

RECORDS
OF
THE GEOLOGICAL SURVEY OF INDIA.

VOLUME XXII.

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ERRATA.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA, Vol. XXII.

PART I.

- Page 57, line 14 from top: for *have* read *had*.
" 57, " 3 " bottom: for *thusgi* read *thurgi*.
" 58, " 2 " top: for *have* read *had*.
" 58, " 9 " " " *flaviventus* read *flaviventris*.
" 58, " 10 " " " *teetum* read *tectum*.
" 58, " 11 " " " *flaviventus* read *flaviventris*, and for *teetum* read *tectum*.
" 58, " 8 " bottom: for *thusgi* read *thurgi*.
" 58, " 4 " " " *flaviventus* read *flaviventris*, and for *teetum* read *tectum*.

PART II.

- Page 137, line 19 from top; for "less of" read "of some".
" 138