The characteristic arrangement of the doubtful gneissic rocks is also better shown here than anywhere I could mention: they appear as regular concentric coatings to the granitoid masses. The area on the south is less elevated, and the diverging dips of the covering rocks range from 5° to 20°; on the northern area they are much steeper as if exposed lower down on the sides of the mass they envelope, but the regularity of the encircling ring is unbroken, and of the same description of rock as on the south, but in thicker masses. Upon the usual evidence of regularly alternating stratification of highly contrasting materials, it is not, I presume, to be questioned that these are true detrital accumulations remineralized; and it might, I suppose, be maintained on the strength of some misunderstood process of hypogene intrusive action that they may have underlaid the Rajgir formation; or it might even be said that the stratigraphical features of the Mahabur region suggest such a relation. But from the evidence before us, I confess to a preference for the contrary supposition: it would require that after the great disturbance and metamorphism of the Rajgir series the whole area was denuded to a much greater extent than now, and that upon the surface thus exposed these accumulations took place, probably of some arkose-like materials, very susceptible to mineral reorganization. Such must have been the composition of the bottom-infra-Bijawurs.* In this Behar area, however, there is ample evidence of a later granitic invasion: in the southern tributaries of the Sukri there are fine sections of great granite dykes traversing all the rocks transversely. This granite is very different from that already noticed; it is highly crystalline; in the centre of the dyke the felspar and quartz form a coarse graphic granite, with associated schorl and beautifully plumose mica. The view I have proposed would imply a prodigious relative antiquity for the Rajgir formation.

The views that have now been presented in connection with the submetamorphic series have manifestly very direct bearing upon the rocks of the great gneissic area. Supposing the conjecture regarding the extensive representation of the peculiar infra-Bijawurs to be correct, there would be four principal geological divisions to be discriminated and mapped, exclusive of all later granites, &c. *1st.* There would be the gneissoid granite, which would seem to be largely present, to be distinguished from true metamorphic gneiss. I should despair of settling this point without the extensive application of microscopical analysis of the rocks; indeed it remains to be seen whether even this test would furnish a criterion, whether the crystals of such a rock would not assimilate more to metamorphic than to fully igneous products. *2nd.* It is more than probable that associated with that granite we should find a most ancient gneissic formation long anterior to the metamorphism of the Rajgirs, and possibly equivalent to the gneiss of Bundelkund. *3rd.* We should probably find remnants of the Rajgirs in their gneissose form. On this point there is some information at hand: far within the great crystalline area, near the Grand Trunk Road north of Burhi, there is an inlier of typical Mahabur (Rajgir) schists. If they always remain so characteristic there will be no difficulty in recognising them. Even here they are attended by the encircling ring of variable quartzites, having high converging dips towards the schists, which occupy the lowest ground in the neighbourhood on the banks of the Barrakar. The quartzites form a narrow ridge round them, and would belong to our next division. *4th.* There would be the hypothetical infra-Bijawurs. The establishment of this series would probably relieve our field work of some perpetually outcropping difficulties, especially in the shape of isolated, discontinuous runs of quartzites and breccias. But apart from these more characteristic beds, I could not now assign a lithological criterion for this series generally: as has been seen they even simulate granitic masses. Great irregularity and discontinuity is one of their features; although frequently presenting excessive contortion, as if when caught between two resisting masses, they are generally comparatively little disturbed; and what disturbance they exhibit seems to be largely determined in direction by local circumstances, resulting in great irregularities of dip. In Bundelkund, where they were first detected, these beds seem to have but little extension; but in Bengal they seem to occupy large areas: I have observed rocks of this description in far distant localities of the great gneissic area.

January 1869.

* As a more recent parallel for such kind of deposits, I would refer to the felspathic beds of the lower Vindhyans as exposed in western Behar, to south-west of Kutumbeh.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1869. [August.

PRELIMINARY NOTES ON THE GEOLOGY OF KUTCH, WESTERN INDIA, resulting from the examination of that district, now in progress, by the Officers of the Geological Survey, by A. B. WYNNE, F. G. S., &c.

The detailed examination of this province has been long looked forward to with interest, as promising to cast light upon the geology of other parts of India where fossil land plants similar to some of those occurring in Kutch have been found to characterize an extensive group of rocks and are almost the only fossils which those rocks contain.

These plants were known to be associated in Kutch with a large number of marine fossils, the Jurassic age of which was determinable, but the relations between the beds containing forms so distinct had still to be ascertained.

With this view a hasty visit was made to the district of Kutch by Mr. W. T. Blanford of the Geological Survey, in 1863, and the conclusions to which his observations led appeared in a short paper among the publications of the Survey. (Vol. VI, pt. 1.)

Except this comparatively recent paper other sources of information regarding the geology of the country, prior to the present investigations, were almost limited to a paper by Captain, since Major, Grant, read before the Geological Society of London in February, 1837; some remarks upon it by Dr. Carter in "Geological Papers on Western India" published by the Bombay Government in 1857; a record of some fossils by Colonel Sykes (Geological Society, London), and an interesting notice in Sir Chas. Lyell's "Principles of Geology," describing the effects of the earthquake of 1819, the elevation of the "Allah Bund," and submergence of Sindree village on the Runn, north of Lukput.

Of these Captain Grant's paper is the most detailed, but while it contains many valuable facts, several of these seem to have been affected to distortion by geological theories, or views, which have vanished since he wrote, and also by a misappreciation of the stratigraphic arrangement of the rocks. The four or five-fold sub-division adopted by him, being natural, is correct, though the sequence was mistaken.

THE ROCKS CLASSIFIED.

The following may indicate the ultimate arrangement of the larger rock-groups, some of the newer ones being perhaps capable of further sub-division:

RECENT AND SUB-RECENT ...	{	Blown sand.
	{	Alluvium.
	{	Concrete.
TERTIARY	{	Tertiary beds and
	{	Nummulitic do.
	{	Sub-tertiary.
		Stratified traps and Intertrappean.
JURASSIC	{	Upper Jurassic (? Rajmahal.)
	{	Lower Jurassic ("Dogger," or Middle Jurassic.)
		Intrusive Traps.

[The syenite of Parkur-Nuggur, Kalinjur hill, &c., at the north-east corner of the Runn might be added to the above as the nearest base known for the Jurassic rocks.]

Of these the two Jurassic groups appear to have been transposed by Captain Grant under the names of "Older and Newer Secondary." The traps were looked upon as almost solely intrusive masses; their interstratification with aqueous beds being indicated at some places where association merely occurs, and at others where intrusion between stratified aqueous rocks takes place.

Locality and Features.

The province of Kutch lies upon the west coast of Hindustan, about 400 miles north-west of Bombay, between the sea-ports of Kurrachee and Surat, or the provinces of Kattywar and Sind.

It is bordered on one side by the Arabian Sea and Gulf of Kutch, while upon all others it is isolated from the main land and the Thurr or little desert, by the grand and smaller Runns which are connected at the eastern side of the province. Its length from east to west is much greater than its breadth,* and, including the Runn, its area is estimated as being equal to about half that of Ireland.†

The whole province presents numerous alternations of hilly ground and open plains, sandy when covered by the detritus of the rapidly decomposing Jurassic rocks, and more earthy when underlaid by the Tertiary formation, both passing, towards the southern coast, into broad alluvial plains of ordinary Indian aspect.

The hills are perhaps as often clusters as extended in the form of ranges, though these latter do occur; and more or less continuous escarpments rising with the outcrop of some of the stronger beds are very frequent. A broken chain passes nearly east and west through the Runn islands of Putchum, Khurreer and Béla to Chorar, (in the former being flanked by a smaller range):—another borders the Runn on the north side of Kutch Proper:—one, called the Charwar range, runs east and west to the southward of Bhooj, the capital of the province: and there are lesser ranges in other parts of the district, with many clusters and isolated hills frequently conical in form.

The hills of the Wagur or eastern side of the district, take no definite direction. They are the denuded remnants of what would have been a somewhat flattened and rolling dome shaped mass if their strata were continuous instead of having been extensively operated upon by denudation.

There are no lofty elevations in Kutch; that which is reputed to be the highest, namely, Dhenodur hill, overlooking the Runn on the western side of the province giving a measurement (by Aneroid) of but 1,070 feet above the Runn; several others, however, have elevations not greatly less.‡

Nearly all the ranges and many of the hills are steeply scarped on the north, and pass by gentle slopes into the plains to the south as a consequence of their structure, the beds in general having long southerly inclinations at low angles from three parallel lines of disturbance or dislocation which extend, 1st, from Putchum Isle to Chorar; 2nd, from Lukput, along the south edge of the Runn, to Doodye towards Wagur; and 3rd, from near Roha to the neighbourhood of Butchao, passing at the northern foot of the Charwar hills. North of these lines, and just in their vicinity, the beds are much contorted, their highest inclinations being always in a northerly direction.

The trap hills, particularly those formed of intrusive traps, are frequently surrounded by precipices, or else sharply peaked; an irregular range, however, formed of, or capped by, the bedded traps, running north-west from their broadest development in the Dora hills near the centre of the province out through its western half, follows the usual rule presenting long slopes upon the dip and steep ones along the outcrop of the beds.

The northern side of the province, generally speaking, has much diversity of form, being often picturesque, while, owing to the absence of jungle and prevalence of sand, its aspect is nevertheless barren; particularly when the view lies across a parched and glaring plain edged

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* According to Captain Grant the extreme length is about 180 miles, and extreme width 50.

† 'Kutch Selections,' a collection of papers by various British Officials, published by the Bombay Government.

‡ Since writing the above, the height of a mountain in the Runn island of Putchum has been taken by Aneroid and found to exceed by some hundreds of feet any elevation measured in Kutch Proper. Dhenodur hill is not a volcano—see paper by Mr. Blanford, above mentioned.

by rugged hills, beyond a bright green patch with a few lonely palms, or other trees, near some village where wheat is laboriously cultivated with the aid of irrigation, and smoky clouds of sandy dust, raised by passing cattle, are driven before the northerly blast, from which those working at the wells shelter themselves by screens.

The peculiar bare, level and extensive plain called the Runn of Kutch is not a marsh, as represented upon some maps. It is periodically covered by water during the rains, and left dry, except a few patches, shortly after they have ceased; when those lower portions on which the water has lain the longest become strongly incrusted with salt,—this frequently extending as far as the eye can reach:—its dazzling surface flickering in the mirage, which magnifies or distorts any object that may happen to be upon the horizon. The source of the salt is probably from sea water, this being said to overflow the Runn, entering by the low ground at the mouth of the Koree river near Lukput, and also at the head of the Gulf of Kutch, when the sea on the coast is raised by the continued south-westerly monsoon winds.* However this may be, the waters from Kutch itself are strongly impregnated with salt derived from the rocks, great quantities of which in solution must be carried out to the Runn whenever there is sufficient rain to fill the rivers.

Although the incrustation is not very thick, being generally from one to two and a half inches, the quantity occurring on the Runn is enormous, and the way in which fish, insects and such organic remains brought in by the sea or down from the land by the Bunass and other rivers are preserved by the salt is evidence of the strength of the solution, if that were wanting.

Notwithstanding that traces of marine denudation are slight and scarce along the southern shore of the Runn,—having been probably removed by subsequent atmospheric action—its whole aspect strongly suggests its being a gradually raised sea-bottom; a broad and slightly elevated tract called the Bunnee, lying along its southern side between Putchum Isle and Kutch Proper, being very possibly a bank or bar formed by the rivers which flow from the higher land in that direction. Over this tract coarse grass, a heathery looking tufted plant and Bâbul trees are irregularly distributed.

Some of the results of the great earthquake by which this country was visited in 1819 are still to be seen in the fallen walls of several of the towns, in the "Allah Bund,"† a low elevation, thrown up by it, which is said to have permanently arrested the southward flow of the water of the Koree or eastern mouth of the Indus, and in the submerged village of Sindree on its left bank; part of the ruins of the fort only being visible above the mud, salt and water by which they are now surrounded, no other trace of the village remaining, and the basements of the building seen being buried in the silt.

Tradition has it that this was formerly the site of a large city surrounded by villages and fields, and to which the tidal ebb and flow reached: subsequently (from elevation of the land probably) the river became so shoal that boats could not reach the port; the city was in a great measure abandoned, and another Sindree built several miles further down the river at a place called Sindu on the map. Here the same thing recurred, and Sindu was deserted, a new city rising at Lukput, once an important place, but now consisting of a few houses in one end of the walled in enclosure. At present boats cannot come even so far as this, and Lukput Bunder is at a distance of three or four miles, while the sea trade is conducted at Kotaisir close to the old mouth of the Koree river. How far the first part of this statement may be true is involved in considerable uncertainty, but it is said there are records in the *Duftter* at Bhooj which would prove the accuracy of some portions of it at all events.

Jurassic rocks.

The Jurassic rocks occupy a large portion of the northern half of the province extending through it almost from end to end, and also forming the hilly parts of the Runn islands before mentioned. The bold scarps and rugged hills exhibit numerous fine sections, showing plainly the structure of the country through which, notwithstanding repeated rolling undulations of the beds and some very marked anticlinal flexures, many recurring southerly and

* It does not appear to what extent this has been proved, though from the aspect of part of the coast, it seems likely to be the case.

† Mound of God.

south-westerly dips place the lowest beds along the north side of the district, except where a great fault coinciding with the northern foot of the Charwar range causes them to re-appear in its centre.

These lower Jurassic beds consist mainly of gray, blue, red and black shales, thick and thin light-coloured sandstones and hard silicious flags, with some more calcareous varieties, and in some places quantities of dun-colored and gray compact earthy or sandy limestone. Pale-purple sandstones and some highly ferruginous bands also occur, the whole presenting so many varieties of color and kind that its general lithological aspect is seen to differ from that of the uppermost Jurassic rocks, sufficiently to warrant an attempt at sub-division, only by regarding the group as a mass and leaving details aside. The passage from the lower beds to the upper is so gradual that no very definite boundary can be assigned between them. Still there is a difference at the extreme ends of the series which would at once prevent their being mistaken for each other, and which, it is supposed, led to their separation into two groups by Captain Grant.

Owing to the numerous faults, undulations and the general lowness of their dip, the thickness of this great series of Jurassic rocks is difficult to determine with accuracy, but it has been assumed, from observations in the part of the district lying eastward of Bhooj, to reach from 4,000 to 5,000 feet, of which measured sections of over 2,000 feet have been made in the lower portion of the group; and there is no reason to suppose its aggregate thickness to be less in the western side of the province. Throughout this large accumulation of strata there is a marked absence of regular zones, indicating successive stages of deposition, and while in such an assemblage of coarse sandstones and muddy shales with frequent conglomeritic beds much constancy of lateral extension might not be looked for, and marks of succeeding zones be probably obscure or absent, no want of material seems to have existed to supply new or similar layers for those which may have died out. The whole formation, particularly in its upper beds, maintains the same characteristics of obliquely laminated strata alternating with finer and more parallel deposits, all of richly varying tints, from black to white, blue, red, orange, brown and gray, and sometimes green with a peculiar golden oolite among the lower rocks which glistens like avanturine.

The lower beds on weathering take frequently a rusty color, and dull olive tints are common, while, where the beds are highly calcareous, a whole mountain formed of them with rounded outlines and a whitish hue in sunshine looks cool, and in cloudy weather as gray as any granite hill. Thick bands of a warm orange sandy limestone with some red beds occur also in the lower rocks, and many of their shales are gypseous.

The upper beds are marked by a predominance of clean white gravelly sandstone with some blackish ferruginous bands and white or lavender-gray, sometimes highly carbonaceous, shale. Between these and the lower beds alternations of almost every variety of rock in the formation occur, ranging through a vertical space equalling a third of the total thickness if not more. Many of the beds in both groups are strongly saline.

The lowest beds are much the most fossiliferous, and the remains are chiefly marine, including *Ammonites*, *Pleurotomaria*, *Ostrea*, *Trigonia*, *Cucullæa*, *Corbula*, *Gryphæa*, *Modiola*, *Terebratula*, and numbers of other bivalves, *Echinida*, *Crinoids*, *Corals*, *Belemnites*, fish teeth, reptilian bones, and fossil wood.

In one certain and one or two doubtful instances some of the upper beds of this lower and marine series were found to contain impressions of (terrestrial) *Zamiæ* in shaly bands interposed between the marine shell-bearing beds. During the examination of Eastern Kutch, the most exhaustive search that could be made failed to find any thing among the upper rocks except these *Zamiæ* and a few other terrestrial plants, but in the west, in a few cases, some marine fossils have been obtained from single beds occurring amongst unfossiliferous strata of the upper portion of the rocks, but still below the uppermost (white) beds seen.

This alternation or intercalation of the marine and freshwater beds (presuming those containing *Zamiæ* to be of purely freshwater deposition) being one of the points to which attention was specially directed, it is satisfactory to have so far ascertained the fact after many months of close search, even though such alternation appears to be much more limited than was supposed, unless it is taken for granted that the numerous fragmentary grass-like plant remains so common in the shales and flaggy sandstones throughout the formation are of freshwater deposition also. Many of these have been searched over and over again

without a trace of a *Zamia* leaf being found, and there seems to be no more reason for supposing them freshwater than some other beds in which ammonites occur lying among a mass of vegetable remains, the woody fibre of which is generally distinguishable, though often obliterated by carbonisation.

Such intimate association of the *Zamiæ* with marine forms has not, it is true, been discovered, but nevertheless it may not be unreasonable to suppose that these plants were floated out from land, and deposited by the sea at depths unsuited to the marine life of the period or at localities where this was from other causes absent. As Mr. Blanford has observed in the paper above mentioned, 'no sudden change in the rocks nor any unconformity has been found to mark the transition from a salt to a freshwater period;' and while it is evident that land plants may be carried out to sea, though marine organisms cannot so readily find their way into freshwater deposits, it is easier to believe that the whole of these salt Jurassic rocks are of marine origin than that repeated alternation of fresh and salt water beds takes place without any marked difference of character or aspect occurring in the rocks.

It may also be observed that though there are but few evidently marine beds, and these not immediately associated with Zamia-bearing rocks in the *upper* part of the Jurassics seen, still these *Zamia* beds contain plants only, no freshwater shells, fish, nor animal remains occurring to contest the possibility of the containing rocks being of marine or perhaps estuarine formation.

Great as is the thickness of the Jurassic beds, it is that only of a portion of the group the base of which is not visible, and the upper beds being unconformably overlapped by the Bedded Trap, they may continue to increase in quantity beneath the latter much further than they can be observed. There are, however, some appearances, along their uppermost boundary, which may be slight indications that the Jurassic period was drawing to a close, and that the deposition of rocks much resembling some of their upper beds ushered in the commencement of the succeeding unconformable tertiary group in those places at least where this succession was not interrupted by the accumulation of the intervening Bedded Trap.

Traps.

By far the largest part of the trap rocks is referrible beyond a doubt to the same period as the vast stratified accumulation known as the Deccan Traps. Some of the lowest flows are very thick, presenting few or no traces of bedding for more than 100 feet, but further up this is as plain as all the other appearances, such as beds of red bole, alternations of amygdaloidal and columnar basaltic flows, presence of zeolites, and so forth, which characterise the formation elsewhere. The trap is sometimes magnetic, and among its lower beds ashy sandstone or calcareous bands occasionally exist. In one place near its local base an interstratified bed of friable red sandstone 30 feet in thickness was observed, and in another a small lenticular deposit of intertrappean calcareous rock containing small fish scales.*

The flows or beds have a low steady southerly or south-westerly inclination, forming a wide hilly belt through the centre of more than the western half of the province, but their deposition does not seem to have extended to the place occupied by the eastern extremity of the district. The thickness of this formation is much less than usual, being estimated at about 2,500 feet.

An obscure group of earthy sandstones formed largely of trappean materials, often indistinctly bedded and containing woody plant impressions, occurs in several places, having but indefinite relations to the lower part of the Bedded Traps, but resting quite unconformably on the Jurassic rocks and often closely associated with masses of intrusive trap near which also white sandstone is often strongly columnar.

The intrusive traps—occur chiefly in the Jurassic area, and probably mark some of the places from which those just mentioned issued.

They consist generally of augitic or basaltic traps varying in color (different black and grayish hues), and in texture from a close compact rock to one coarsely crystalline, the crystals of glassy felspar being interlaced, and the deeply weathered soft light-colored surface taking

* Within the last few days information has been obtained of the discovery by Mr. Fedden of intertrappean beds, containing *Physa Prinsepii*, in the western extension of the trappean formation, furnishing still further proof of the identity of these with the Deccan Traps.

much the appearance of a syenite in similar condition. Fine muddy-looking or ashy trap, weathering to an olive-green minutely divided detritus, is another variety. Some of the dykes, &c., are of fine-grained purple colored trap, with white steatitic specks, a soft earthy or lava-like texture, are much less dense than the varieties abovementioned, and are sometimes salt to the taste.

With regard to the manner in which all these intrusive traps occur, nothing could well be more varied: dykes are particularly numerous in some localities; they also occur in faults, while local intrusions form hills projecting from the plains and Jurassic broken ground, like knots in decaying wood. In such cases, their outlines are either conical or combinations of this with steeply scarped forms. Some intrusions range through the country for many miles, presenting the most irregular lines both in plan and elevation, cutting across the aqueous strata, including large masses, intruded between them or forming hills either capped or underlaid by the Jurassic beds, or both one and the other, these being altered by the contact into various kinds of porcelainous or quartzitic rock, while one case occurs where a whole stream section of the aqueous rocks seems to pass by gradual intensity of alteration into solid trap in which planes resembling the original bedding can be traced for some distance as if the strata had been melted *in situ*, no marked difference of texture however existing in the trap, although the stratified rocks consist of alternations of calcareous sandy and thin shaly bands.*

Other instances occur in which sandstone seems to have been completely melted and taken up by these traps; the matrix having yielded first and the quartz fragments and grains gradually becoming more separated and disappearing until they are quite lost at a very short distance in the dark trap. This can be seen in hand specimens.

Generally speaking, these large intrusions have an intricacy of arrangement forming a tangle which defies all effort at accurate representation upon a map of small scale, and sometimes their basaltic trap is so magnetic as to deprive compass bearings taken from these points of any value, the variation being of inconstant amount.

Sub-tertiary group.†

As already stated, the Jurassics or Dogger beds of Kutch, consisting of a calcareous or sandy and shaly marine series below, passes upwards into alternations of more ferruginous and more purely argillaceous and arenaceous beds,—in which land fossils (Zamiæ, Ferns, &c.) are either rare or locally numerous,—these forming what are at present considered an upper member of the same group. At some period subsequent to the Jurassic, not clearly marked, but arguing from local as well as distant sources of information (in the Deccan and at Bombay), probably an early Tertiary one, the volcanic activity which produced the Bedded Traps came into operation. Observations here only show that traps were extensively intruded through the Jurassic rocks, and that other traps, very probably connected with these as centres of eruption, constitute a thick series resting with marked unconformity upon these Jurassic strata.

But overlying the Bedded Traps and, where these are absent, the rocks upon which they rest, is a marked band of most peculiar aspect, having, in contact with these traps, a very volcanic appearance, but one entirely different from theirs. Its predominant colors are deep red and pure white, but it is finely varied with purple, orange, greenish, brown and black or blue tints, even brighter and more strongly contrasted than those of the Jurassic beds. Its lowest stratum in junction with the uppermost of the trappean flows is a curiously mixed and mottled one, brecciated, concretionary on a large scale, in places containing small white quartz grains, but generally consisting of a pure chalk-white or variegated purple and lavender, unctuous, argillaceous, rock occasionally saline and speckled with white kaolin patches, giving it the appearance of an amygdaloid, sometimes to such a degree that it becomes undistinguishable from the purple trap found in several dykes among the Jurassic rocks.

* This passage as it were of stratified into intrusive amorphous rock is so very peculiar that it may perhaps be deceptive. A place where the alteration of the beds ceased laterally and the trap might be said to commence was sought for in vain, and the lines which may be, or at least simulate, original stratification apparently continuous with those of the unaltered bedded rock cease to be traceable beyond a few yards into the trap.

† The name Sub-Tertiary used here is only provisional. An examination of the fossils will probably cause it to be altered for another. It merely means that the beds are below the highly fossiliferous Nummulitic and other Tertiary beds though above the Bedded Traps the Intertrappean beds of which are believed to be of Lower Tertiary Age.

Along the line of junction with the underlying Bedded Traps their uppermost layer is very commonly a greenish amygdaloid, also more or less generally concretionary, rusty or decomposed looking; instances occurring in which the concretions of the mottled rock have been found to exhibit an apparent passage towards their centres from one variety to the other, the cores being formed of rusty amygdaloid quite similar to that beneath. In other cases the lowest stratum of the mottled series or uppermost one of the trap is a pale greenish earthy trappean looking rock, not quite so concretionary as usual, with much of the external character of the mottled breccia, but containing yellowish green steatitic amygdala. Where these sub-tertiary beds rest on the Jurassic rocks the peculiar brecciated white bed is seldom strongly developed, but still is frequently present.

This breccia passes upwards within greater or less distance, as the bed is thick or thin, into gnarled and ponderous laterite of various red, black, brown and purple tints, either brecciated or of the brick-like character so well known elsewhere.* Its junction with the white rock below often shows rough stalactitic looking masses of the laterite vertically penetrating the lower bed all along the line of contact as if infiltrated from above. In the same group are other bands of laterite and some very coarse obliquely laminated white quartzose and ferruginous sandstone containing much of the white earth distinguishing the lower layer. Associated with these, but not always upon the same horizon exactly, are dull purple, brown and black, in some places highly carbonaceous, gypseous or pyritous shales containing numerous impressions of large and small *exogenous* and *endogenous* leaves. These occur also in fine flaggy pale lavender or white beds of the same group, but of uncertain place.

Apparently among gypseous reddish shales of this group a thin band was found to contain *Fasciolaria, Arca, Nucula, Cyprina* and *Venus*, which are not, however, in such a state of preservation as to warrant more than an opinion at present that they may be of either cretaceous or eocene age, while some bones of large reptiles, including part of a skull, have been found in very similar shales and on what seems to be very nearly the same horizon.

Close above these some brown flaggy sandstones containing a few shark's teeth and shells and occasional beds of earthy orange mudstone begin to appear, and indicate the approach to others abounding in tertiary fossils.

The thickness of this group (the 'Red—? New Red-sandstone' of Grant) varies much, from a mere band consisting of a few beds or only one, to a maximum, in some places, of between two and three hundred feet. Until the fossils have been examined, it is obviously difficult to say how much of this group may be of Tertiary age, if indeed it be not entirely so. It forms a marked basement to that series however, and where it rests upon the Jurassics without the intervening trap, its junction very commonly appears quite conformable, the line, however, being almost impossible to see when the gypseous shales of the one group overlie those of the other.

Tertiary formation.

As the Tertiary rocks are still undergoing examination, they can be but slightly noticed here, although they form a large and important feature in the geology of Kutch.

Their principal development takes place in the southern half of the western side of the district, where they form wide rolling plains under which the beds undulate, wrapping round the western termination of the Jurassic and Trap formations, and appearing at intervals along the southern shore of the Runn, on the margin of at least one of its islands, and at a few spots in the eastern portion of the province.

They consist, as a mass, of rubbly shales interstratified with yellow mudstone bands, and thick beds of sand or sandstone. Occasionally the rocks become sufficiently calcareous to be called limestone, and most of those containing fossils are highly so—an agglomeration of shell-casts in an earthy or sandy calcareous matrix.

Among the lower beds *oysters* and *turritella* are particularly numerous, whole beds being formed of the latter, and a flat echinus (*clypeaster*), being very common.

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* At some localities in Eastern Kutch the laterite is associated with quantities of Agates both *in situ* and left in a thick layer by its weathering down, strongly recalling the appearance of some very similar ground similarly situated near the base of the tertiary rocks in Guzerat.

At a short distance above the base of the formation, on an average not more and often greatly less than 200 feet vertically, are soft and harder white calcareous beds crowded with *nummulites* and *fasciolites*, the former of several kinds, and associated with them are numerous *echini*, bivalves, &c.

The Nummulitic beds are generally nearly horizontal; they produce ground of singularly barren aspect, reminding one of the Egyptian desert, the white nummulites weathered out lying thickly upon the surface in place of soil, and from their abounding in that neighbourhood being called by the native Lukput paisa.

For several miles eastward of Lukput, along the edge of the Runn, these rocks are brought against the Jurassics by a fault, and having followed the low ground round the western limits of Kutch they disappear for a considerable space in the country north and north by east of Jackow, but set in again in the low lands further east.

In other parts of the low country, unoccupied by the Nummulitic group, highly fossiliferous tertiary rocks abound, containing a large number and great variety of genera, including *turritella, ostrea, conus, fusus, voluta, strombus, natica, trochus, oliva, cassis, cerithium, scalarium, cypræa, balanus, pecten; clypeaster, cidaris*, &c.:—of crustacea, some well preserved crabs, besides large bones and great molar teeth, and very many other interesting fossils, complete lists of which it is hoped will hereafter appear.

The thickness of these rocks is not yet sufficiently clear to be stated, but is considerable, probably exceeding 500 or from that to 800 feet.

It seems most likely that these Tertiary beds have been deposited in shallow water under shore conditions and subject to causes producing great irregularity of deposition. The occurrence of leaf beds in the group repeats the case of the Jurassic beds with regard to the alternation of fresh and salt water periods, and among the upper beds the predominance of sands almost devoid of organic remains indicates a different state of things from that under which the highly fossiliferous strata accumulated.

Post-Tertiary.

In several places a coarse concrete is found containing numerous fossil oysters, generally of large size. It appears to rest unconformably upon the Tertiary rocks, and may be an old member of the coast series or "littoral concrete" of Western India.

Other post-tertiary and superficial deposits, such as alluvium, blown sand, river concrete, and a rock much resembling the latter, found high upon the banks of many of the hills, have merely to be mentioned, their occurrence here being in all respects similar to that in other localities.

Coal is often mentioned as occurring in Kutch. Carbonaceous shales have been met with in several places both in the Jurassic and Tertiary rocks, but chiefly in the former, and these sometimes contain layers of bright coal. This is usually very thin, forming but small parts of the bands quite too limited in thickness and extent (so far as known) to repay the cost of working.

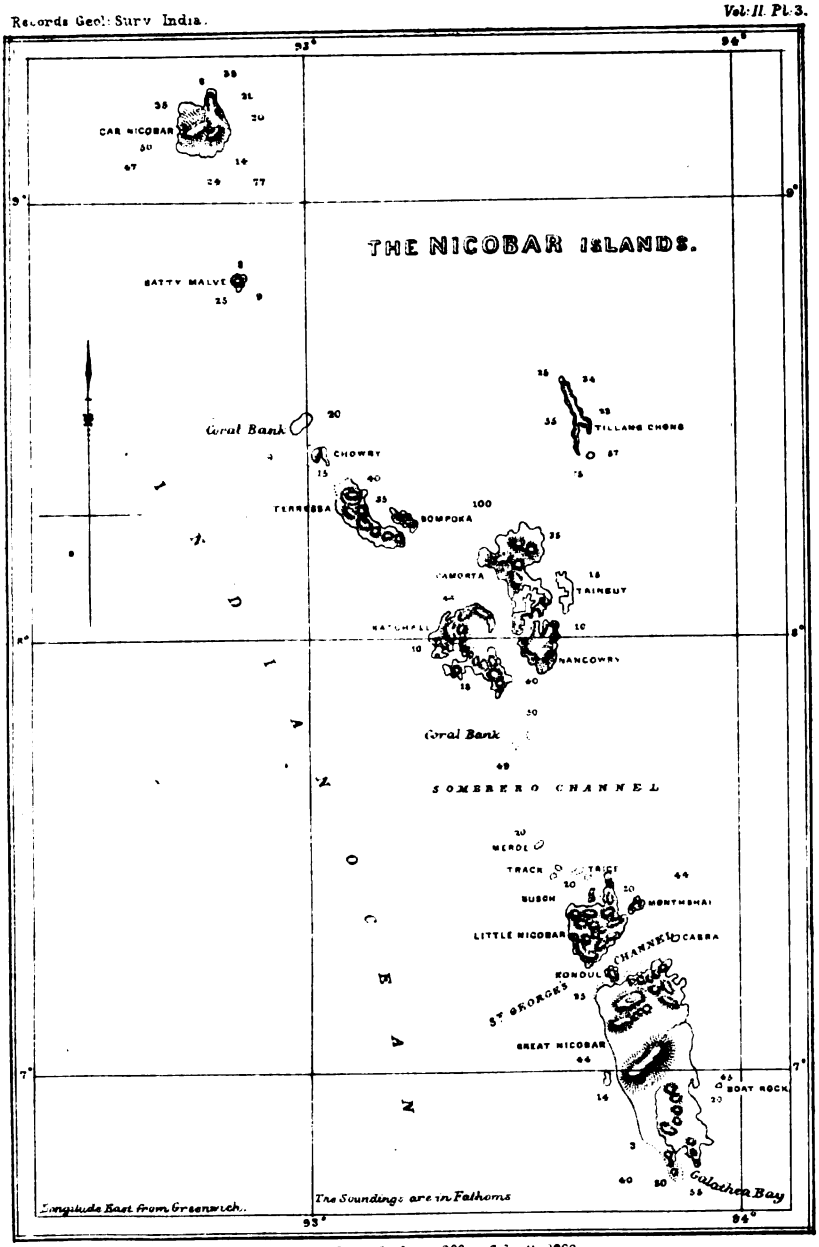
The largest layer, opened upon formerly at the village of Trombow, north-north-east of Bhooj, is now concealed by the workings having fallen in.

Alum is extracted in considerable quantities from the sub-tertiary shales of Western Kutch.

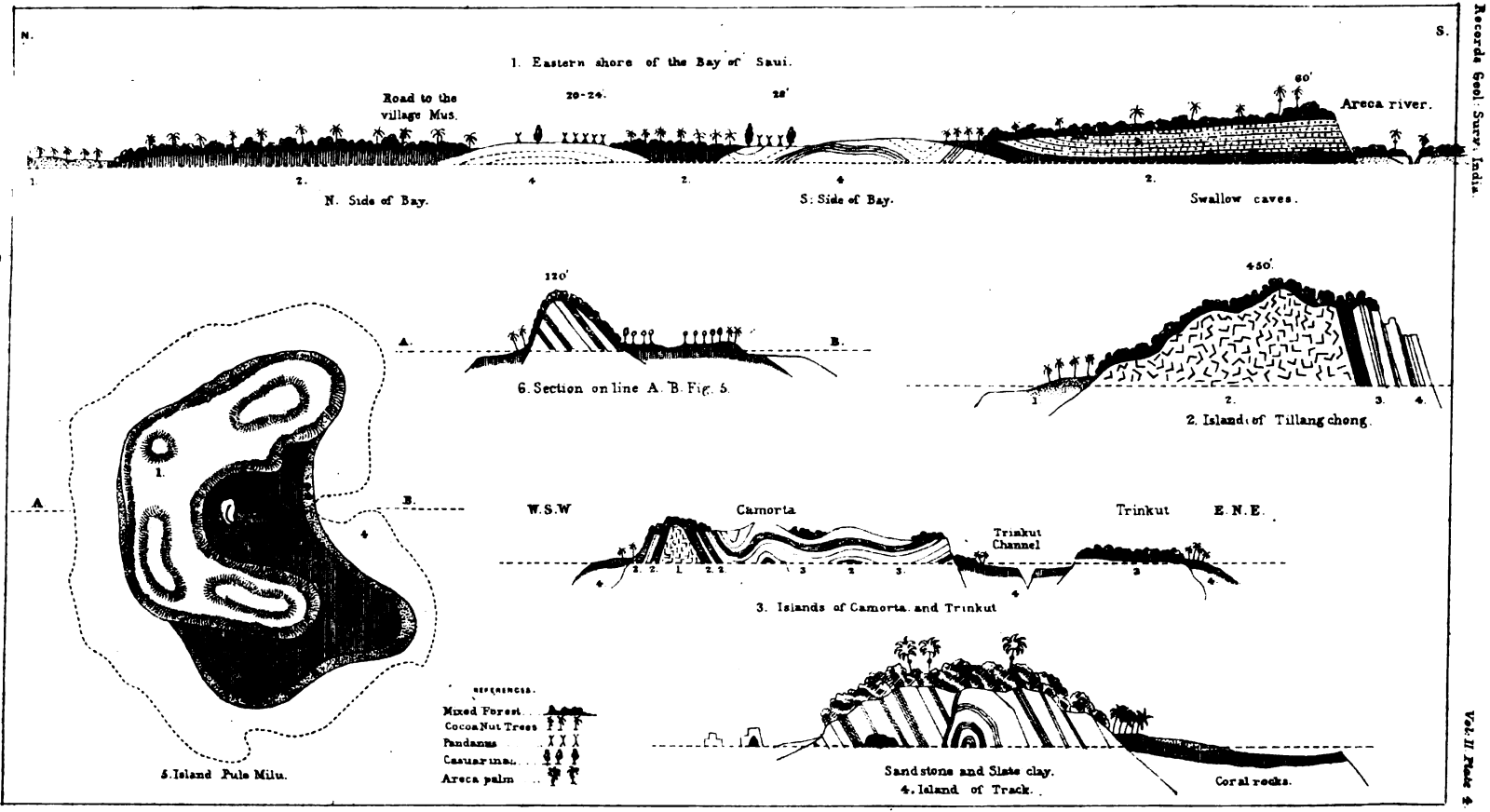
Iron used to be made in various parts of the province, but the manufacture has ceased in consequence of the facility with which Foreign iron can be obtained.

In conclusion, it remains only to be stated that several points of interest necessarily passed over in this hasty sketch have been reserved for subsequent consideration in the report to accompany the map, data for which are still being collected.

Amongst these are some facts tending to afford further proof of the association of aqueous deposits with the earliest beds of the Stratified Trap, and also indications that their highest flows or beds were not much older than the lowest Tertiary rocks, if indeed some of them were not contemporaneous.



Printed at the Geol Surv: Office, Calcutta, 1869.



Printed at the Geol. Surv. Office, Calcutta 1868

The occurrence here of the persistent and well-marked band of laterite and its associated white clay or steatitic breccia, passing conformably upwards into the Tertiary beds, and less regularly, but still with an appearance of transition, into some of the bedded traps below, though differing from certain of the facts observed in the country north-east of Surat, may possibly modify some of the conclusions with regard to the more obscure occurrence of the same three groups, *i. e.*, the bedded traps, lateritic beds, and Tertiary rocks of Guzerat, or may, at least, confirm the impression of the volcanic activity which produced the bedded traps dating from early Tertiary times.

If, in the absence of fossils, lithological similarity be admitted as evidence, it may be possible that some of the white felspathic sandstones, considered as Upper Jurassic, overlying the Zamia-beds of Kutch, may represent some of the frequently similar looking Mahadeva or Bâgh beds of Central India and the Nerbudda Valley.

The evidence for a Jurassic age comes chiefly from the lower part of the series, which is certainly marine so far, and the occurrence therein of a band of shale containing *Zamiæ* may bear the explanation before suggested, but at present the discussion of these points is almost premature.

April, 1869.

Much interest having been excited in the history of the Nicobar Islands, which have recently been taken possession of in the name of Her Majesty the Queen of England, I have thought it desirable to print here a brief summary of all that is known regarding their geological structure. This could most effectively be done, by giving a translation of the reports of Dr. F. v. Hochstetter, who accompanied the Austrian '*Novara*' expedition as geologist. Dr. Stoliczka, long a colleague and friend of Hochstetter's, has translated this report. The geological portion is given nearly at full. The part relating to the vegetation and its connection with the soils, however interesting to those who have never seen a tropical vegetation, contains little that would be new to residents in this country; and only a few extracts are given. A few remarks on springs and temperature conclude the paper.

The geology of the Nicobars has many points of the highest interest to the Indian geologist, as bearing on the structure of the adjoining Andamans, and the continuation of the same features into Burmah and northwards, on which connection some information will be given in future numbers. T. O.

CONTRIBUTIONS *to the* GEOLOGY AND PHYSICAL GEOGRAPHY OF THE NICOBAR ISLANDS, *by* DR. F. VON HOCHSTETTER, *(translated by* DR. F. STOLICZKA, *from the "Voyage of the Austrian Frigate* NOVARA *round the world in* 1857-1859." *Geological part, 2nd vol., pp.* 83-112. *Vienna*, 1866).

The Nicobar islands (Pl. 3.) belong to an area of elevation which can be traced from the Bay of Bengal far into the southern seas. Beginning under the 18th degree north latitude in the group of the Cheduba and Reguain islands on the coast of Arracan, passing through the Andamans and Nicobars, then continuing through Java, Sumatra, and the south-western group of the Sunda islands, this line of elevation bends in an oblique S-form through New Guinea, to the north of the Australian continent, and forms in New Ireland, the Solomon Islands, New Hebrides and New Zealand a curve, concave towards the west, the small group of the Macquarie islands being possibly considered as the extreme southern end of this curve. Winding from the northern into the southern hemisphere through 70 degrees of latitude, this line, or area, is characterized as one of elevation by two phenomena, totally different in their nature, but nevertheless equally grand, and in certain respects related to each other. These phenomena are, first, the activity of the interior of the earth, showing itself in the volcanic action; and secondly, the activity of the coralline animals, disclosing itself in the formation of that kind of coral reefs which Darwin has distinguished from the barrier or lagoon reefs under the name of fringing or coast reefs.

Both phenomena, the volcanic action with its elevatory power, and the formation of coast reefs, are, in certain respects, related to each other, as has been placed beyond a doubt by Darwin's observations, although both do not appear together along all parts of this area.

In the southern extra-tropical latitudes, where coralline life does not exist on that large scale, the volcanic action is the only marked one, and equally so in tropical latitudes to the north of the equator,—where that action is locally wanting,—the peculiar formation of coral reefs must be considered as the principal argument for the continuation of this line of elevation. This is the case at the Nicobar islands.

These islands occupy a gap without volcanoes, between the volcanic range of Sumatra, and the Barren and Narcondam islands, which lie to the east of the Andamans.

Whatever may be hidden in the interior of the Nicobar islands, covered with perfectly impenetrable primeval forests and grassy plains, the occurrence of younger volcanic rocks is the least probable. Although I have found on the north side of Car-Nicobar, the northernmost of the islands, two pieces of a porous basaltic rock, the size of a man's hand, in a coarse gravel in the forest near the village Mus, and a larger angular fragment in the coral sand on the strand near the village Saui, still there is more reason to believe that these fragments were transported to the coast of Car-Nicobar in the roots of stranded trees,* or even that they were remains from the travelling bags of the Danish naturalists of the Corvette *Galathea*,—who in 1846, shortly before they landed on Car-Nicobar, visited the volcanic Barren island,—than that they came from the interior of the island. I have in vain searched for similar pieces in the stream- and river-gravels of Car-Nicobar, and I have not met with them on any of the other islands on which we landed.

On the other hand, the Nicobar islands are distinctly characterized as a portion of the chain of oceanic elevations, which began in former geological periods and still continues, by the upheaved coral banks and by the continuous formation of coral reefs, which slowly, but in the course of hundreds and thousands of years perceptibly, enlarge the territory of the islands.

The Austral-Asiatic area of elevation, above indicated in its entire extent, has in the Nicobars a mean direction to north-20°-west or from south-south-east to north-north-west, possessing a length of 148 Engl. (=37 Ger. geogr.) miles, and a width of 16 Engl. (=4 geogr.) miles. This direction indicates at the same time the strike of the strata on all the islands, while the dip is either towards east or west. The synclinals and anticlinals in the geological structure of the islands are thus coincident with the direction of the great geological line of elevation which connects the northern point of Sumatra with the group of the Andaman islands.

The total area of all the islands is calculated to be 33 to 34 German (geogr.) square miles (equal to about 525—544 Engl.).

1.—*Geological Formations.*

To render properly intelligible the results which will be given in the following pages, I may be permitted to make a few preliminary remarks.

It is at present extremely difficult to make any detailed geological observations on the Nicobar islands. One is limited to the sea coast, as impenetrable forests and grassy plains make the interior of the islands perfectly inaccessible and hide the rocks. On the northern smaller island, this circumstance is of less importance, because the extent of the rocks through the whole island can easily be ascertained, as soon as it is possible to observe them on two opposite sides of the coast in the same stratigraphical relation. The case is different with the southern larger islands. Sambelong or Great Nicobar has an area of 17½ geographical square miles, and is larger than all the other islands put together; it offers in the mountain ranges (rising up to 2,000 feet), and deep valleys, such a variety in the configuration of the ground, that it is impossible to suppose that what is to be seen on one or the other point at the coast should be characteristic for the whole island. The mouths of rivers being generally occupied by mangrove swamps, it is even impossible to come to any conclusions from gravels as to the rock which is to be found in the interior. But even on the coast there are great obstacles to geological investigation. Wherever the inquiring eye of the geologist observes promising cliffs, there breakers make it generally impossible to land, and where landing can be effected, we usually meet only a flat coast.

* Chamisso mentions the transport of stones in the roots of stranded trees on the Radek group, and Darwin gives a similar example from the Kieling islands. (Darwin's natural history travels, part II, p. 242).

Thus one is limited in his observations to the few points, where during low water it becomes practicable to reach from the sandy shore some rocky promontory; and even under the best circumstances I was always restricted to that part of the coast on which the frigate anchored, for no amount of promises and offers could induce the natives to undertake longer trips with their canoes, neither was it possible to obtain a boat from the frigate at my disposal. I hope that other geologists, who may in future visit these islands, will be more successful in this respect.

My observations were therefore confined to the following places:—

1. *North-western coast of Car-Nicobar.*—A low precipitous coast accessible along its entire extent. Thick clay beds, with some more solid strata of sandstone, containing *Fucoids*, are on this coast overlaid by upheaved coral banks (coral conglomerate and coral sandstone); these are in some places still in direct communication with living coast reefs.

2. *Southern Bay of Car-Nicobar.*—Flat coral ground with fringing reefs, and at the breakers banks of a recent sandstone.

3. *Novara Bay on the west coast of Tillangchong.*—Precipitously rising cliffs of serpentine and gabbro conglomerate; at the breakers' coast reefs.

4. *Channel between Camorta and Nancowry, or the Nancowry Haven.*—A deep transverse cleft through yellow clay-marls containing magnesia, alternating with beds of serpentine and gabbro traps, and pierced through by serpentine and gabbro. A long stretching coral reef formation exists in the channel, but coral ground is very limited.

5. The small islands *Trice* and *Track*, north of *Little Nicobar*; precipitously upheaved; clayey sandstone beds with imbedded pieces of bituminous brown coal; coral and conglomerate banks and fringing reefs.

6. *Pulo Milu.*—A small island on the north side of Little Nicobar, consisting of strongly raised sandstone beds, with flat coral ground, fresh water alluvium, and fringing reefs round the whole island.

7. Island *Kondul* on the north side of *Great Nicobar.*—Sandstone, sandy slates, and beds of clay-marl alternating with each other, flat coral ground of very limited extent, fresh water alluvium, and fringing reefs.

8. *A small bay on the northern coast of Great Nicobar.*—Sandstone hills, salt-and brackish-water swamps.

9. *East side of the southern bay* (Galathea Bay) *of Great Nicobar*, in which flows the Galathea river; sandstone mountains; flat coral ground, coral and conglomerate formation at the level of the breakers, fringing reefs; pebbles of bituminous coal on the strand.

These places are, with the exception of Car-Nicobar, the same as were seen by the Danish geologist Dr. Rink, accompanying the expedition of the Danish Corvette *Galathea* in 1846, and were, beside many others in the Archipelago, visited by him during a stay of four months, described in a special work.*

As to scientific inquiry, I left the Nicobars quite unsatisfied in spite of the comparatively long time of one month which we spent in their waters; I know well how little my own observations increase the geological knowledge of the islands, for which we are indebted to Dr. Rink; for just the grandest objects, the islands *Terressa*, *Little* and *Great Nicobar* remained for me totally a *terra incognita*. But I am conscious to have done every thing that it was possible to do under the circumstances, and in this point of view the few observations I can offer must be criticised.

Car-Nicobar is a low island, the average height of which above the level of the sea amounts to about 45 feet; only two ridges, which may be from 180 to 200 feet high, rise in the interior above the forest covering nearly the whole island. The west, south, and east, coasts are flat and sandy, and the north-west and south-east monsoons accumulate upon them gradually higher and higher fragments of corals and shells, which pass over the fringing reefs surrounding the whole island. The south coast is in part swampy, only the northern or rather the north-western coast, forming the shore of the bay of Saui, is precipitous, allowing a view of the geological structure of the island; the section of this coast is given

* Die Nikobarischen Inseln, eine geographische Skizze, mit specieller Berücksichtigung der Geognosie, Kopenhagen, 1847 (The Nicobar islands, a geographical sketch with special reference to geology).

in the sketch Pl. 4. Fig. 1.—*Eastern shore of the Bay of Saui.* 1, Loose coral and shell-sand: 2, Dead coral-banks: 3, Indurated rock-beds of dead corals and shell-sand: 4, Plastic-clay with bands of sandstone.—

The eastern shore of the bay gradually rises from north towards south up to a height of about 60 feet, and includes two small lateral bays in which massive banks of a gray clay crop out below upheaved coral banks which form the projecting corners of the cliff. It is very characteristic that the boundary of the calcareous and clay strata on the surface of the coast terrace is at the same time a sharp limit of vegetation, inasmuch as on the clayey ground the *cocoa-palm* is replaced by *Pandanus*, *Casuarina* and grass, forming locally quite extensive grassy plains. The clay-deposits, without any distinct stratification, show a cubical cleavage. The prevailing color is light-gray, only single bands are darker colored, others are ferruginous, containing numerous clay-ironstone nodules. The clay is a little calcareous, effervescing with acids. In the southern lateral bay also appears between the clay beds a more solid stratum from two to three feet thick, and from its projecting part larger and smaller plates are broken off. On one of these plates I observed the impression of a large species of *Fucus (Chondrites Nikobarensis*, Hochst.) The strike of the strata is from south-south-east to north-north-west in both bays, the greatest thickness observable in the strata amounts to 20 or 30 feet. This clay deposit on the northern coast of Car-Nicobar is characterised as a marine formation by the numerous *Foraminifera* which it contains, but I did not succeed in finding any recognizable remains of *Mollusca*, except indistinct and badly preserved bivalves *(Pelecypoda)*.*

Farther towards the south, the clay beds again sink under the level of the sea, and in their place again appear coral banks, the precipitous coast becoming constantly higher, but at the same time gradually more inaccessible. On this coast the sea has washed out deep hollows, and the coral-banks are overlaid by massive banks of a white rock consisting of shell and coral sand, and being rather soft on the weathered surface. On the Areca river, in the innermost corner of the bay of Saui, the plateau of about 60 feet rapidly terminates with a fault, and the southern shore of the bay only exhibits a flat sandy strand richly overgrown with cocoa trees, being at the same time thickly populated. Judging from a few lumps in the gravel which I found on the northern as well as on the southern side, I conclude that there is somewhere in the interior of the island a gray fine-grained sandstone with little flakes of white mica and also a compact limestone *in situ*. The natives use the sandstone from the gravels as grinding stones.

Batty Malve is a small rocky island with precipitous shores all round. It rises on the south-eastern and eastern side in two terraces to about 150 feet. On the western and north-western side, it runs into a low flat cliff; judging from a distance of two or three nautical miles—we did not come nearer—the island is inaccessible. The extreme shore seemed to be covered with grass only, the interior was a low jungle, the crown of cocoa-palm being here and there visible at its margin. Only opposite Car-Nicobar can the island give an impression of a "relatively bare rock," as Steen Bille† says.—The rocks to be found on the island are most probably the same as those of Car-Nicobar.

Tillangchong, situated opposite Car-Nicobar, is a narrow mountainous island with precipitous cliffs, stretching from north-west towards south-east; it consists of two ragged mountain ranges separated by a depression of only 30 feet in depth. Where, on the south-east side, both ranges meet, a deep bay is formed, which during the north-west monsoon offers an excellent place for anchorage. The less precipitous south-western coast is accompanied by a few rocky cliffs, while the north-eastern coast is highly precipitous all along the shore. The highest hills are situated in the northern part of the island, apparently rising to an elevation of about 500 feet. Serpentine and gabbro form no doubt the great mass of the island.—Pl. 4, Fig. 2.—*South-east coast of Tillanchong.* 1, Coral-rocks; 2, Serpentine and Gabbro; 3, Breccia; 4, Sharply elevated rock-beds.—

In the small bay on the south-western coast, the Novara bay, in which the frigate was lying at anchor for a few hours, the irregular and cliffed-like shores are composed of common

* The description of the very well preserved *Foraminifera* from the above described clayey beds was undertaken by Dr. K. Schwager. His very valuable paper will be appended to this chapter of the Nicobar Islands, and for farther results I here refer to this paper.

† Captain Steen Bille was Commander of the Danish ship *Galathea*.—T. O.

serpentine, often traversed with veins of hornstone, and the same is the case with the thickly wooded mountain slopes, as far as could be observed in the small rocky beds of streams. The shore exhibited a very great variety in the color of the serpentine, jasper and hornstone pebbles: besides these, however, there were noticed also numerous pebbles of a dark green diallage rock, which must no doubt be *in situ* somewhere on the same coast at no great distance.

From the angular fragments of serpentine and other masses in the course of decomposition, a ferruginous breccia is formed at the foot of the hills, while in the breakers the serpentine gravels are being cemented by coral and shelly sand forming solid sandstone and conglomerate banks which recall the Verde-antique, (Ophicalcite). The plateau of the coast-reefs extends 2 to 300 feet from the precipitous shore into the sea. The whole of the island was covered with thick primeval forest which thrives well, even on the serpentine ground.

In passing along there were observed on the southern part of the island and on the eastern coast thin-bedded rocks with a high dip; these were in massive cliffs almost perpendicular in the south-eastern bay with a columnar structure; their true nature remained, however, unknown to me, for I was unfortunately obliged to use the telescope in place of the geological hammer.

Camorta, Trinkut, Nancowry with *Katchall* form the middle group of the Nicobar islands. Trinkut is situated in front of the eastern entrance of a channel between Camorta and Nancowry; it is a low island surrounded by coral reefs, and on its southern coast whitish-yellow argillaceous marls crop out. *Camorta* and *Nancowry* exhibit a greater variety of formation.—Pl. 4, Fig. 3.—*Sections of Camorta and Trinkut.* 1, Gabbro and Serpentine; 2, Breccia and tufa; 3, Clay marl with sandy beds; 4, Coral-rocks.—The channel between the two islands, the Nancowry haven, has numerous small bays and corresponds with a transverse cleft, while the Trinkut channel is a longitudinal cleft. The precipitous shores of the former offer, therefore, the most instructive geological section.

The narrow western entrance to the Nancowry channel is marked by two projecting rocks, which have been washed out by the force of the waves, making thus a natural gateway of rocks. Both cliffs rising almost perpendicularly to about 80 feet, are formed of a coarse breccia, composed of angular fragments of serpentine and gabbro* firmly cemented. I could not observe any stratification in this rock on the Camorta side; it is here in cliffs with large quadrangular blocks. On the Nancowry side, however, coarser bands alternate with finer tufa-like ones, with a strike from south-south-east to north-north-west and dipping about 85 degrees towards west. On the Camorta side, there crop out at two places below heaps of masses of rocks, which Rink very properly regarded as friction-breccias, cliffs of a more or less serpentine or gabbro-like massive rock.

Among the pebbles on the strand, I also met with numerous fragments of a reddish-brown rock traversed by white calcite veins, the rock which Rink called Eurite.

These phenomena at the western entrance to the Nancowry-haven are thus perfectly identical with those which Rink has observed at the entrance of the Ulala bay, situated only a few miles to the north; they are represented (l. c. p. 68) by Rink in a section. Further to the north the mostly bare hills on the west coast of Camorta, recalling by their external shape conical volcanic forms, attain a height of from 4 to 500 feet; they no doubt indicate the further extension of the serpentine and gabbro-rocks, which on Camorta and Nancowry are traversed from south-south-east to north-north-west by a longitudinal cleft.

In the interior of the Nancowry haven, wherever the rocks are exposed on the projecting angles, they appear to be well-bedded, whitish-yellow, clayey marls, alternating with banks of a fine-grained sandstone, with serpentine and gabbro tufas.

Most instructive in this respect is the precipitous south-eastern corner of Camorta at which the coast line bends into the Trinkut channel. The argillaceous marl formation is here well exposed in cliffs of from 30 to 80 feet high. On the southern side of the corner the transverse section of the strata can be observed, dipping at 25° to 30° towards west, while on the eastern side, parallel to the longitudinal break, the beds crop out horizontally one above the other. The argillaceous marl does not contain fossils, is of a yellowish white color,

* Gabbro is a rock composed of diallage, smaragdite or hypersthene with labradorite or saussurite, and often some other minerals in an irregular mixture.

and on the perpendicular walls it was covered with inch-long, white, very thin, crystals of a silky lustre. The examination of these showed them to be sulphate of magnesia. The clay itself contains, according to Rink's analysis, besides silicate of alumina, iron-oxide and magnesia.

The whitish-yellow clay marls of Camorta and Nancowry being entirely free of lime have become famous since Professor Ehrenberg (Berl. Akad. Monatsberichte 1850, p. 476), by an examination of the samples brought by Dr. Rink, has shown that they are true *Polycistina*-marls, like those of the Barbados. Ehrenberg discovered in 1848 about 300 species, which were by Professor Forbes believed to belong to miocene (tertiary) deposits. Ehrenberg says: "Especially well developed is this material on Camorta, where, near Frederickshaven, a hill 300 feet high is covered all over with variegated *Polycistina*-clay, while the Mongkata hills on the eastern side of the island are according to Rink entirely composed of a whitish-clay resembling meerschaum; this is, according to my analysis, a nearly pure agglomerate of beautiful *Polycistina* and their fragments, beside numerous *Spongiolites*."* The species of *Polycistina* on the Nicobars are, according to Ehrenberg, the same which compose the similar marl on the Barbados, situated in nearly the same latitude; but there are also some new forms.

Near the level of the sea, the clay marls, which locally contain angular fragments of serpentine and gabbro, alternate with more solid strata of a psephitic rock, which is composed of strongly-cemented angular fragments of serpentine and gabbro, and can therefore be best designated as gabbro-tufa. It is remarkable that this rock again includes larger and smaller pieces of the clay marl. On the eastern coast, near the village Inaka (Enaca) a reddish micaceous sandstone appears between the clay marls.

Similar are the geological conditions on the northern coast of Nancowry. Between the villages Inúang and Malacca, the whitish-yellow clay marls crop out in slightly inclined strata; between Malacca and Injáong, however, lies a precipitous cliff, on which these strata rise almost perpendicular, and are gradually replaced by an accumulation of fragments of serpentine and gabbro. At the projecting corner itself, the traveller faces a precipitous cliff of about 60 feet in height, but being cracked and decomposed, the true nature of the rock is recognised with difficulty. On a fresh fracture, however, one soon observes a massive diallage rock, the laminar diallage being clearly traceable in the nearly solid mass of felspar. Narrow veins of quartz pass through the rock.

From here up to the village Injáong the strand is again flatter, and nowhere nearer than on the other side of the village high, dark-colored, rocks are a second time visible, indicating a massive rock. These are the two places which Rink also has marked on his maps as plutonic rocks.

Trice and Track.—On the north-western point of the small island Trice, highly upheaved banks of a fine-grained argillaceous sandstone of a greenish-grey color form a low precipitous shore. The same stratified rocks alternate with thin-bedded sandy slates, showing on the south-eastern coast margin of the small island Track, only a few cables length distant, the accompanying section. Pl. 4, Fig. 4. Besides a fault, the strata form a saddle and strike from south-south-east to north-north-west. In a sandstone bank I found here imbedded a rolled fragment of a bituminous coal, the same of which I met with a larger but equally rolled fragment on the strand of the island Trice. Of coal seams there was, however, no trace to be detected; what might be mistaken for them from a distance was only the shadow of softer sandstone banks deeply weathered out, or the darker color of some strata.

Pulo Milu.—A small island on the northern coast of Little Nicobar, which Dr. Rink has so excellently described in all its peculiarities, consists, in the higher parts, of a grey, fine-grained, micaceous and calcareous sandstone in massive banks. Very often spheroidal concretions are to be observed showing on the soft weathered surface like cannon balls. No trace of fossils could be found. The massive banks have thin-bedded sandy slates interstratified. The strata strike from south-south-east to north-north-west, dipping to east at an angle of 45 degrees. Dr. Rink (loc. cit, p. 50) mentions a fossil resin in the sandstone of Milu.

* The result of examination of a Nancowry specimen is figured on Plate XXXVI of Ehrenberg's 'Mikrogeologie.'

Pulo Milu was particularly instructive for me, because the dependence of the vegetation on the soil and its geological basis could be perfectly well recognised. The vegetation and the geological formation of the ground stand in the closest relation to each other, as clearly shown by the accompanying sketch plan. The sandstone hills are covered with jungle; the coral (calcareous) ground with high forest trees; the saline, calcareous, sandy ground is occupied by cocoa-palms, and in the fresh water swamp on the declivity of the hill range, which resembles in its curve a horse shoe, thrives the finest forest of *Pandanus* which we have seen on the Nicobar Islands.—Pl. 4, Fig. 5. *Plan of the island of Pulo Milu.* 1, Sandstone with bushy forest; 2, Coral conglomerate, with high tree forest; 3, Coral and shell sand, with forest of cocoa-nut trees; 4, Coast reefs; 5, Fresh water alluvium, with forest of *Pandanus*. Pl. 4, Fig. 6, *Section of same island on line A. B. Fig.* 5.

We have not visited the coast of Little Nicobar, the mountains of which rise to 1,000 feet elevation above the sea.

Kondul—between Little and Great Nicobar,—consists of a hilly ridge, 1½ nautical miles long and ½ mile broad; its strata strike north-north-west., and dip at 70° towards east. The western side is the precipitous one. The strata represent an alternation of more or less sandy or clayey beds. The sandstone predominates, yellowish-white, with ferruginous reddish-brown particles. The clayey beds partly consist of a greasy plastic clay, partly of a crumbling yellowish clay marl, with intercalated thin-bedded sandy slates. The only organic remains which I found were indistinct traces of *Algæ* and small rolled fragments of coal.

Great Nicobar.—What shall I report of Great Nicobar? With the exception of some sandstone hills on the northern coast, and the sandstone ranges on the eastern side of the Galathea Bay in the south, I have not seen anything. Great Nicobar, with its mountains rising up to 2,000 feet, is geologically quite a *terra incognita*.

A very remarkable earthquake, which is said to have lasted from the 31st of October to the 5th December, 1847, on the Nicobar Islands, at which time also earthquakes occurred in the middle and western part of Java, is described from the *Penang Gazette* in *Junghuhn's Java* (part II, p. 940). On this occasion fire is said to have been seen on one of the mountains of Great Nicobar.

Can the highest mountain of Great Nicobar be a volcano? Its form is that of a volcano, but as Junghuhn says that one could land on the southern coast of Java, wander about many days among sandstone and slate rocks, without obtaining through any of the phenomena even a trace of the stupendous volcanic nature of Java; in the same way there may be in the interior of Great Nicobar, rock-formations hidden, of which one does not get an idea along the coast. However, I do not attach any importance to the rumour that fire has been seen on Great Nicobar, though the description of the earthquake seems trustworthy, as I had myself occasion to observe on Kondul the mountain-slips referred to in the account.

These few observations, combined with those of Dr. Rink, give us the following, though probably still very imperfect, idea of the geological nature of the Nicobar Islands.

Among the various geological formations on the Nicobar Islands, *three* are the most important:—1, *An eruptive serpentine and gabbro formation;* 2, *Marine deposits, probably of a younger tertiary age, consisting of sandstone, slates, clay marls and plastic clay;* 3, *Recent coral reef formations.*

The serpentine and gabbro formation of the Nicobars is characteristically of an eruptive nature. The tertiary sandstones, slates and clay-marls appear forcibly broken through; their strata are partly inclined, partly bent in flat, parallel, wave-like, undulations. These rocks are accompanied by coarser and finer breccias composed of angular fragments of these same rocks, and they can partly be regarded as friction-breccias, partly as sedimentary tufas in which beds of an argillaceous marl are interstratified. The eruption of these plutonic masses appears, therefore, to fall in a time when the formation of the marine deposits was partially completed, partially still in progress. They broke through, on lines of fracture of which the principal strike from south-south-east to north-north-west agrees with the longitudinal extension of the islands. On the middle islands, the serpentine and gabbro attain their greatest development; on Tillangchong, Terressa, Bompoka, Camorta and Nancowry they form bare hill-ranges of from 2,500 feet elevation, and their configuration often marvellously

resembles those of younger volcanic formations. The elevatory power has, however, acted most strongly on the southern islands, and has here upheaved sandstones and slates probably to heights of 1,500 to 2,000 feet above the level of the sea; on the low northern islands the same power was, on the contrary, weakest.

With regard to the sedimentary deposits, I may state that Rink called the argillaceous deposits of the northern islands "older alluvium," and the sandstones and slates of the southern islands "brown-coal formation." In separating them from each other, he considers the former as being derived from plutonic rocks through chemical and mechanical decomposition, and as only of a local character. According to this the archipelago of the Nicobars is divided by him into two geologically different groups,—an opinion with which I cannot agree.

The clays and clay-marl formations of the northern islands, Car-Nicobar, Teressa, Bompoka, Camorta, Trinkut, Nancowry, and the sandstones and slates of the southern islands, Katchall, Little and Great Nicobar, appear to be only petrographically different products of one and the same period of deposition. There are at the same time very few materials from which the age of the marine formations could be determined, as the only fossil remains which have been found in their strata are fragments of *drift wood* changed to brown coal, plant impressions resembling *Fucoids, Foraminifera and Polycistinæ*. But all these remains indicate more or less distinctly a young tertiary age.

The same conclusions are derived from a comparison with the geological conditions of those islands which lie on the same line of elevation as the Nicobars; I refer especially to Sumatra and Java.

I have not the least doubt that the clay-marl and sandstone formation has its perfect analogue among the tertiary deposits of Java, which I had myself the opportunity of studying and comparing in their distribution and lithological character. These became first known through the late Fr. Junghuhn, whose researches on the physical geography of Java are of such merit.

According to Junghuhn, one-fifth of the surface ground of Java is alluvial soil. This is especially prevalent on the northern side of the island, extending from the coast inwards either one, or sometimes five to ten English miles; one-fifth of the island consists of volcanic cones, and their immediate vicinity where the lower rocks are covered up by volcanic products. These conical hills chiefly occupy the interior of the island, sometimes in a double range stretching from west to east; while three-fifths of the area are occupied by tertiary rocks. Either in flat protuberances or in clod-like elevations, these tertiary rocks surround the volcanic range always on two sides, on the southern as well as on the northern. On the northern side, the less highly upheaved tertiary strata underlie the alluvium, and therefore occupy on the surface a small area. In an unequally greater degree, the tertiary deposits are developed on the southern side of the volcano, both as regards height and horizontal extent. They are mostly visible split in clods (schollen) which always rise higher towards one side,—the north, or towards the volcanoes,—and are at their highest edge upheaved to 2, 3 and even to 4 thousand feet. It is also principally on the southern side that plutonic rocks occur in the neptunian deposits of Java, which are occasionally only represented by narrow and sharply defined veins, without any influence upon the structure and configuration of the surface; sometimes, however, they form small hill ranges or isolated hills, similar to the serpentines and gabbros of the Nicobar islands.

According to the reports of the Dutch Mining Engineer, Huguenin,* a repetition of the geological formations of the Nicobars appears to be met with in the Tjiletuk Bay (the southern lateral bay of the Wynkoop Bay on the southern coast of Java). The prevalent formations here are sandstone-conglomerate and highly developed greenstone-breccias, besides plutonic rocks of the greenstone group. From specimens which I had an opportunity of seeing in the local collection at Beutenzorg, I found that these plutonic rocks are serpentines, gabbros and aphanites, exactly similar to those of the Nicobars. Equally identical appears to be the chalk-white clay-marl in the middle portion of Bantan, and the fine white marls in the southern portion of Tjidamar, mentioned by Junghuhn (loc. cit., p. 13), with those occurring on the Nicobar islands.

* Naturkundige Tijdschrift voor Nederlandisch Indie, Theil XII, p. 110, 1856.

At the time of my stay in Java (1858), and from all I could find described, as well as from my own observation, I came to the conclusion that in the tertiary deposits of Java two principal groups can be distinguished, setting aside the limestone formation, the proper place of which in the system of Javanese deposits is as yet doubtful:* 1. *A lower coal-bearing group:* numerous workable seams of brown coal are imbedded in quartzose non-calcareous sandstone and slate-clay with silicified stems of trees; marine shells are very rare, or absent. To this I referred the coal seams discovered by Junghuhn in the south-western part of Java, as also the coal formation on the Kapuas river in West Borneo, and the extensive coal districts in Southern and Eastern Borneo, finally the coal of Benkulen (Bencoolen) on Sumatra, and numerous other similar deposits scattered over the Indian Archipelago. 2. *An upper group without coal:* a clay and sandstone formation with plastic clay-slates, argillaceous marls, calcareous sandstone, trachytic tufas, breccias and conglomerates, rich in marine shells, fossil plants, fossil resin, but merely with nests of coal in place of coal seams.

Reasons, which I have given elsewhere,† have induced me to regard this complex group of strata as probably of Eocene age. This opinion may even now stand as regards the lower group, while as regards the upper group, I gladly accept the opinion of my friend Baron v. Richthofen, and the conclusions derived by H. M. Jenkins,‡ from which these fossiliferous deposits appear to be younger Miocene.

I suspect that to this upper Miocene group correspond the tertiary deposits of the Nicobars, although fossils confirming this suggestion have yet to be discovered. It is also beyond doubt that these deposits are not wanting on Sumatra, in certain respects a connecting link between Java and the Nicobars. Junghuhn (loc. cit., p. 8) justly remarks: "The tertiary formation appears to have a sub-marine extent over the whole of the Indian Archipelago, because wherever within this Archipelago the earth's surface rises above the level of the sea, this neptunian formation is observable. I know this for certain as regards Northern Sumatra, where the tertiaries are especially found in the Batta districts (Batta ländern). With the exception of the trachytic island Dungus Nasi all the islands in the Bay of Tapanuli (situated exactly in the prolongation of the Nicobars), besides the adjoining low shores of Sumatra, and partially also the mountains near Tuka, are composed of more or less upheaved sandstone strata, containing, though sometimes rarely, tertiary shells." Thus it appears to be principally on the southern coast of Java and the south-west coast of Sumatra that we find a repetition of the geological conditions of the Nicobars.

The commencement of the eruptive formation is in Java inaugurated by serpentine, gabbro, massive rocks resembling diorite (greenstone trachytes as in Hungary); more or less typical trachytic rocks follow, and the grand volcanic eruption extending up to the present time from the termination of the enormous eruptive phenomena in the Indian Archipelago. At the same time it appears that the eruptive line has been shifted slowly, on Java from south to north, and on Sumatra from south-west to north-east, so that this line would strike east as regards the Nicobar group in the same longitude in which east of the Andamans it reappears on the volcanic Barren Island and Narcondam.

The young tertiary age of the serpentine and gabbro eruptions on the Nicobars and Java has its perfect analogue in the eruptions of the same rocks in Central Italy, which, according to Signor Perazzi, in Turin, and Prof. Savi, are partly Eocene, partly Miocene, and which, on account of their copper ores, are of importance to the miner.

The third principal formation of the Nicobars are coral formations, belonging to the most recent or the present period. Coral banks of great thickness are found on Car-Nicobar, Bompoka and several other islands; they consist partly of a compact coral limestone, partly of a coral or shell conglomerate, upheaved up to 30 and 40 feet above the present level of the sea; on all the islands, the original area is to be observed enlarged by coral-land, which is only separated by the higher sand dunes along the shore, from the still continuing formation of the coral reefs surrounding all the islands in the character of fringing reefs. Although these raised coral banks are a decided evidence, in favor of the long continued

* According to Junghuhn this limestone is the youngest of all the formations, and is always to be found only in superficial banks.

† Reports on the doings of the mining engineers in Netherlands India (Jahrbuch der k. k. geol. Reichsanstalt, Wien, 1858, p. 277).

‡ Quart. Jour. Geol. Soc., London, Feb., 1864.—F. Baron v. Richthofen, Zeitschrift der deutschen geol. Gesellschaft. Bd. 14, p. 327.

upheaval of the islands,—that in connection with the eruption of the serpentines and gabbros,—the formation of the flat coral-land elevated only a few feet above the level of the sea can, on the other hand, be explained by the accumulation of coral fragments, of sand and shells by the waves and breakers on the shallow surface of the fringing reefs. A detailed description of the peculiarities of the Nicobar coral reefs and of the formation of the low coral-land has been already given by Rink. (loc. cit., p. 88, &c.).

II.—*On the occurrence of coal and other useful rocks and minerals on the Nicobar Islands.*

The question regarding coal was the principal point of inquiry during the first expedition to the Nicobars, which was undertaken in 1845 by the Danish Consul *Mackey* of Calcutta, the Englishman *Lewis* and the two Danes *Busch* and *Löwert*.

The solution of this question was a second time the problem undertaken by Dr. Rink, as geologist with the royal Danish Corvette "Galathea." The order of the day No. 5, which contained the instructions and directions for the survey and exploration of the Nicobar islands on the part of the scientific expedition of His Majesty's Frigate "Novara," made the reply to this question my duty also.* The facts on this point are as follows:—

The results of the first expedition were confined to the discovery of single pieces of coal on the strand of the southern islands. Dr. Rink found several localities of coal on different places of Little Nicobar, Trice, Milu and Kondul. "These localities at which coal occurred proved, however, everywhere to be isolated masses varying from one to two inches in thickness." The incorrect (as already stated) designation of "brown coal formation" for the sandstones and slates of the southern island might have been the cause of misunderstanding; but Rink himself (loc. cit., p. 53) expressed his results thus:—"There appears nothing found on the Nicobar islands which would correspond with the coal formations of South-Eastern Asia. The coal localities were met with here and there without any order either in sandstone or in slate, and appear to me therefore to be derived from driftwood which was deposited with the clay and sand. I nowhere found anything which could indicate an accumulation of plants in basin-like depressions, in which the plant would be growing *in situ* and through which the surrounding masses of clay would be impregnated with organic ingredients and mixed with portions of plants. The question, therefore, still remains pending whether those brown coals occur in considerable quantity, as the quantity and size of the collected pebbles would seem to indicate."

I also did not succeed farther than finding single fragments of brown coal. The first fragments were met with on the strand of the small island Trice; it was a brown coal with conchoidal fracture, but still with distinct structure of the wood. The pieces were all rolled, and the largest—5-inches long, 4-inches broad and 2-inches thick—was bored by *Pholadidæ*. I do not doubt that these pieces were derived from the beds of the sandstone or slate of Trice; but on the opposite island Track, I was fortunate to knock out of the sandstone, *in situ*, a small fragment of coal also rolled. Exactly in the same way I also found small fragments of brown coal on Kondul and on the south side of Great Nicobar, partly on the strand, partly on the sandstone or slate rock, and it is certain that these pieces occur all through the group of islands. The condition of all the brown coal fragments met with tends to show that they were only singly imbedded driftwood pieces, which were changed to coal, not that they belonged to large coal seams through the destruction of which they have come into younger strata. Only on the strand of Pulo Milu have I obtained pebbles of true coal with laminated structure, such as is only to be found in seams. It is, however, much more probable that these pieces of coal came from the steamer "Ganges" accompanying the "Galathea" in 1846, and stopping for some time about Pulo Milu, than that they were derived from coal seams on the Nicobars. I therefore entirely agree with Rink's opinion, that so far as it is possible to make observations nothing speaks in favor of the existence of true coal basins on the Nicobars, and that the occurrence of workable coal is not probable. However the area of Great and Little Nicobar is large enough to hide under the thick primeval forest formations of which no trace

* This instruction runs:—According to the report of the naturalists of the Danish expedition, coal and probably also precious metals occur. As far as this may be verified, samples in sufficient quantity ought to be taken: equally so in case of metals being found. In general it is however to be reported, as regards geological conditions, how far conclusions can be drawn from the existing rocks as to the occurrence of useful minerals, &c. Of the rivers and springs, the temperature should be measured, &c., &c.

may be observed along the coast. Until the interior of these islands has been examined, the question regarding coal on the Nicobars cannot be answered in any other way than it was by the first expedition.

Equally unfavorable must be the opinion regarding the occurrence of ores or other useful minerals. Nothing of the kind has yet been found on the Nicobars. Gold and useful minerals are partially rich on islands and along coasts which, viewed geologically, belong to the same area of elevation as the Nicobars, as I have already pointed out. The natives who long ago observed those fragments of coal, who use glass pearls, silver fragments, &c., as ornaments, who know the plants and animals of their islands pretty well, and who have for all more common phenomena, for all useful products of the animal and vegetable kingdom special names, these inhabitants have as yet found among the rocks of their islands nothing that they would be able to make use of for ornament or other useful purposes. The only traces of ore which I found were those of iron pyrites and copper pyrites, finely disseminated through dioritic and serpentine-like rocks. The possibility of the occurrence of copper ores in the eruptive formation cannot be denied; however, no discovery has as yet been made which would indicate it. On the other hand, the islands are rich in useful building materials. The sandstones of the southern island must give excellent working stones; the plastic clays of the northern islands could no doubt be equally well worked into bricks or into pottery; the natives of Chowry make large pots of it. Finally lime is offered by the coral reefs in inexhaustible quantity along the coasts of all the islands.

III.—*The soil and its vegetation.*

[Only brief extracts of this section are given.]

Dr. Hochstetter states that vegetation in its original state always indicates the character of the soil, provided the atmospheric conditions are the same. This is, however, on the Nicobars, highly the case. 'Neither the difference in the latitude from the most northern to the most southern islands (2½ degrees), nor the difference of the absolute elevation (the highest hills on Great Nicobar only attain about 2,000 feet above the sea), is large enough to produce on the single islands, or parts of them, such a difference in the climatal conditions, that on it alone an altered character of vegetation should depend. Rocks, soil and vegetation are, therefore, on the Nicobars in such a degree related to each other, that the areas marked on a map as indicating various rocks would almost coincide with those indicating the varieties of vegetation. Unfortunately the sketching out of such maps for the larger inaccessible islands is impossible; to indicate it I can only attempt a representation of the small island Milu (Pl. 4, Fig 5.) and the north-western bay of Little Nicobar.'

'The results of these observations may be seen in the following tabular view:—

Geological character of the underlying rock.	Character of soil.	Respective character of vegetation.
1. Salt and brackish swamp, damp marine alluvium.	Swampy ground not capable of cultivation.	Mangrove-forest.
2. Coral conglomerate and coral sand, dry marine alluvium.	Fertile calcareous soil; principal constituents, carbonate and phosphate of lime.	Cocoa-palm forest.
3. Coral conglomerate and coral sand beside dry freshwater alluvium.	Fertile calcareous sandy soil.	Large forest trees.
4. Freshwater swamp and damp freshwater alluvium.	Swampy ground, capable of being cultivated.	Pandanus forest.
5. Plastic clay, magnesian clay, marls and partially serpentine.	Not fertile clayey soil; principal constituents, silicate of alumina and silicate of magnesia.	Grassy plains.
6. Sandstone, slate, gabbro, dry river alluvium.	Loose clayey, sandy soil, rich in alkalies and lime, very fertile.	Jungle (the true primeval forest).

'*The Mangrove forest.*—Several deep channels, rich in fishes and navigable by the canoes of the natives, occasionally extend in serpentine turns through these mangrove swamps. One meets not uncommonly at the end of such channels in a hidden locality villages of the natives, as for instance, on Trinkut the pirates' village Dschanoba.' (Janoba).

'The brackish-water alluvium, the ground of the *Rhizophori* and *Cerithia*, must, therefore be considered as a soil perfectly unfit for cultivation. It occupies only a small area as compared with that of the islands, but it is nevertheless of a mischievous importance. For it can justly be said that the Nicobars owe their unhealthy climate principally to these brackish-water swamps, as they occasionally extend for miles from the mouths of the rivers into the interior. In these swampy districts, the change of the fresh to salt water causes a decay of the organisms, which can only exist in the former, the reverse takes place in salt water changing to fresh water. The ebb exposes large areas, and decomposition of the organic life takes place, filling the air with most poisonous miasmas.'

Dr. Hochstetter says that he especially had opportunity of studying these marked changes on a grand scale on the northern coast of Great Nicobar (west of the Ganges harbour). On the other hand, the coral land appears to be fertile, capable of cultivation, and healthy at the same time, and the dry marine and freshwater alluvium, to which on the sea coast belong the cocoa-palm forest, and further inland extending to the back of the hills, a beautiful forest of various kinds of large trees. This is the ground which the natives of these islands have selected for their abode, finding here all the necessaries of life.

The cocoa-palm forest is described by Dr. Hochstetter as the picture of life, and he thinks that if the cocoa-palms had not been there, the islands would have been probably uninhabited up to this time. He further states that, taking the number of the inhabitants of all the islands to be 5,000, there would be about five and a half millions of nuts required for annual use. The annual export of cocoa-nuts can further be estimated as about ten millions, for Car-Nicobar alone exports between two and three millions. This gives fifteen and sixteen millions of cocoa-nuts to meet the annual demand. On the northern islands, the cocoa-palms occupy comparatively a larger area, while on the southern islands, especially on Great Nicobar, they are nearly altogether wanting. The northern islands are, therefore, the most thickly inhabited, and the cocoa-palms are there divided as property, but on the southern islands they appear to be the free, common, goods of all.

'The Nicobarese not only lives on, but also in, the cocoa-palm forest, having selected for himself not only the most comfortable place for his hut, but being on the dry coral ground, exposed to the current of the wind, also the most healthy situation.'

'*The high forest.*—This is chiefly composed of large trees with rich foliage.' Several valuable timber trees, and others, useful on account of their fruits, are here mentioned.

'The finest high forest I saw on the southern coast of Car-Nicobar.'

'*The Pandanus forest*, in which this remarkable tree suppresses all other vegetation, except a few *Areca*- and *Rotang*-palms, occurs only on the swampy fresh-water alluvium along the course of rivers and streams, especially near the sea where the rivers form more or less permanent basins. Here it is *Pandanus Milore*, the largest kind of *Pandanus*, which forms the forests. I believe that what we saw of the Pandanus forest on Pulo Milu, was one of the most peculiar pictures of tropical vegetation seen during the whole of our journey.'

'The *Pandanus* is not cultivated on the Nicobars; it is most flourishing in a wild state, and is, after the cocoa-palm, the most important plant for the natives as regards food: it is the truly characteristic plant of the Nicobar islands.

'*Grassy plains.*—If one has succeeded in marching from the flat coral-land through the high and *Pandanus* forests, he generally reaches the foot of hills, rising on the larger southern islands, on Great and Little Nicobar to a height of 1,000 to 2,000 feet above the sea, but on the northern islands they are not above 500-600 feet. This hilly land certainly occupies $\frac{3}{11}$ to $\frac{1}{4}$ of the whole area. It is composed of rocks of the gabbro and serpentine formation, and of the clayey and sandy tertiary beds formerly noticed. The eruptive rocks are comparatively of small extent. Where felspathic gabbro forms the ground, this being produced by the decomposition of the rocks may be said to be fertile, it is covered with thick forest, but even the serpentine island Tillang-chong has a flourishing primeval forest. On the other hand, a remarkable difference is perceptible in the vegetation of the tertiary ground.'

'The hills of the northern islands are to a great extent only covered with grass, those of the southern, however, chiefly with a thick forest vegetation. This distinction rests upon an essential difference in the composition of the ground. The hills of the northern islands consist of a sterile argillaceous soil, those of the southern islands, on the contrary, of a fertile calcareous, sandy-argillaceous soil.'

'Where the most favorable tropical climate could produce nothing else, but stiff and dry Lalang-grass *(Imperata)*, and rough Cyperaceæ *(Scleria, Cyperus, Diplaceum)*, surely there nature has clearly enough left the stamp of sterility, yet just between such grassy hills, which from a distance look so homely resembling fields of corn, have the colonists on the Nancowry channel built their houses and gardens. The grass grows now high enough above their burial grounds; the breakers play with the bricks with which they built the houses; gardens and fields, every path has disappeared. On Car-Nicobar I saw these grassy plains partially cut down, because the natives use the grass for thatching their houses, and on Kamorta large strips were in flame.'

The grass vegetation, says Rink (loc. cit., p. 136), which to the greatest extent covers these islands, is, in the valleys at the base of the hills, very thick and high; it becomes however, higher up thinner and shorter. On the places which are sufficiently damp many soft grasses may occur rich in juice; but on the tops of hills, where the dry magnesian claystone locally penetrates through the scanty layers of soil, and is also partially covered with a coarse ferruginous sand, while the showers of rain carry all the finer particles which may be produced by decomposition into the valleys, there, as a rule, only dry and rough siliceous *Gramineæ* and *Cyperaceæ* are to be met with.

The area which may, therefore, in future be successfully cultivated is that of the southern islands, composed of sandstone and slate, producing a fertile argillaceous sandy soil. On Little and Great Nicobar with the small islands Pulo Milu and Kondul, the hilly land may be estimated at nearly two-thirds of the total area. These islands are therefore in point of colonization the most important, and a comparison with Ceylon and Pulo Penang shows what could prosper where now impenetrable primeval forest covers the whole surface.

'*Primeval forest.*—This is of great extent, and the coast inhabitants of Great Nicobar tell of the existence of a wild tribe, forest-men, ("jungle men"), with long hair, inhabiting small huts or trees and living upon honey, roots and game. But no European eye has yet sighted these forest-people.' Dr. Hochstetter describes in vivid language the evermore forest-clad parts of Great Nicobar, which were visited by some of the party along the deeply indented water courses and ravines.

IV.—Springs, Streams and Rivers.

The annual rainfall of the Nicobars is unknown. But very likely it is considerable; I think 100 inches is an exaggeration, because the two seasons, usually distinguished,—the dry one during the north-east monsoons between November and March, and the wet one during the south-west monsoons between April and October,—are not so strictly separated on these islands as on the neighbouring continent, and according to present experience showers are also not rare during the dry season. The driest month of the year may be March. We had, during our stay on and round the islands, in this month only three times rather heavy showers of rain. In April they become more frequent, until in May and June the south-west monsoon rolled constant and heavy clouds over the islands.

If, therefore, peculiar geological conditions do not facilitate a rapid flowing off of the rain, the islands cannot have in general a want of water. And of this we could convince ourselves, inasmuch as the end of the dry season was unfavorable for the quantity of water in streams and rivers. Even the smallest islands, like Pulo Milu and Kondul, though their small streams hardly had any water flowing, still had an abundance of fresh water in the numerous basin-like depressions of their beds. From the forest-clad heights of Tillangchong still rippled out everywhere spring water. The numerous streams and rivers of the southern large and woody islands, Little and Great Nicobar, possess abundance of water all the year round. But the northern island, as far as the argillaceous beds extend, appears to be deficient in water; this specially is the case on Nancowry, Camorta, Trinkut, and probably also on Terressa and Bompoka. I found the small streams on Nancowry and Camorta, leading into the Nancowry haven, perfectly dried

up. The natives only drank cocoanut-water, and they probably obtain the fresh water which they require for domestic purposes, &c., like the boiling of Melori, from the fresh water swamps, which are locally to be met with in ravines. Of wells, except that made near the village Malacca on Nancowry and which is now half in ruin, I saw nothing. Car-Nicobar, however, though also composed of argillaceous strata, as the abovementioned islands, has no want of good drinking water, because the large coral land raised from 8 to 12 feet above the level of the sea, permits the digging of those remarkable wells, the fresh water of which falls and rises with the ebb and tide. The explanation of this rare phenomenon does not rest in the filtering of the seawater by the coral-sand, but is rather the fact that the lighter rainwater floats on the heavier seawater, and the porous coral rock only prevents the mixing of the two. I have seen several such reservoirs on Car-Nicobar near the villages Mus and Saui, they were all dug from 8 to 10 feet through the coral mass nearly to the level of the sea at its highest flood, and contained good drinking water. Besides this, a river flows into the Northern Bay of Car-Nicobar, which we named Areca River from the luxuriously growing Areca-palms on its banks; this river is navigable with flat boats two miles upwards, and near the small rapids which one meets it also offers good drinking water, containing only a small portion of calcareous constituents in solution.

I have not become acquainted with any mineral or warm springs. The clay-marl rocks of the Nancowry haven are, however, seen covered with an inch-thick incrustation of sulphate of magnesia (epsom salts) in fine fibres with a silky lustre; this indicates a quantity of sulphate of magnesia in the clay-marls, and by digging holes in them, epsom salt waters may probably be obtained, such as is the case with the bitter sandy-marls near Bilin in Bohemia.

V.—Observations on the temperature.

As we had, according to our instructions, to measure the temperature of rivers and springs, and as this task fell to my lot, as far as opportunity offered itself, I would put upon record here the few observations in this respect, besides a few remarks on the temperature.

a.—Temperature of the different waters.

1. 23rd February, on Car-Nicobar, water in the well near the village Saui in 8 feet depth in perfect shade ... ... 25·7C.
2. 27th February, on Car-Nicobar, Areca river in the shade of the primeval forest ... 25·0C.
3. 4th March, on Tillang chong, western side, a spring in the shade of primeval forest 25·5C.
4. 4th March, on Tillang chong, another spring ... ... 26·0C.
5. 8th March, on Nancowry, old well of the Moravian Brothers near the village Malacca, water in 8 feet depth in shadow ... ... 25·7,C.

If it were permitted to make from these few observations a conclusion upon the mean of the annual temperature of the Nicobars, this mean would be 25·58C. (=78·04 Fahrt.)

I have also measured the temperature of several other wells and streams, but as their water was temporarily exposed to the sun, very different results were obtained, as for instance:

on Car-Nicobar
24th February, well near Mus, water in 3 feet depth ... ... 27·0C.
25th „ a stream between Mus and Saui ... ... 27·8C.
26th „ river near Saui ... ... 29·0C.
on Camorta
9th March, two streams with muddy stagnant water ... ... 27·0C.
on Pulo Milu
18th March, stagnant stream water ... ... 26·5C.

b.—Temperatures of the soil.

To obtain further materials for the determination of the mean annual temperature I made a few observations on the temperature of the soil, and these gave the following results:—

8th March, on Nancowry near the village Inuang, the thermometer, after it had been exposed in a permanently shaded place for 6 hours, showed, when buried in 3½ feet depth underground ... ... 25·7,C.
20th March, on Kondul, also in 3½ feet after 6 hours ... ... 25·3,C.

These two observations give, as did those made in water, an annual mean of ... ... 25·5,C. (=77·9 Fahrt.)

This result is smaller than the records known up to the present, but these also do not rest upon sufficiently decisive observations. Rink, who, during a stay on the islands between January and May 1846, never saw the thermometer under 25°C. and never above 33°C. in perfect shade, believes 28°C. to be the most probable mean.

According to Johnston's Physical Atlas, the line indicating the temperature of the sea surface of 30·5C passes just across the group of islands, the annual isothermal being 26·1C., with the January isothermal of 25·0C, and the July isothermal of 27·2C.

As regards the monthly means, we obtain from the observations of the Danish Corvette *Galathea* every four hours:

for January 1846 ... ... 28·2C.
„ February „ ... ... 28·6C.

According to the hourly observations on board of the Frigate *Novara* the mean is—

For the days 23rd,—28th February 1858 ... ... 27·2C.
„ „ „ 1st,—26th March ... ... 27·5C. } mean 27·25C.

With this agrees pretty fairly the soil temperature which I measured at a depth of one foot.

On the 26th February near Saui ... ... 27·7C.
„ „ 20th March on Kondul ... ... 27·0C. } mean 27·26C.
„ „ 26th „ on Great Nicobar ... ... 27·0C.

Finally, with regard to the daily means, they will be found for the time of our stay on the Nicobars in the observations recorded on board of the vessel. It occurred to me when on Car-Nicobar to see whether the temperature of the water of young cocoanuts, when freshly cut down from a tree standing in shadow, would not indicate approximately the mean daily temperature. I found on the 26th February, in two nuts, a temperature 27·2C. and 27·4C., as a mean 27·3C. The journal kept on board of the Frigate gives for the same day, as mean, also 27·3C.

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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1869. [November.

On the beds containing Silicified Wood in Eastern Prome, British Burmah, by Wm. Theobald, Junr., Esq., Geological Survey of India.

No fact relating to the geology of Pegu is better known than the abundance of silicified wood occurring in the valley of the Irawadi, but as no detailed account has hitherto been published of the beds from which this fossil wood has been derived, it is my intention in the present notice to give such a sketch of them as will show their most salient points of interest and facilitate the recognition of the group elsewhere, where its occurrence might from its mineral character be overlooked and its beds confounded with other and more recent deposits. At the same time I shall, as much as possible, restrict myself to the area of Eastern Prome and to the fossil-wood group proper, only incidentally alluding to the great series of beds with which it is intimately connected, and on which it rests, as each group has a marked facies of its own, is generally, as a rule, easily recognizable and characterised by entirely different organic remains, though the balance of evidence as yet tends to prove a passage from one to the other and an undisturbed sequence in the beds composing them. The fossil-wood group, too, is the smaller and, as regards its organic remains, the simpler of the two, and can therefore be treated by itself more conveniently than in connexion with the lower, from which the organic remains require much additional study and comparison with living species, for which very imperfect facilities at present exist.

The most familiar form in which fossil-wood occurs in the Irawadi valley is that of well rolled and polished pieces of from one to six inches in length, distributed through the coarse shingle which underlies the ordinary alluvial clay of the province and is freely exposed in the bed of the Irawadi at a variety of places, as, for instance, under the station of Thaiet-mio and on the opposite bank under the deserted fort of Miadé. Opposite Prome also a great thickness of this gravel, less coarse than at Miadé, but equally well supplied with well worn and rounded fragments of fossil-wood, occurs, fully 30 feet thick, and rising to a height of about 60 feet above the present flood-level of the Irawadi.*

Besides the ordinarily sized pebbles of fossil-wood, there occur in the gravels towards the frontier, as close to Thaiet-mio, for instance, well rounded logs of silicified wood, some two or three feet or more in length. These, of course, have never travelled very far from their original site, and we accordingly find the parent beds of this quasi-ubiquitous fossil-wood in force but a very few miles from the river, whilst irrefragible evidence presents itself of the former extension of these beds over a much larger area than now occupied by them even as far south as Rangoon in the chips of logs of fossil-wood of a size too great for distant transport, either resting on some lower member of the group, or encased in more recent deposits, the detritus of the beds which originally enveloped them, and with no greater change of position than that wrought by the mere action of gravity during the long process of denudation going on around them.

It is not easy very precisely to describe the distribution of this group without reference to a map, but in Eastern Prome the area it occupies may be taken at something less than

* The coarse character of this gravel or shingle, the well rounded and polished condition of its ingredients, consisting of the hardest silicious rock, and the somewhat mixed size of the pebbles, seem to me greatly in favor of the marine origin of this gravel at a period antecedent to the formation of the present river valley, when the sea was wearing away the shaly rising beds I am now about to describe, though I cannot so much as guess at the source of those silicious rocks of which most of the pebbles consist, so different are they from anything now found in the neighbourhood, or I might say province.

700 square miles, of which not more than a bare fifth or sixth is covered by the highest sandy bed with which the fossil trees are associated, and which from its incoherent character has everywhere suffered to the greatest extent from the action of denudation. There can be no doubt that the entire group formerly extended as an uninterrupted deposit far below the latitude of Rangoon, though the highest member of the group with its associated fossil-trunks does not extend down now in force nearer than 130 miles or thereabouts to that town, or not south of the Tounguyo nulla. The exact termination to the south, however, of this fossil-wood bed is rendered very obscure, by its merging, so to speak, in the debris which has resulted from the waste of the group, and beneath which it sinks and is lost sight of. That it formerly extended much further south is rendered certain (and perhaps the occurrence, *in situ*, of patches beneath the newer accumulations at the present time is also indicated) by the occurrence of large pieces scattered about within the area of the detrital beds above mentioned, of a size such as to preclude the idea of transport from a distance; as, for instance, between the Okhan and Thonsay streams, where a log of not less than four feet in length is embedded in a mass of confused detritus fully 65 miles south of the spot I have assumed as the southerly limit of the group containing the fossil wood *in situ*. Smaller pieces of fossil wood are found much nearer Rangoon and in cuttings in the neighbourhood. These pieces on my first visit to Rangoon, and before I entertained any suspicion of the connexion of the beds at Rangoon and those containing the silicified wood, I was inclined to regard as brought to the spot by human agency, as the Burmese are fond of surrounding their religious buildings with posts of this wood "Engin chouk," but I am now convinced that such is not the case, but that the pieces in question are derived either from the wasted and missing upper beds or from the lower ones of the group still remaining, which, as I shall show, contain the same fossil-wood, though sparingly and never in the same sized pieces as the upper or emphatically *the* fossil-wood bed of the province. Thus the fossil-wood in the Prome district occurs in two distinct formations and under very different conditions, *viz.*, in the form of entire trunks *in situ* or fragmentary pieces, but little rolled, and in well worn or polished pieces, some of large size, but more frequently as pebbles, which form a conspicuous ingredient in the recent gravels.

Below I give, in descending order, a table of the main divisions into which the miocene beds east of the Irawadi may be divided, the upper three of which constitute the fossil-wood group of which I am now treating:—

MIOCENE.

(Descending).

Fossil-wood group.

(a).—Sand—in parts gravelly and conglomeratic—characterised by the profusion of concretions of peroxide of iron associated with it; fossils, trunks of silicified exogenous wood and locally mammalian bones. In the subordinate beds of conglomerate, rolled fragments of wood as above, silicified, (that is, mineralized subsequently to their entombment), mammalian and reptilian bones and teeth of cartilaginous fish.

(b).—Fine silty clay with a few small pebbles mixed with sand in strings here and there the whole very fine and homogeneous and devoid of fossils.

(c).—A mixed assemblage of shales, sand, and conglomerates, the last very subordinate, partaking much of the characters of beds *a—b*; a little of the concretionary peroxide of iron Fossils, rolled wood silicified; mammalian and reptilian bones and cartilaginous fish teeth. Towards the base, the beds contain marine shells, and pass into those of the next group.

Pegu Group.

(d).—An enormous succession of sandstones and shales of unknown thickness and not usually fossiliferous. Particular beds, however, contain fossils in profusion:

(*e. g.*, *d*-1.—Hard sandstone with corals *(Cladocera).*

d-2.—Blue Kama clay, highly fossiliferous.

d-3.—*Cytherea Promensis* bed or Prome sandstone,
and numerous others which cannot be specified till their fossil contents have been more especially examined).

(a).—This bed which we may fairly suppose to have been once co-extensive with the rest of the group is now greatly diminished in area by denudation, which its mineral character even more perhaps than its position at the top of the same has tended to encourage, so that even within the area where it is at present best preserved it by no means constitutes the entire surface, being everywhere deeply scored through to the underlying beds below. The surface is everywhere protected by a gravelly layer composed of small quartz pebbles and ferruginous concretions derived from pebbly strings and irregular courses of conglomerate dispersed through the sand, which readily washing away leaves the residual layer in question at top; to the protection afforded by which against further waste, the existence of what still remains of this incoherent bed is largely due. This surface layer is of variable thickness, its development being, to some extent, a measure of the denudation this group has undergone. On the surface and impacted in it at different depths where it is very thick lie logs of silicified wood of all sizes from a foot or so to trunks of 40 and 50 feet, not entire, but jointed up into pieces of various lengths through spontaneous fracture, probably brought about by their own weight, and irregular subsidence during the removal of the friable matrix wherein they were originally encased. Though, as a rule, these large logs occur as described in a gravelly debris, they sometimes occur relatively to the incoherent sand so as to leave no doubt of its being the bed wherein they were originally deposited, and on which they may be sometimes seen apparently *in situ*, as between Thanat-ua and Kiungee, and not only in this bed but in the beds beneath it, the same fossil-wood occurs, though in smaller pieces, and much less abundantly. The larger logs are quite unrolled, but the smaller pieces are often rounded by transport, though never to the extent seen in the pieces of fossil-wood contained in the recent gravels. When this sand rises into hills, the sides are invariably steep, and not unfrequently scarped, exposing a clean vertical section of sand with its crust of gravel at top. This sand weathers into curious pinnacles wherever an isolated stone, shell, stick, leaf, or other foreign body has afforded shelter from the direct impact of rain, and the incoherent rock all round washing away eventually leaves the protecting substance perched on a slender pinnacle of sand, which recalls the similar phenomenon of the "earth-pillars of Botten" figured by Sir C. Lyell in the 10th Edition of his "Principles."

In color this sand is greyish, very fine and uniform, and with only a certain admixture of impalpable argillaceous matter forming, where exposed to traffic, a fine dust, or, in the beds of streams where the argillaceous portion has been removed by water, a clean silver sand very fatiguing to travel over. Though the sand I am describing unquestionably contains silicified wood, yet it seems probable from the great abundance of large trees strewed over the surface, that they existed more plentifully in that topmost portion which has almost disappeared through denudation leaving only these bulky memorials behind it, than elsewhere. The structure of the wood has been to a considerable extent obliterated by decay before its mineralization was effected, and all that can be definitely said of it is that the wood is exogenous and not a conifer. I have remarked but one species in Prome, though the Burmese, from trivial distinctions in color and weathering, affect to recognise the modern Enjin *(Hopea suava)* and the Thiya *(Shorea obtusa)*, an identification of course quite illusory. This wood nowhere exhibits any traces of marine action as might have been anticipated had it floated about till water-logged in a brackish or purely salt estuary, and hence it may be inferred with considerable probability that it floated about in a fresh-water sea, or chain of lakes fed by a sluggish stream, till it sank where it became ultimately silicified. It must at the same time be remembered that the wood found in beds containing marine fossils is also free from perforations, but these are small pieces, much rolled prior to their entombment and probably under conditions on some sub-marine bank unfavorable to the presence of either *Pholas* or *Teredo*. In some pieces of fossil wood I have noticed minute tubular cavities (perforations?) about ·02 or less in diameter, which might have been produced by some insect whilst the trunk was still standing, but such cases are rare. Associated with this sand, and forming sometimes irregular beds in it, or more frequently lenticular courses, now thickening, now thinning out, occur some hard sandstones, sometimes very fine grained, at others a pebbly grit, or even coarse conglomerate. No regular position in the sand can be assigned to these subordinate layers, but the fine hard sandstone often occupies a high position in the deposit, whilst a coarse conglomerate is not unfrequently met with towards its base. Both sandstone and conglomerate are usually richly charged with shark's teeth of small size *(Lamna)*, the conglomerate being usually ossiferous as

well, though throughout the deposit the occurrence of bones is irregular, capricious, and local.

A good section displaying the relation of these grit-courses to the less coherent rock around them, is seen in the hills about three miles east of Shuebandor, or about fifteen miles east of Alán-mio. The hills are here steeply cut in the bed I am describing, the surface being covered with the usual gravel, with abundance of silicified wood and ferruginous concretions, the former completely blocking many of the deep gullies cut on the hill side. Strewed about here may likewise be seen numerous lustrous fragments of iron slag, from the native furnaces once scattered over these hills. The sand here presents its usual incoherent, typical character, but a compact sandstone, passing into a coarse grit in patches, is somewhat freely developed in irregular lenticular courses in it. On the surface of the incoherent sand at this spot, and evidently weathered out of it, I picked up a fragment of the lower jaw of a deer, and from the immediate vicinity I collected mammalian bones, mostly ill preserved and fragmentary, shark vertebræ and teeth, and chelonian plates *(Colossochelys* and two species of *Emys)*. In the great slabs of grit lying about amidst the debris of the wasting sand which enveloped them shark's teeth were plentiful, accompanying mammalian bones and fragments of wood, many of which had been perfectly rounded by attrition before they were embedded. These pieces of wood are, however, not common. Another locality where bones are still more abundant is one-half mile north-east of Talok, or fourteen miles north-east of Thaiet-mio on the east bank of a stream not marked on the map. Bones are here far from scarce, but friable and ill preserved. They occur both in the incoherent sand and also in the coarse grit and conglomerate associated with it, together with shark's teeth and small pieces of wood. At this spot there is a good deal of coarse conglomerate, and in accordance with the indications afforded by these coarser beds we find the bones of a larger size, and many of these much rolled and abraded before they were finally embedded. Here I got a fragment of the lower jaw of an elephant, together with fragmentary portions of the limb bones of that animal, all imperfect either from original violence or subsequent decay, the former cause certainly operating in some instances.

I may here remark that the bones found in this group (within the area I am now concerned with) are not all in the same mineral condition. The majority are somewhat imperfectly mineralized and consequently decay very readily when bared to the atmosphere by the wasting of the surrounding rock, and this I am convinced is the reason of so few bones being found on the surface, even in spots where the rock is seen to contain them somewhat plentifully. A few fragments may here and there remain, but most of the bones noticed by me were so tender, that it was clear that a short exposure to atmospheric action would reduce them to crumbling masses, which would break up and leave scarcely a trace behind them. A bone is, however, here and there found in the water courses well mineralized and calculated to defy atmospheric action, but the scarcity of these fragments attests that such is not the usual condition of bones in these beds. That these well mineralized bones are derived from the same beds as the more friable ones is undeniable. The best mineralized bone perhaps met with was the part of a deer's jaw above mentioned, and this most certainly was derived from the soft incoherent sand whereon I picked it up. The astragalus of a ruminant *(Cervine?)* found also by me during a former season, was in like manner an isolated example of well preserved bone, though being found in a small stream its parent bed was not demonstrable. In Upper Burmah well mineralized bones are probably more common to judge by those which have been at various times collected there, and the difference is merely the result of different conditions at the time of their deposition, such as we might expect to prevail, and depending probably on the irregular access or supply of silica in solution. That the supply of this silica must have been at some period abundant is testified by the enormous amount of silicified trunks everywhere met with, but the horizon of these is certainly higher than that at which the bones in question occur, and although small pieces of silicified wood occur commingled with the bones, it does not therefore follow that the same abundant effusion of silica took place at the time of their deposition as subsequently occurred when whole forests were silicified, and this I should be inclined to regard as the true explanation of this condition of *most* of the bones in this sand, *viz.*, an insufficient supply of silica in solution.

As a rule, it is not, however, in the sand but in the coarser and more conglomeratic beds that the bones seem mostly to occur, of which a good instance is seen midway between Omouk and Lema, some 19 miles east-south-east from Thaiet-mio. Here a great bed of

conglomerate is seen dipping 30° south-east in which I noticed the tusk of a small elephant, but too friable to be extracted from its hard matrix, together with other bones, all in a poor state, and more or less injured by rolling about on a coarse shingle before their final consolidation.

Next to the presence of silicified wood, a remarkable development of concretionary peroxide of iron seems to characterise the sand I am describing. The ore occurs occasionally as a thin band, up to perhaps a thickness of three inches, breaking up or jointing into rhomboidal concretionary masses of different sizes and shapes. More usually the ore occurs in the form of variously shaped concretions from one to four inches in length, though occasionally even larger. These concretions are found in both the sand and conglomerate, to which last when numerously developed they impart a peculiar varnished look, which might sometimes be almost styled (but for the technicality of the term) viscous or slaggy. The more usual shape of these concretions is flattish oval or amygdaloidal, but they occur spherical, cuboidal, cylindrical, with both flat and hemispherical ends, discoidal and any intermediate form, but always symmetrically proportioned, and the result of a segregative action or process in the clayey and ferruginous components of the bed when in a plastic condition. Of whatever shape however, their structure is extremely uniform, consisting of an external crust of concentric layers of brown hæmatite surrounding a kernel of pure white or yellowish clay, lying loose and shrunken in the interior.

Externally these nodular concretions are roughened from the adhesion of the sand enveloping them, but this rough crust scales off readily, leaving their surface perfectly smooth. Internally they often present a blistered appearance from the mammillary crystallization of Limonite which lines them, becoming on exposure to the atmosphere and rain lustrous and varnished. Where the bed has been of too harsh a character to permit the regular segregation of the ore, it is found lining sinuous cavities in the coarse matrix, leaving flat, approximating walls, evidently produced by shrinkage, which gives such portions a very peculiar aspect and one which simulates a viscous condition. In some places even a botryoidal structure is induced where the rock is less coarse.*

The thickness of this upper sand cannot be closely estimated, but 40 feet is probably more than the average thickness of what now remains of it.

(b).—Below the last described sand occurs a deposit of very uniform character composed of pale silty clay which passes upwards into the overlying sand. This silty clay is very fine, thin bedded and homogeneous, with merely a few strings of sand here and there, and an occasional small pebble in the sand. It is everywhere seen at the base of the last bed into which it seems to pass, though their respective characters constitute a good means of demarcation between them. It is entirely devoid, as far as observation goes, of organic remains. A good section of this silty clay is seen south of Thanat-ua, between Alán-mio and Kiungalé, but the bed presents no special point of interest.

It is also largely exposed in section 1¾ miles east of Talok on ascending out of the stream (previously noticed as unmarked in the map), but it merely presents the same uniform character and absence of fossils, which distinguish it elsewhere. Where the upper sands have been completely denuded so as to leave exposed a large area of this bed, an undulating country is the result, possessing a marked character. The surface of the country does not there greatly differ in appearance from that seen within the area of the alluvium, and it would not

* Under the Burmese rule this ore was extensively smelted, but no furnaces are now anywhere at work in the district. Remains of furnaces which were merely rectangular kilns, cut in the firm alluvial clay of some steep bank, which gave easy access at top for replenishing ore and fuel, and below for withdrawing the products, are numerous about Shuebandor, Kiungalé, and Yebor, together with slag-heaps, sometimes of no inconsiderable dimensions. Throughout the area of these upper sands, however, slag may be found here and there scattered about, as the iron-workers shifted their scene of operations from spot to spot, wherever charcoal and ore was for the time most plentiful. The works must have in many cases been conducted in the dry season only, as the hearths of some furnaces still standing open into the beds of streams which during rain would certainly have found an entrance to them. The blowing apparatus was probably the effective *vertical cylinder* bellows formed of large bamboos still in use in the district by blacksmiths, but the oldest inhabitant could give me no particulars of the manufacture, as none of the class of iron-smelters now remain in the district. The introduction of English iron and steel has doubtless been the main cause of the abolition of this branch of industry, aided by the harsh and injurious system of the Burmese officials during the early struggles with the British, but in some places it was alleged that the iron-workers had fled the country to avoid being forcibly transported to Calcutta to make iron for the terrible foreigners. This may seem very absurd, but those who know the ingrained credulity and ignorance of Asiatics will be inclined to give some weight to the reason stated, though it is probable that this fear, strongly as it may once have operated, is no longer felt, though the state of the market and the price of iron now ruling in Pegu prevents the resuscitation of the trade.

be easy in a limited space to discriminate the clay in question from the ordinary alluvial clay of the valley. Where, however, freely exposed, it presents much the appearance of a 'regur,' save in color, which is a pale yellowish-gray, quite devoid of any tinge of red which the alluvial clay generally possesses, and equally so of the dusky carbonaceous hue of a regur. From some peculiarity in its composition or hygrometric qualities it in dry weather opens out in great cracks, and is always covered with a sparse crop of stunted grass in separate tufts, and a tree jungle of a peculiar aspect from the dwarfed character of the trees composing it, present among which are the Toukkian *(Terminalia macrocarpa)*, Te, (*Diospyros.* sp.), and the "Shábiu" of the Burmese *(Phyllanthus emblica)*.* The country around Laidi comprising the doab between the Pade and Myo-hla streams is composed of this clay with sparing remnants here and there of the upper sands. It is largely exposed, too, in the broad valley about Lepaláh (Let-pan-hla) and between that village and Chouk-soung ("stone fang"). Towards the mouth of the Myo-hla stream near Toukkian-daing, (Htouk-kyun-deing,) this clay forms the open country and is dug for making pottery. It might here be readily mistaken for the alluvial clay of the valley, but for the occurrence here and there strewed over it of small pieces of silicified wood derived from the denuded sands which once covered it. The thickness of this bed I cannot estimate, but I should not place it under 40 feet; how much more cannot be determined.

(c).—Below the last described clay, a group of beds occurs of rather varied character, resembling, to some extent, the beds both above and below it. It contains, though sparingly, the same description of fossil wood as the sands at the top of the group, and some of its beds present characters very similar to portions of those beds; whilst towards its base, it appears to pass insensibly into the lower group characterised by marine fossils. It is, however, generally very devoid of organic remains, though, as a convenient lower horizon to it, I have taken a sandstone which is generally recognisable where the junction is clear, by a few organic remains not very well preserved, among which a coral *(Cladocora)* is most characteristic, which we may regard as the highest member of the lower group.

A section of these beds is seen in the Kini-choung (Kyeeneech) above Mogoung, which may be taken as illustrating their general character, and some portions so resemble the ossiferous sands and gravels of the upper beds that I searched confidently, though in vain, among them for like fossils.

(Descending).

Pebbly sandstone ... ... seen, about ...	50	0
Pale silty shale	3	6
Very false-bedded pebbly sandstone	16	0
Harsh sandstone, rather irregular	0	1
Compact yellowish silt with a central band of kidney-shaped nodules 1 to 2 feet in diameter	2	0
Gravelly sand	0	2
Yellow pebbly sandstone	3	0
Pebbly conglomerate, loose and gravelly	(a few feet).	
	74	9

This section, though not a thick one, will illustrate the general character of the upper portion of this division *(c)*. The silty shale much resembles the shale in division *b*, whilst the sands equally recall the uppermost sands, *(a.)* Close on the horizon of the above section

* The clay above described and the sandy beds of the same group, respectively, offer good instances of the connection of particular soils with particular kinds of vegetation. So generally does this hold good in Pegu that in some instances it affords a good empirical criterion of the geological formation beneath. In the area of the fossil-wood sands, the most prominent tree is the Eng *(Dipterocarpus grandiflora)*, and this tree so commonly affects a sandy soil that the Burmese call such soils, whether within the limits of the fossil-wood sand proper or the zone of detrital accumulations skirting the hills, "Engdaing," or the tract of the Eng tree, and though, of course, Eng trees are found on other descriptions of soil, yet it is on this sandy belt that the Eng flourishes most vigorously from probably being there less competed with by other trees, well fitted as it for a sandy soil. The "Thiya" *(Shorea obtusa*, Wall,) the "Kanyin" *(Dipterocarpus alata*, Wall,) and the "Engyin" *(Hopea suava*, Wall,) equally affect the sandy "Engdaing," though not in sufficient numbers to characterize the forest. On the other hand, these trees abhor the clay described above and are most miserably dwarfed on it. The Toukkian *(Terminalia macrocarpa)*, though dwarfed, seems to answer best on this clay, but from some cause or other it does not seem favorable to vegetation. I think this must be due rather to its hygrometric properties, than to any injurious ingredient in it, and that if artificially irrigated, it would give better promise to the cultivator than the densely wooded sands to which it offers so unpleasant a contrast.

Bamboos are not usually much developed on the Engdaing, and a striking demarcation is not unfrequently seen where the Engdaing meets the boundary of the older beds on which bamboos flourish with great luxuriance. The Burmese are fully alive to this fact, and if an enquiry is made regarding a village, say, if it stand within the Engdaing, will answer it negatively, "it is among the bamboos," an expression quite equivalent in their minds to saying it is *not* on the Engdaing where bamboos are rare and never are the characteristic vegetation.

must probably be placed the ossiferous beds, at the top of the river reach above Talohmhor (Keng-yua in map), yellowish sands pebbly at top and passing up into rather soft conglomeratic sandstone containing bones, both mammalian and chelonian, shark's teeth and vertebræ, fossil-wood and rolled fragments of oysters and other shells.

A small but instructive section is also seen of these beds in the Myouk Naweng, a little below Thambyagon (Tham-bya-ga-gon), where pale silty shales are seen supporting a great thickness of rusty incoherent sand traversed by thin layers of shale and a coarse quartzose conglomerate with clay galls and cavernous hollows incrusted with a layer of the brown hæmatite, as seen in some sandy beds of the upper division *(a)*. In this conglomerate I found mammalian bones, shark's teeth, and a small log of fossil-wood about two feet long of very similar character, though less completely mineralized than that found so abundantly in bed *a*. No other fossils were discernible here, nor, as a rule, throughout this division, though towards its base, sandstones come in containing marine shells and corals, though neither plentifully nor well preserved. These marine beds, however, are naturally more connected with the great group which follows immediately below the present, and which nowhere contains the fossil-wood so characteristic of the present group.

It only remains to add a few words on the very close restriction to the eastward of fossil wood after leaving the area of the fossil-wood group. Nowhere within the area occupied by this group is fossil wood, in pieces of the largest dimensions, more liberally distributed than along the eastern margin of the deposit along which it is everywhere found abundantly, but directly the boundary of the group is passed there is an almost complete absence of fossil wood, even in moderate sized pieces. A very close and careful search in some of the larger nullas may result in finding a piece here and there for some few miles from the boundary, but that is all, and the question at once presents itself,—has this fossil-wood sand extended formerly across the ranges to the eastward and to the Sittang Valley, or was its extension in that direction limited by a boundary somewhat corresponding in its general direction with the present boundary of the group? Without any detailed knowledge of the extent of the group on the eastern side of the Pegu range, we know the single fact that this fossil-wood group occurs in the Sittang Valley, and this and the presumed conformity of it with the lower group which constitutes the bulk of the intervening ranges of hills, would strongly lead us to regard the group as having once stretched uninterruptedly from the valley of the Irawadi across that of the Sittang, or over the entire country bounded to west and east, respectively, by the Arakan and Poung Loung chains. That this must have been the case with the great bulk of miocene rocks so largely developed in this part of the Irawadi Valley is certain, but one argument, though a negative one, is, I think, sufficient to make us pause before accepting the idea of a continuous extension of the fossil-wood bed over the same area as those of the group below it. This argument is the absence which I have alluded to of fossil wood for a distance not far short of 50 miles, that is, throughout the entire breadth of country occupied by the precipitous hills and tortuous streams of the Pegu range. When we reflect on the large size of some of the silicified trunks which may be said to strew the country along the eastern boundary of this group in Eastern Prome, and the abrupt cessation of any save the veriest traces thereof, and these but for a short distance from the boundary, and consider also the imperishable character of much of this fossil wood as evinced by its abundance in the hard and well worn gravels of the Irawadi Valley, we are irresistibly led to question the former extension of this fossil-wood bed across a belt of country wherein it has left no traces. The evidence is about as forcible as negative evidence can be. Additional weight is also given to it by the fact, that its admission presents no difficulties, but quite harmonises with the process which the geological history of the district seems to indicate as having occurred. We have only to suppose that the deposition of the vast series of miocene rocks developed in Pegu proceeded uniformly (during, possibly, a synchronous elevation, in a gradual manner, of the ocean bed) till the entire series, save the topmost members, had been deposited. Lacustrine conditions we may now presume to have supervened over portions at least of so large an area, and the elevation of the Pegu range of hills commencing about this time would cause the first land to appear on a low belt of country occupying in its general arrangement the present line of the Pegu range. In other words, the deposition of the uppermost beds of the group and notably of the fossil-wood sands would be arrested along a line of country not greatly differing from the present boundary of the group. The elevation of the Pegu range and its corresponding disturbance of the adjoining strata certainly continued

down to a period subsequent to the final deposition of the fossil-wood group, though from the mineral character of the upper beds, any movements they have been subjected to are with difficulty determined, and these movements may have, to some extent, interfered with the effect of a *coup d'œil*, but from several points of elevated ground beyond the area of the fossil-wood beds, I have been struck by the manner in which those beds were spread out; on a lower level, in a fashion strongly suggestive of their accumulation under lacustrine conditions along a stretch of elevated country almost coincident with the present boundary. This is notably the case at the extreme north of the district near the British boundary above Teybin and Bilugon, and is also to be remarked elsewhere, though the forest is so dense that it is rarely one is able to get a glimpse of any large extent of country. Had it been otherwise than here supposed, it would be extremely hard to understand how the imperishable testimony of fossil-wood logs and fragments had been so completely removed from the hilly tract, where as a matter of fact they are wanting. They are certainly the hardest bodies met with, and having held their own among the quartzose rocks which comprise the bulk of the Irawadi gravels, must, *a fortiori*, have no less successfully withstood the destructive action of denudation amidst the softer miocene beds which alone are met with in the Pegu ranges. I need not, however, dilate more on this subject, which will be readily enough cleared up when the geology of those regions above the present British frontier comes to be carefully examined into which these fossil woods extend, and wherein they seem to be more largely developed than within British territory.

MINERAL PRODUCE OF INDIA.

Towards the close of the year 1868, I solicited from the Commissioner of Kumaon (and some other officers) information as to the quantity and value of the minerals raised and brought to market within their jurisdiction. Such local operations, where minerals are raised solely for local use, and in reality are never exported, or, only in very small quantities, even transported from one district to another, taken separately, are of small importance, but when aggregated for the country at large, they represent an amount and value which must be very considerable. And these small local mining operations can only become known by the assistance of the local officers. To Colonel H. Ramsay, C. B., Commissioner of Kumaon, I am indebted for the returns now given for *Kumaon* and *Gurhwal*. The information has been collected, under his orders, by Mr. Lawder, Civil Divisional Engineer, Kumaon. Mr. Lawder was for several years one of the office staff of the Geological Survey, and possessed, therefore, a general knowledge of the subject referred to him, and has evidently devoted himself with zeal to the collection and preparation of information.

I was, I confess, surprised at the quantities stated to be raised and the extent of the mineral industry. Viewed merely as a source of employment of labour, these returns show the equivalent of the continuous labour during *every day in the year* of no less than 154 persons, and yet the effect is scarcely felt beyond the narrow limits of the province itself, excepting in so far as this local supply obviates the necessity for imports of materials from elsewhere.

MINERALOGICAL STATISTICS OF KUMAON DIVISION, collected under instructions from THE COMMISSIONER, COLONEL H. RAMSAY, C. B., by A. W. LAWDER, ESQ., Civil Divisional Engineer.

My endeavours to collect reliable memoranda of the mineral resources of Kumaon have not been so successful in their result as I could have wished. The entire absence of reliable native information, and the general unwillingness exhibited by the inhabitants to speak at all on the matter, arising from the fear that any knowledge they might communicate would perhaps eventually be the cause of increased rental demand or of the appropriation by the Government of the land in which the minerals occurred, have presented many difficulties. The information obtained from the Bhoteeas was given with great reluctance.

Owing also to my having but little surplus time to devote to the full elucidation of the subject, the memoranda supplied here are doubtless somewhat imperfect and incomplete; my duties, although carrying me to all parts of the Kumaon district, confine me (with some exceptions) more particularly to the roads, and I have probably repeatedly passed by old mines, or places rich in minerals, in utter ignorance as to their existence, not to mention other places remote from any frequented thoroughfare.

In the following notes I am indebted to reports already published for much information.

The principal economic products in the Kumaon Division are the following: gold; copper; lead; iron; arsenic; sulphur; alum; lignite; bitumen; limestones; flags; slates, &c., &c.

Detail of Localities.

Kumaon District.

Copper.—Ores of this metal are found at Rai in Gungoli, Síra Barabísí, Kharai, Kemokhét (each bank of Luddya river), Geewar, &c., &c.

Rai.—This mine is the principal one in the Puttí. The ore is chiefly pyrites, and occurs in a matrix of steatitic and talcose schist. I visited these mines in the winter of 1868-69, and found the mines closed up by a landslip, and the entrances full of water. The ore is extracted by means of drifts slightly inclining upwards to allow for drainage, as appears to be the mode most generally adopted throughout the hills. A specimen of ore which I found on the spot seemed rich. I also discovered slight traces of copper pyrites in quartzite near Gunai in Athagaon Puttí.

Síra Barabísí.—Síra is noted for its copper mine. Dolomitic and talcose rocks form the gangue. The ore is a mixture of copper and iron pyrites.

Kharai.—Goul is the principal mine. The ore is worked in the same manner as at Rai. Steatite and limestone are the neighbouring rocks, the former being the matrix principally.

Kemokhét.—Copper is found in small quantity on the east bank of the Luddya river in Kali Kumaon. I have seen no specimen of the ore.

Geewar.—There is a small mine of copper in this Puttí.

At Gurung and Chinkakolly there are mines which have been closed for some time; also at Beler and Shore.

Iron.—Iron is found in Dhuniakote, Agar, Geewar, Kutolí, Ramgurh, Tullí Rao, Chowgurka, &c., &c.

Dhuniakote.—There are the remains of some mines or burrows just opposite the staging bungalow on the left bank of the Khyrna river. The ore is hæmatite, occurring in irregular masses in quartzite. The rocks in the neighbourhood are more or less impregnated with oxide of iron. These mines are now unused.

There is also a mine south of Semulkha in this Puttí, and another in Utehakote, both now unworked.

Agar.—This Puttí is very rich in iron ore, almost every village having its mine. The ore seems to be a brown hæmatite. It occurs here generally in beds or clefts, and sometimes in irregular masses. The rocks in the vicinity are silicious. Only a few of these mines are now worked to any extent.

Geewar.—Iron occurs in quantity in the neighbourhood of the villages Khetsari, Maelchour, Tilwara, Simulkhét, Gudí, and Burlgaon. I can give no opinion as to the kind of ore, having no specimens.

Kutolí.—At Suyalgurh there is some iron ore which is not at present worked to any extent.

Ramgurh.—There are several mines in this Puttí, some largely worked.

Munglalékh.—This mine in Tullí Rao Puttí is highly esteemed for the quality of its ore, which is raised in quantity.

Chaugurka.—The ores of iron are plentiful in this Puttí, and are worked in some places.

At Jhirratolí in Darún the ore is magnetic.

Dechouree and Khúrpatal.—There is not, I believe, any ore, being at present worked by the Kumaon Ironworks Company.

Graphite.—This mineral crops out at Kaleemut hill to the north of Almorah in the Jagésur range, and on the spur of Baninee Devee, facing Almorah on the Lohughat road.

Gurhwal District.

GOLD: Sona River.—This stream rises in the lower ranges of hills, and joins the Ramgunga river in Puttí Dhún. Its sands yield gold, and the bed of the Ramgunga below the junction is auriferous. The washing is not very profitable, scarcely averaging 4 annas a day to each workman.

Taluka Chandí.—The sands of the Ganges running through Chandí contain gold, but the profit arising from the washing is not greater than in the Sona river.

COPPER: Dewalgurh.—The Dhanpur and Dhobrí mines yielded largely in former times, but of late years operations have not been so vigorously carried on, owing to the intricacy of the workings, and the idea prevailing among the miners that very little ore remains in the mines. The ores are principally copper pyrites, and grey or vitreous copper ore, with the red oxide and green carbonate in smaller quantities. The matrix is calcareous. Galena is associated with the copper ore.

Nagpúr.—There are several mines here none of which appear to be at present worked.

LEAD: Dhanpur; Tacheeda.—These mines do not seem to be extensively carried on. The ore is galena, and the matrix principally of silex, with varying proportions of felspar and calcspar.

There are some lead mines at Ghertee in the snowy range between Milum and Niti which have been long since deserted, also at Rallum, Bainskum on banks of the Goree river, and Baidlee Baghir.

IRON: Tullí Chandpoor.—This ore is probably a hæmatite with a little magnetic iron. It has a slight repelling action upon the needle.

Tullí Kalíphat.—This specimen resembles specular iron ore.

Mullí Dussolí.—The specimens are highly magnetic and rich in ore.

Tulla Chandpúr, Rajbúnga.—This hæmatite ore is largely worked.

Nagpúr.—This ore gives no definite result with the ordinary rough tests. It may possibly be a carbonate of iron.

Lohba.—Here a rich hæmatite is raised in quantity.

Mulla Nagpúr.—The ore is most probably hæmatite.

Painu.—This ore is brittle and hard, and possesses the iron black colour and metallic lustre of magnetic iron, but the specimens of it failed to affect the compass in the manner characteristic of that ore. It may possibly on analysis be found to contain manganese, and if so, it will be an interesting mineralogical discovery.

Iriakote.—It is difficult to say what form of ore this is. Its streak fails to convey a definite idea of its composition. It would appear to be an hydrous form of sesquioxide of iron.

Pokrí.—These mines have been reported on by several officers.

SULPHUR.—This mineral is found both in Kumaon and Gurhwal. In the former district at Moonsyaree, in the northern parts of the district, and there are also some sulphureous springs, as that at Nynee Tal. In Gurhwal it is found in the range of hills to the north of the Pindur river within a couple of marches of Nundpriag; also at Mulla Nagpúr and Mulli Dussolí, but is not now collected to any extent.

ARSENIC.—Yellow arsenic (*Hurital*) is found in the northern parts of the district near Moonsyaree. Only small quantities are brought down to the Bagésur Fair by the Bhooteas.

LIGNITE.—Indications of lignite appear near Raneebagh, close to Huldwaní, and in the streams of the sub-Himalayas north of Nujíbabad. They do not give promise of any workable fuel, and judging from the experience obtained in other parts of the hills, it is questionable whether any lignite deposits will ever be discovered of such extent that they will repay the cost of opening them up.

An analysis of a specimen of the Ranibagh lignite gave—

Carbon	60·0
Volatile matter	36·4
Ash	3·6

The percentage of ash 3·6 contrasts favorably with that of the ordinary Indian coal raised in Bengal. The ash is colored by the presence of iron.

BITUMEN or mineral resin (*Salajit**) occurs near the summit of many mountains where it exudes from crevices in the rocks.

In the neighbourhood of Kotegaon, Gowarseo, south of Paoree, it is seen near the top of large cliffs, and is worked by natives by means of a scaffolding suspended from the summit. I am unable to state the amount of it extracted. It is generally used as a medicine and exported to the plains. Medicine from *Salajit* is also prepared in Gunguli in Kumaon, but I have been unable to ascertain from whence the mineral is originally obtained.

LIMESTONE.—The Kumaon hills are prolific in limestones, occurring both in immense masses, exhibiting various shades of color and structure, and as local Tufa deposits.

In the newer geological formations of the lower hills it occurs sometimes as a light colored rock, and sometimes as the cementing material in conglomerate beds and very frequently as Tufa deposited by local springs and streams. The process of deposition is most active during the monsoon rains, and in nearly all the springs emanating from limestone rocks, the waters are highly charged with calcareous matter.

These tufaceous deposits occur less frequently in the higher ranges, but there the blue hard limestones generally containing silex, and other hard varieties, prevail, forming well defined beds, and in many instances they are the predominant rocks of some of the larger hill runs. Small blocks of very pure black limestones are sometimes to be met with, and I have picked up some small nodules of kunkur in the Luddya river.

The principal material utilized by the natives of this district is Tufa, it being more easily burnt and prepared, and more suitable to the kutcha kilns in ordinary use. Where it has in its composition a little iron it seems to yield a strong mortar.

The localities in which lime is manufactured are very numerous, the most important being Naini Tal and Jeolí for use in the neighbourhood.

In the Kharai range, half-way between Bagésur and Almorah, from which the latter station is almost wholly supplied. At Chitailí, in the hills north of Dwara Hat; at Simulkha, Baital Ghat, and Dekolí, in the Kosí valley, for consumption in the works in progress in the new military station at Ranikhét, and on the new cart-road from thence to Ramnagar. There is also lime, somewhat silicious, in Agar Puttí, in the Retha Gâr range, Athagaon, and in almost all the hills in Gunguli. At Ramésur it skirts the road for miles.

It also occurs near Khyrna on the Almorah road, at Mulwa Tal, and in Geewar, &c.

ROOFING SLATES, &c.—Roofing flags are very plentiful in the district of Kumaon, and are generally micaceous or chloritic.

At Chitailí near Dwara Hat there are some beds of imperfectly metamorphosed clay slate, the planes of cleavage seeming to occur almost in the same lines with the bedding. The quarry was formerly used to some purpose, but owing to the neglect of former owners, it has been for years filled up with debris, so that I was unable to observe the beds properly.

Clay slate occurs also in the neighbourhood of Naini Tal, but the cleavage is imperfectly developed. There are a couple of quarries on the banks of the Ramgunga in Sult Puttí.

BUILDING STONES.—Almost everywhere in the district within easy reach good building stone is to be had. At Almorah fine-grained evenly-bedded quartzites and mica schist form the hill itself, and supply material not to be excelled for

* Mr. Lawder is here in error in calling *Salajit* bitumen or mineral resin. It is an alum or native sulphate of alumina which forms on the aluminous shales in the hills. At least such is the *Salajit* of Nepal, where it is well known and from which it is more largely exported than from Kumaon. Wonderful medicinal virtues are attributed to it, and in the plains it often sells for its weight in silver (see Notice of a native sulphate of alumina from the aluminous rocks of Nepal, by J. Stevenson, Esq., Supt., H. C. Saltpetre Factories; Journal, Asiatic Society, Bengal, Vol. II, p. 321. Also On the alum or Salajit., of Nepal, by A. Campbell, Assistant Surgeon, &c., &c., *ibid*, p. 482; also a second note by Mr. Stevenson, p. 605). Whether the mineral referred to by Mr. Lawder be really the same as *Salajit* I cannot assert.—T. OLDHAM.

durability and facility of dressing. Mica schist seems to form the principal beds for some distance to the east and west of Almorah, reaching to Dwara Hat and Massí on the west, Palí, Ranikhét, Síahí, Devi, Dole, and towards Kalí Kumaon to the east, and also in the formation of the Jagésur and Binsar ranges to the north.

At Nainí Tal the stones used are limestone and clay schist.

At Ranikhét a pale colored gneiss forms both a handsome and a lasting building stone.

Sandstone is abundantly found in the lower hills.

Gneiss and chlorite schist are used frequently as building stones in the district.

Imports.—The chief importations are BORAX (Tincal), SALT, and GOLD from Thibet.

BORAX.—Borax is obtained from the borders of a lake at Chappakanni, a few koss from the Kylass mountain in Thibet.

It is collected from June to September and sold at the several fairs—Ganpa, Gupa Chín, Sibbillum, Chakra, Taklakhal, Dhabakar, &c. It is purchased here by the Bhootea traders and brought down to Bagésur. At these fairs the price of crude borax is something under 2 Rupees per maund (about 50 seers), and in the same state it fetches from Rs. 8 to 9 per maund at the Bagésur Fair, which is the chief mart of the Jowarí traders. The borax bought up here is despatched to Ramnagar, where it is refined and redisposed of at about Rs. 22 to 24 the maund.

Traders from the Byanse, Chowdanse, and Darma Passes transact sales of borax at Dharchula and Burmdeo, and the Gurhwal Bhooteas from Niti at Kanaseo and Ramnagar, nearly all the borax is disposed of to plains traders—

Probable amount of borax brought through Milum Pass in 1868-69	...	17,000 mds.
Probable amount of borax brought through Darma and Byanse in 1868-69	...	15,000 „
Probable amount of borax brought through Niti and Mana in 1868-69	...	15,000 „
TOTAL	...	47,000 mds.

SALT.—Is found at Rhuduk in Thibet, and is sold at the same fairs as borax. It is also found at Silungsakka in Thibet—

Probable amount imported *viâ* the Jowar Pass (Milum) in 1868-69	...	4,000 mds.
Probable amount imported *viâ* Darma and Byanse in 1868-69	...	3,000 „
Probable amount imported *viâ* Niti and Mana in 1868-69 ...	...	2,000 „
TOTAL	...	9,000 mds.

Salt is purchased in Thibet at the rate of 1 Rupee 12 annas per maund (roughly measured) and sold at Bagésur or Almorah at from 5 to 6 Rupees per maund. Almost all the salt imported from Thibet is consumed in the hills.

GOLD.—Is found in many of the rivers in Thibet; at Silungsakka, &c.; it is sold at the same fairs as the salt and borax either in nuggets or in grains. About 10 to 12,000 Rupees' worth is brought down annually, some of which is disposed of in the hill districts (Kumaon and Gurhwal), probably about one-third, and the remainder most likely finds its way to Delhi, Agra, &c., &c. It is sometimes found to contain copper.

Return of amount and value of all kinds of mineral produce brought to market or raised for private use in Zillah KUMAON *for the year* 1868.

Name of Putti.	Name of Mines.	Description of ore.	How worked.	Probable number of persons employed during the year.	Amount raised for private use.	Amount of ore sold.	Amount of metal sold after melting ore.	Amount of metal exported and to what direction.	Amount of metal imported and from what direction.	Mines of lead.	Mines of slates.	Mines of lime.	REMARKS.
					Maunds.	Maunds.	Maunds.	Maunds.					
Kutowlí	Suyalgarh ...	Iron ...	By digging rock.	600 *	1	50	9	7					Partly sold in the neighbourhood and partly brought to Almorah and Huldwaní.
Ramgarh	Dusonia ...	,,	,,	4,200	200	300	150	150					Bageesur, ditto ditto.
	Buna ...	,,	,,	2,000	90	140	70	70					Ditto, ditto ditto.
	Pálí, &c. ...	,,	,,	2,200	110	160	80	80					Ditto, ditto ditto.
Agar	Pathora ...	,,	,,	4,000	130	200	100	100					Ditto, ditto ditto.
	Mujera ...	,,	,,	4,400	100	300	100	150					Ditto, ditto ditto.
Geewar	Ketsarí ...	,,	,,	8,800	100	600	200	200					Ditto, Ramnagar ditto.
	Goodí, &c. ...	,,	,,	8,000	50	700	200	200					Ditto, ditto ditto.
Buraon Gungúlí ...	Raní	Copper.	Deep shaft.	3,840	1	10	8	9					Ditto, ditto ditto.
Burra Gungúlí ...	Belarh ...	,,	,,	200	1	1	1	1					Ditto, ditto ditto.
	Lettí, &c. ...	,,	,,	540	.....	1	2	2					Ditto, ditto ditto.
Kharai	Goul	,,	,,	2,200	.....	2	...	6					Ditto, Thul ditto.
Barabísí, Síra ...	Haralí ...	,,	,,	3,840	1	3	8	10					Ditto, Shore, Ramésur ditto.
	Puthrowlí ...	,,	,,	200	.....	1	1	1					Ditto, ditto ditto.
Tullí Rao	Munglalékh ...	Iron ...	By digging rock.	4,200	200	300	150	150					Ditto, Burmdeo ditto.

Salt, borax, gold imported from Bhoot, north of Kumaon. Copper chiefly imported from plains.

There is one mine of lead in Putti Kharai, which is lying unworked.

There are many mines of slates in the district.

There are eight mines of lime, one in Kharai, one in Geewar, one in Kosyan, and one in Borarau, one in Shore, one in Síra, one in Dhyanírao and one in Charál.

* These numbers express the number of men for one day.

Return of amount and value of all kinds of mineral produce brought to market or raised for private use in Zillah GURHWAL *for the year* 1868.

Name of Putti.	Name of Mines.	Description of ore.	How worked.	Probable number of persons employed during the year.	Amount raised for private use.	Amount of ore sold.	Amount of metal sold after melting ore.	Amount of metal exported and to what direction.	Mines of sulphur.	Mines of slates.	REMARKS.
Dhanpúr	Dhanpúr	Copper...	Deep shaft	1,200	Quantity not discoverable.	Not sold, but worked on spot.	Not melted yet.	None.	There are two mines of sulphur in Mulla Nagpúr and one in Mulla Dusowli which are all lying unworked.	There are many mines of slates in the district.	Partly sold in the neighbourhood and partly brought to Sreenagar Bazar.
Ditto	Tachída	Lead ...	„	100	3 mds.	3 mds.	...	...			Sold at Sreenagar.
Tullí Chandpúr ...	Sakund	Iron ...	„	600	60 „	...	7 mds.	...			Is sold within the Putti.
Tullí Kalíphat ...	Rajkhan	„	„	50	24 „	120 „	20 „	...			Ditto ditto.
Mullí Dusowlí	Dumtí	„	„	200	100 „	100 „	30 „	30			Purchased by the people of native Gurhwal, Barasyún, and Sulan.
Ditto	Kalabun and Mokh ...	„	„	500	400 „	400 „	100 „	100			Ditto ditto.
Sílí Chandpúr	Rajbínga	„	„	1,100	...	120 „	15 „	...			Sold within the Putti.
Boongí	Buwaní	„	Collected from different marts.	120	20 „	20 „	...	...			Ditto ditto.
Lohba	Simulkhét	„	Deep shaft	2,250	400 „	1,800 „	223 „	223			Sold at Ramnagar and in native Gurhwal.
B. Nagpúr	Jugtolí	„	„	250	150 „	...	10 „	...			Sold in the neighbourhood.
Ditto	Búkunda	„	„	150	80 „	...	6 „	...			
Ditto	Gooleth	„	„	80	60 „	...	4 „	...			
M. Nagpúr	Hat Jaisal	„	„	116	3 „	4 „	1 „	...			Sold within the Putti.
Painu	Chuiya	„	By digging earth.	184	8 „	12 „	...	...			Ditto ditto.
Jériakote	Dandatolí	„	„	150	25 „	16 „	8 „	...			Ditto ditto.

GURHWAL;
SENIOR ASSTT. COMMR.'s OFFICE,
CAMP ALMORAH,
The 3rd April 1869.

(Signed) C. J. GARSTIN,
Offg. Senior Asstt. Commissioner.

Captain Garstin, in submitting the numerical return from Gurhwal, says—

"The return has been prepared from statements sent in by Putwarees, and I do not think any great reliance can be placed on their correctness, as it must have been most difficult for them to find out the information required; the people working the mines themselves not having the slightest idea of the amount of ore they either collect or sell.

"The copper mines in Dhánpur used formerly to bring in a much larger revenue than they now do; the fact being that the shafts have been sunk so deep into the hill, and the passages are so intricate, that very few people will venture into them. The miners also say, that the mines are nearly worked out.

"There is, one may say, no export of ores from this district, the mines worked only being sufficient to supply the wants of the people.

"I regret that I cannot give further information, but the agency at my disposal is too limited to enable me to collate any that I would deem trustworthy."

1*st July* 1869. A. W. LAWDER.

The mines noticed in the above return have been known for many years. Some of them were noticed by the earliest European visitors to these hills. And when there was no communication with other countries and no supply of imported metal, they were naturally of higher importance and of greater value than in later years, when their rudely extracted products have had to contend with European manufactures. The earliest description, *in any detail*, of these sources of mineral wealth was given by Captain J. D. Herbert in 1829 in his report on the mineral productions of that part of the Himalaya mountains between the Sutlej and Káli (Gágra) rivers, &c. (Asiatic Researches, xviii, Pt. 1, 227). In this almost every locality noted above is mentioned. Dhánpur and Dhobrí at that time paid a revenue or royalty for the right of working of Rs. 1,200 per annum; Gangúli and Síra of Rs. 1,000; Pokri Rs. 600. The localities, modes of working, and rocks are described, and the means of improvement noted. The iron and lead mines are also noticed, as well as the non-metallic products of the hills—sulphur, alum, bitumen, graphite, borax, limestone, &c., &c. The inaccessibility of the various places is also noticed.

In 1838 a report on the copper mines of Kumaon by Captain H. Drummond appeared in the Journal of the Asiatic Society of Bengal (vol. vii, p. 934). In this he gives the results of an examination of many of the mines by a practical Cornish miner, Mr. Wilkin, whom he had brought out from England. The Rye (Rai) and the Sheera (Síra) mines, both noticed above, are specially referred to. Mr. Wilkin recommended certain trials and improvements in the mode of working, taking a favorable view of the prospects. An experimental trial was then made with the view of opening a regular mine at Pokri, in Gurhwal. Extensive workings had here been carried on from very early times, and one mine, called the Rajah Khán or Rajah's mine, had, it is said, yielded in one year more than Rs. 50,000. At the time alluded to (1838-39) the right of mining was leased for Rs. 100 per annum. Two galleries or adits were commenced, one in each of the two ravines in which the copper was known to occur, the Rajah Khán and the Chumitti ravines, about 500 yards apart. Up to May 1839, 149½ feet had been opened in the Rajah Khán drift, and 111 feet in the other. (Lieutenant Glasfurd, On the experimental copper mine in Kumaon, Jour. Asiat. Soc., Beng., viii., 471).

The work was continued until June 1841, when the estimated cost had been largely exceeded, and as no sufficient returns were obtained, the trial was finally stopped. At that time 257½ fathoms of ground had been driven through. In addition to the two old mines noticed above, the Rajah's and Chumitti (or Chaomuttee), a new opening was made, when good specimens of ore were found near the surface, but at a depth of 15 fathoms they ceased, and at 23½ fathoms it was abandoned. Details are given by Mr. Wilkin as to other mines in the neighbourhood of Pokri also.

The total sum expended in this experimental trial was Rs. 7,384 and there was realized by sale of copper during the time Rs. 779½. Mr. Lushington, who gives these details, mentions the real obstacles to success which have to be contended with. The distance of the mines from the plains, the slowness and expense of carriage, the cheapness and abundance of English copper, the superficiality of the mines yet known, and the want of coal are all serious drawbacks.

At the time Mr. Lushington wrote (1843) the mines of Dhánpur were rented for Rs. 1,700 per annum in 1812. Under the Ghoorka Government, the rent fixed for mines for the whole province was only Rs. 3,500 (Company's Rupees). Since 1815, when Kumaon was conquered by the British, up to 1846, the *average* revenue derived by the British Government was for copper in Kumaon Rs. 800 to 1,200, in Gurhwal Rs. 2,086, the highest revenue for any year, for all mines being Rs. 5,417. Iron yielded an average of Rs. 1,900 in Kumaon, and Rs. 226 in Gurhwal. (Account of experiment at Khotree copper mine, with notices of other copper mines, by G. S. Lushington, Esq., Commissioner, (Jour. Asiat. Soc., Beng., xii., 453).

Again, in September 1845, Mr. Sigismund Reckendorf, Mining Engineer, reported on the same mines, (Jour. Asiat. Soc., Beng., xiv, 471). Dhánpur and Pokri are on opposite sides of the Douliganga, each about six miles from the river, or 12 miles apart. Dhánpur is 1,000 to 1,500 feet higher than Pokri. Both are said to be on the same layer of talcose slate, which is stated to head north-15°-west. Mr. Reckendorf thinks, indeed, that the whole of the known copper mines from the Nepal terai on the east to beyond the Pokri mine on the west are only parts of one layer of no great thickness, sub-divided occasionally into two or three! He considers the ore not to occur in a regular lode or vein, but in a bed. He thought all previous trials had been misdirected, as they had been carried out in the old workings, and that new ground altogether ought to be opened up. He formed a much poorer idea of the chances of success at Dhobrí, but considered that everything tended to show that at Pokri copper could be obtained in large quantity. He urgently deprecates, however, Government attempting anything itself.

In 1854 the Hon'ble Court of Directors sent out Mr. W. Jory Henwood, with two mining assistants and an iron smelter, to examine and report on the metalliferous deposits of Kumaon and Gurhwal. After going over all the districts, Mr. Henwood reported in May, 1855. This report gives much useful information, but, so far as regards the copper mines, the opinion formed was most unfavorable, and indeed condemnatory. Speaking of Pokri he says: "We have never before seen a spot so scantily sprinkled with ore, and offering, in our judgment, so small a prospect of improvement so extensively and perseveringly worked." (Selections from Records of Government of India, Home Department, viii, p. 5). The greater part of the report is devoted to the rich iron deposits of these hills, regarding which we cannot at present speak.

Subsequently to this (1855) I know of no systematic attempt to work the copper mines of Kumaon or Gurhwal. The native miners have, however, continued to delve out annually in a wretchedly insecure way a few hundred maunds of ores, an amount which, from Mr. Lawder's returns given above, appears to be more considerable than I should have expected.

The Geological Survey has not yet had an opportunity of visiting these hills.

October, 1869. T. OLDHAM.

COAL-FIELD NEAR CHANDA, CENTRAL PROVINCES.

Since the first notice of this field was published in the Records of the Geological Survey (August 1868, p. 23), a systematic examination of the field has been commenced. It was fully pointed out by Mr. W. Blanford, in the paper referred to, that the country was in parts so covered that it would be impossible to obtain any satisfactory knowledge of its structure without boring or sinking. Since then two skilled borers and boring tools have been obtained from England, and further sets of tools are on their way. The season had already far advanced before these were available, and as the rains were then near at hand, it was considered desirable that these men who had just arrived, and who were therefore quite unacquainted with the peculiarities of life in this country and of the climate in which they were to work, should, for a time at least, be kept where good house shelter could be obtained. The work was placed under the immediate charge of Mr. M. Fryar, M. E., Mining Assistant on the Geological Survey. And he was requested to select spots for boring within reach of Chanda or Ballarpur during the rainy season and to keep the men at first together, so that they could aid one another in any difficulty which might occur at first starting.

Under Mr. Fryar's instructions the first bore-hole was commenced in the beginning of June. This bore-hole (No. 1) was very near the south-east corner of the boundary of the Nuggeena Bagh, north of the native town of Chanda. This bore was put down 80 feet

and was then stopped, "as the material bored through continued to be simply stiff sand." A second bore was then commenced about 230 feet from the first, in the direction of the dip of the rocks,—about east-15°-north. This passed through the following section :—

Feet.	Inches.	
12	0	Of ochrey arenaceous shale.
8	0	Soft shale of deep red and purple colour.
20	0	Of the same material as found in No. 1 bore-hole.
Total ... 40	0	

At this depth, 40 feet, this bore-hole was also stopped.

No. 3 was then commenced at about 450 yards still further in the direction of the dip, or into the field, or about 527 yards from No. 1. This bore-hole was near the junction of the Ghimoor road and the Nagpur road, its bearing from No. 1 (magnetic) being about north-38°-east.

This third boring gave the following section :—

Feet.	Inches.	
5	0	Brown soil.
11	0	Red brongel.
3	0	Brown sand.
1	0	Hard red ironstone.
17	0	Light pipe clay.
2	0	Dark brown clay.
13	0	Soft light sandstone.
3	0	Light brown sandstone.
10	0	Light colored sandstone.
7	0	Very light colored sandstone, very coarse.
2	0	Yellow sandstone.
4	0	Very dark sandy shale.
25	0	Variegated sandstone.
10	0	Yellow sandstone.
11	0	Brown sandstone.
9	0	Variegated sandstone.
1	0	Coarse brown sand.
25	0	Variegated sandstone.
2	0	Light blue sandy shale.
2	0	Good *coal (a)*.
12	0	Very dark blue shale, a little sandy.
7	0	Light blue sandstone, a little shaly.
24	0	Light colored sandstone.
1	6	Black shale mixed with *coal (b)*.
16	0	Light blue sandstone.
1	0	Dark sandy shale.
0	6	Iron pyrites.
18	0	Light blue sandstone and brown sand mixed.
Total ... 242	0	

"And as in this depth we have entered something of a Talchir appearance, I have stopped this hole and commenced one at Ballarpur." (Mr. Fryar's report, 24th July).

Specimens of the *coals* passed through in this pit, as brought up by the pump, were assayed, and yielded—

	Carbon.	Volatile.	Ash.
(a) two feet bed	47·8	41·0	11·2
(b) eighteen inch bed...	42·7	41·2	16·1

both poor coals, neither containing 50 per cent. of carbon. The beds are also from their small thickness unworkable with profit at that depth.

A fourth boring was made near the dâk bungalow to the west by south, and between the bungalow and the Jhurput nala. This (No. 4) was put down with small rods, "and ought to have entered coal a few feet from the surface, if the apparent dip of rocks at the surface had been a guide approximately to the dip of the coal beds below." (Mr. Fryar, 28th July). This boring was about 500 feet to the west of one put down by Mr. Binnie, C. E., in which coal was said to have been cut. No. 4 did not reach coal, and was abandoned.

Preparations were made for a fifth boring (No. 5) about six chains from the Jhurput nala on the left bank, due south of the town of Chanda, but no boring was carried out here.

At Ballarpur, the first boring alluded to above was put down on the left bank of the river, nearly opposite the point where coal is seen on the right or Hydrabad side of the river, and about 300 feet from the river bank. This position was injudiciously selected, as proved to be the case. It was in fact within the limits of the old bed of the river, and was

abandoned, as there was not tubing "enough to carry the hole through the running sand and gravel met with." This difficulty might certainly have been avoided, but unfortunately it was not. The probability was in fact pointed out in April 1867 (see p. 25, Records, Geological Survey of India, 1868), where it is said, "in sinking upon the Chanda side, it is far from improbable that only alluvial clay may be met to the depth mentioned." The boring tools were then shifted to a second position where rocks were visible close by. This second hole was put down about a mile to the north-east near the town of Ballarpur (less than half a mile). This boring was carried down to a total depth of 236 feet.

The following is the section passed through :—

Feet.	Inches.	
3	0	Red iron brongel (moorum).
6	0	Soft brown sandstone.
9	0	Strong blue clay.
2	0	Very dark-red sandstone mixed with iron.
10	0	Brown sandstone.
30	0	Soft light colored sandstone.
12	0	Variegated sandstone.
1	0	Red sandy clay.
6	0	Dark colored sandstone.
3	0	Brown sandstone.
1	0	Hard red sandstone mixed with iron.
10	0	Brown sandstone, with mica.
16	0	Yellow sandstone.
0	9	Good *coal*.
0	9	Black shale.
1	6	Good *coal*.
2	0	Very dark shale.
3	0	Green looking sandstone (blueish).
10	0	Dark-blue sandstone mixed with shale.
26	0	Light colored sandstone.
0	9	Iron pyrites.
26	0	Light colored sandstone.
2	10	Black shale, a little coaly.
10	0	Dark blue sandstone mixed with shale.
26	0	Light colored sandstone.
0	9	Iron pyrites.
0	9	Light colored sandstone.
3	0	Black shale, a little coaly.
11	6	Dark colored sandstone, a little shaly.
1	6	Iron pyrites.
1	6	Light colored sandstone.
Total ... 236	7	

Mr. Fryar reported on the 16th September that he had ordered this hole to be stopped, "as we are evidently in the Talchir sandstones." He adds, 'you will observe a similarity of section by comparing the second hole at Ballarpur with the No. 3 one at Chanda' (given above). There is doubtless some little similarity, but I am unable to see the proof that the bore was evidently in the Talchir beds.

The boring rods were then moved from Ballarpur to a point on the road to Moolk from Chanda, between two and three miles from Chanda town, near the place where the road crosses the Jhurput nala, in the corner between the stream and the road to the south of the road. This boring was in progress up to date of last report, and on the 12th instant had reached a total depth of 124 feet 6 inches. The following is the section :—

Feet.	Inches.	
5	0	Loose sand and loamy soil.
6	3	Yellow sandstone and bands of ironstone.
1	3	Hard red ironstone.
7	0	Variegated sandstone, with little clay.
11	0	Soft red ironstone.
0	6	Ironstone band.
8	0	Red sandstone mixed with iron.
4	0	Yellow sandstone.
11	0	Variegated sandstone.
1	10	Yellow sandstone.
0	8	Very hard red rock.
7	6	Brown sandstone.
28	0	Light brown sandstone.
9	0	Light red sandstone.
1	0	Coarse light brown sandstone.
2	6	Hard red rocks.
20	0	Variegated sandstone.
Total ... 124	6	

It is evident that the rods have not yet touched a bed of the coal-bearing rocks in this section, all the beds passed through belonging to the Upper or Panchet series.

Reviewing the results thus obtained, we find that borings at Chanda, which are represented as having passed through the entire thickness of the coal-bearing rocks there, and to have pierced the Talchir beds below, (in which no coal is known), exposed only two thin beds of poor coal, so thin as to be unworkable. While at Ballarpur also, a boring of about the same depth (about 240 feet), said in like manner to have gone through the entire thickness of the coal-bearing rocks and to have pierced the Talchirs, showed also two beds of coal, one of 18 inches, one of 9 inches in thickness.

It need scarcely be said that none of these are workable at the depth at which they occur.

Before these explorations had commenced, Major Lucie Smith, Deputy Commissioner of Chanda, who deserves the highest credit for the sustained zeal and intelligent earnestness with which he has prosecuted these enquiries, had a pit opened on the bed of coal visible in the Wurda channel, near Googoos, or Chendoor. And from the coal there met with, at a depth of 30 feet below the surface, a considerable quantity was raised for experimental trials to which I will presently refer. As, however, this pit was within the limits of the ordinary flood level of the Wurda, a bore-hole was put down about 330 yards from the bank of the river and nearly in the line of strike of the beds. This bore-hole was carried out by Corporal Carson, of the Public Works Department, under the orders of Major Lucie Smith, Mr. Fryar also assisting. As was tolerably certain at such a distance the coal was found to continue. This bore-hole was sunk altogether to 121 feet 6 inches, and gave the following section :—

Feet.	Inches.	
3	0	Surface clay.
5	0	Red moorum.
40	0	Variegated sandstone.
8	0	White sandstone.
6	0	Yellow clay.
10	0	Dark-brown clay.
2	0	Black shale.
3	0	*Coal.*
3	0	Dark sandy shale.
3	0	*Coal.*
5	6	Blue shale.
12	0	*Coal.*
4	0	,, mixed with iron pyrites.
5	0	*Coal.*
0	6	Shale.
11	6	*Coal.*
Total ... 121	6	

Below this is white sandstone streaked with black shale. It is much to be regretted that the boring was not continued, so as to ascertain the thickness of the formation here and the position of this thick deposit of coal in it.

The coal having thus been proved here, a pit was commenced and is now in progress.

A second bore-hole was then commenced about a mile to the south, and to the west a little south of the village of Googoos. This is as nearly as can be the locality recommended by the Geological Survey in 1867, "about 300 yards west of the village of Googoos." This bore-hole was carried down in all about 112 feet, giving the following section :—

Feet.	Inches.	
6	0	Surface clay.
22	0	Variegated sandstone.
0	3	Ironstone.
21	6	Variegated sandstone.
2	6	Red rock.
4	0	Yellow clay.
6	0	Dark shaly clay.
3	6	Shale.
2	0	Crimson colored sandstone.
17	0	Clay and sand.
20	0	Light colored sandstone.
7	0	Variegated sandstone.
Total ... 111	9	

At this depth the mineral lifter jammed, and after several days' unavailing efforts to lift it, it became evident that it would be necessary to sink to it, in order to relieve the tools. After some delay this sinking is now in progress and had reached 27 feet on the 12th instant.

Such is the progress made in the exploration of the field.

As regards the important question of the quality of the coal, several trials have been made. The coal raised from the pit near Googoos was first sent to the Great Indian Peninsular Railway for trial in their locomotives. The Locomotive Superintendent reported on the 16th April "that the coal was not suitable for locomotive purposes, being very dirty. Out of 1 ton 4 cwt. used, there were 6 cwt. of clinker, but very little in the smoke-box, with a load of 4 cotton wagons and one brake. Great quantities of sparks came out from the chimney, and remained on fire for some time. From Boorhanpore to Khundwa, the brake-van alone was attached to the engine, and although the fire had been cleaned at Chandnee station, it had to be cleaned again before getting to Dongergaon (17 miles). We could not get a welding heat with the coal, although it contains great quantities of gas."

The fire-boxes on the Great Indian Peninsular Railway are constructed to suit English coal, and the engineers are accustomed to its use. There appeared, therefore, sound reason for not admitting this to be a conclusive trial. More coal was raised, and better coal selected, and this was sent to the East Indian Railway at Jubbulpore, some to the works in progress under the Public Works Department at the Kanhan bridge, and also a second supply to the Great Indian Peninsular Railway. The results of these trials are decidedly encouraging. It is said that the coal took the train on the Great Indian Peninsular Railway down as far as Budnaira (100 miles) without difficulty; the engineers were agreeably surprised with its capabilities, but did not "think it quite up to the mark." At the Kanhan bridge works, it was tested in a small portable engine. "With Chanda coal steam was got up in 1 hour and 25 minutes with a consumption of 36lbs., the coal being wet, a strong breeze blowing and rain falling at the time. The coal burnt clear, and freely and very clean, leaving a small residue of gray ash without clinkers, and evaporated on the average 4lbs. of water per 1lb. of coal consumed. With English coal steam was raised in 1 hour 35 minutes, with a consumption of 28lbs., the coal being drier, but small and deteriorated from exposure, but the weather was fine at this part of the day and very little wind. The evaporation was at the rate of 6·5lbs. of water per 1lb. of coal." The Chanda coal is specially noted as "burning clean."

The trial on the East Indian Railway was the only one in which the Chanda coal was compared with other Indian coal. "The Locomotive Superintendent reports that the consumption of Chanda coal on two trials was 88¾ cwts. and 85 cwts. per 100 miles, against 67 cwts. of Ranigunj coal for the same distance. The coal did not work well at first, partly, it appears, owing to the construction of the fire-boxes, and partly, perhaps, to the stormy weather in which one of the trials was made, but it did better afterwards."

These trials show the 'duty' of the coal to be as compared with English coal ('small and deteriorated by exposure') as 4: 6·5, or 61 per cent., or, in other words, it is ⅓ths worse than this English coal.

As compared with Ranigunj coal, its duty was as 67 to 87 (mean of 88·75 and 85·), or 77 per cent., or nearly ¼th worse. It is not stated what "Ranigunj" coal was in use.

The coal, however, did the work required of it, and in a satisfactory manner.

These coals were, as mentioned, from the pit sunk at the Wurdah. To test the coal met in the boring near that river, as given above, Mr. Fryar was requested to forward specimens. Of these he sent 33, one from each of the three-feet seams above the thick coal and 31 from it, these being taken from the material brought up by the pump at intervals of about a foot of sinking. These were all assayed carefully by Mr. Tween, and the results are given below.

There can be no doubt that assays of this kind, and more especially when made on the stuff broken down by a boring-chisel, are only approximate indices to the value of the coals tested. But in the absence of better means, they do afford fairly comparable results, and do unquestionably give a fair indication of the economical value of the coals. Indeed, the very results given above are singularly confirmatory of this. The assays were completed for several weeks before the above results of actual trials were received.

The 33 specimens tested gave the following results:—

Depths, &c.	Carbon.	Volatile.	Ash.	Depths, &c.	Carbon.	Volatile.	Ash.
A (1st three-feet seam) ...	46·9	44·0	9·1	16	38·5	36·7	24·8
B (2nd three-feet seam) ...	37·4	28·0	34·6	17	44·2	31·4	24·4
1 (from thick coal)	48·0	36·6	15·4	18	29·3	23·5	47·2
2	45·5	36·4	18·1	19	36·8	33·0	30·2
3	44·0	39·4	16·6	20	43·0	39·6	17·4
4	43·5	40·0	16·5	21	46·3	41·1	12·6
5	44·4	39·8	15·8	21*	44·9	42·5	12·6
6	44·7	39·5	15·8	22	42·7	30·6	26·7
7	47·4	36·8	15·8	23	45·3	33·0	21·7
8	47·7	36·8	15·5	24	52·4	32·0	15·6
9	47·6	40·0	12·4	25	40·3	24·5	35·2
10	48·2	39·8	12·0	26	45·6	32·8	21·6
11	46·6	44·6	8·8	27	44·2	29·0	26·8
12	40·7	44·5	14·8	28	55·1	32·0	12·9
13	60·4	33·0	6·6	29	35·6	32·8	31·6
14	38·3	28·1	33·6	30	56·2	31·6	12·2
15	37·8	28·8	33·4				

It is obvious from these results that while this thick deposit contains some layers which are really good coal, there is also a large amount which is scarcely deserving of the name of coal at all. Stuff with 30 and 40 and even up to 47 per cent. of ash—useless matter—would be of no avail excepting for purely local demand in such work as lime-burning, &c., while coal such as is represented by No. 13 or No. 30, or the bed A, would hold just comparison with some of the best coals in India. Probably the fairest way, seeing that although the specimens are taken from about every foot, the actual matter assayed may really represent only an inch or two in thickness, is to take the whole as one, and take as the mean composition the average of all the results (neglecting for the present the two separate 3 feet seams). And for comparison, to take 30 specimens of Ranigunj coals from different worked beds, and take the average composition of these.

Taking the 31 specimens of the Googoos coal, the average result of all is—

Carbon	44·51
Volatile	35·34
Ash	20·15

And the average result of 30 Ranigunj coals is—

Carbon	50·9
Volatile	34·6
Ash	14·5

that is, the Googoos (average) coal is 6·39 per cent. inferior to the *average* of Ranigunj coals as to the main heating power, and it is also 6 per cent. worse than the same as to amount of useless matter. Or, viewing it in another way, it may be said that out of the 31 odd feet of 'coal' there are 28, which contain less carbon than the *average* of 30 Ranigunj coals, good and bad, and only 3 which contain more; while there are 23 which contain more ash than the same average, and only 8 which contain less.

These results appear unquestionable, so far as the coal yet obtained is concerned. That this coal will at the same time prove highly useful cannot for a moment be questioned; and we must only continue to seek for better.

The results of these trials showed the duty of Chanda coal roughly, as compared with Ranigunj coal, to be as 67 to 87. The comparison by assay gives 45: 51, or the trial by rail gives the work in the ratio of 1·00: 1·29, that by assay as 1·00: 1·14. As compared with English coal the duty was by actual trial as 4·0 to 6·5, by assay as 44·5: 68, or, in the first case, as 1: 1·63, in the latter as 1: 1·53.

These are very close approximations and fully bear out the value of such assays. In all cases, it is worth notice also, the result as per assay is more favorable than that by actual trial. Both methods of testing the value prove that good useful fuel exists near Googoos in considerable quantity.

The explorations are being carried on with vigour, and the results will be given from time to time.

In connection with this enquiry, it is necessary to give publicity here to some important facts regarding which considerable misapprehension has evidently existed. In the last general report on the Central Provinces, the Chief Commissioner has (p. 76) said: 'so far coal has only been discovered in that known as the Damuda series, and it remains to be proved whether the Kamptee group is carboniferous.' This name 'Kamptee group' has never been published before or defined, and without such definition it is meaningless. It was a term used by Mr. W. Blanford on a preliminary sketch map of the district, copy of which was given to the officer of the Geological Survey working at Chanda for his information. But the term was simply one of convenience, and for temporary local use as applied to a series of beds in the vicinity, and signifying nothing more than those local beds; simply a name used instead of a long phrase to convey certain peculiarities in texture, &c. It is one of many such short names which, used for a time merely locally, give place to others when relations and connections have been traced out. It has therefore never been published or used in any other way than as a term of convenience among the officers of the Geological Department. It is in fact meaningless without definition.

But having thus been used, I may state that the local beds so called "Kamptee" are nothing more nor less than the Central Indian representatives of the great *Panchet* series of rocks, so well seen in the Ranigunj coal-field, still better developed in the Jherria, the Bokaro, the Karunpura, and other detached coal-fields towards the west, and which series of rocks can be (and have been) traced across all the intervening country up to Nagpur and Chanda. And as in the Ranigunj field, so in every other section exposed throughout the hundreds of miles of country (thousands of square miles) not a trace of coal is known to occur in them. This induction is far wider and far more satisfactory than any examination of the Central Provinces alone could afford.

But, in addition to this, accompanying this extension and development of the Panchet series, there is, from east to west, a steady and continuous but rather rapid diminution of the true coal-bearing rocks (the *Damuda* series), so that the formation which in the east is of several thousand feet in thickness, with more than one hundred beds of coal of varying thickness, and which is there easily divisible into three groups, on passing to the west so dwindles down, that, in the Nerbudda valley and in the Chanda field, the total thickness of the formation does not exceed as many hundred feet as it was thousands in the east, and that all the coal is confined to a few beds of great irregularity near the base of the series. These facts also have been established not by any local investigation, but by a long continued and systematically carried out series of examinations and measurements spread over hundreds of miles of the country.

There appears not a doubt as to the fact that coal does not occur in the Panchet rocks. There is equally no doubt that coal is not in the Talchir rocks below, and the simple point that remains to be proved in the Chanda field is the extent, thickness, and value of the coal which does accompany the Damuda rocks. If the country were not so much covered the limits of these rocks could readily be traced; there is no difficulty in distinguishing them. But unfortunately there is a large part so concealed by superficial deposits that the existence of these coal-bearing rocks must be probed out by boring. And this is what is now being done by the Geological Survey for the Government of India.

The borings at Chanda and at Ballarpur given above are additional proofs of the very limited thickness of these rocks. The entire thickness of the Damuda series, as it there exists, together with all the overlying beds, is said to have been passed through within about 235 feet. Of this more than one-third belongs to the upper series, leaving the thickness of the entire Damuda or coal-bearing formation here not more than about 150 feet!

The 18th October 1869. T. OLDHAM.

LEAD *in the* RAIPUR *District:* CENTRAL PROVINCES.—To the information already given regarding this lode of lead-ore but little has been added since then (*see* Records, Geological Survey of India, 1862, Pt. 2, p. 37). At the close of the season, Mr. Smart, the Revenue Surveyor engaged in that district, completed a small plan of the locality and immediate vicinity on a scale of four inches to the mile. He found fragments of the metallic vein scattered upon the top of the hill, on which it was seen for a distance of half a mile from the spot where it was discovered last year. 'The direction of dip of the vein could not be ascertained owing to the confused and fractured arrangement of the surface rocks.' Mr. Smart had no means of proving the vein.

I hope to be able to have the locality examined this season.—T. O.

METEORITES.—To the kindness of Dr. Waldie we are indebted for the remaining portion of the specimen of the Khetree stone, (fell February 1867), which he analysed with care, and of which he gave an excellent description at the meeting of the Asiatic Society in June 1869. Dr. Waldie states how it is frequently so difficult to procure specimens of these highly interesting bodies which fall from the heavens, as the people, in their ignorance looking upon such visitors as evidence of the wrath of their deities, carefully reduce to powder and dissipate all the pieces which they can procure. Only two pieces are known to exist, both small; one is in the collection of the Asiatic Society, and this one in the collection of the Geological Survey.

From Dr. Tschermak, the successor of the much regretted Dr. Moritz Hörnes, in charge of the Imperial Mineral Cabinet at Vienna, we have also received a very good specimen of the fall which occurred at Slavetič, in Croatia, on the 22nd May, 1868, and described by the indefatigable Haidinger, on the 3rd December, 1868, to the Academy of Sciences, Vienna.

Also, a specimen of the Ornans (Doub) fall, of which we were already in possession of a fine piece through the good offices of M. Marcou, (see Records, Geological Survey of India, February, 1869). This fall took place on 11th July, 1868.

Also, a specimen of the very interesting stone which fell at Krähenberg near Zweibrücken (Pfalz) on the 5th May, 1869.

These valuable additions to our numerous collection are further proofs of the friendly aid and co-operation we have invariably experienced from the Geologists of Austria.

October, 1869. T. OLDHAM.

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BALL, JOHN.—A Guide to the Eastern Alps, 12mo., London, 1868.

BARRANDE, J.—I. Réapparition du genre *Arethusina*, Barr.

II. Faune Silurienne des environs de Hof en Bavière, 8vo., Leipzig and Paris, 1868. THE AUTHOR.

BEAUMONT, ELIE DE.—Rapport sur les progrès de la stratigraphie. Recueil de Rapports sur l'état des lettres et les progrès des sciences en France, Roy. 8vo., Paris, 1869.

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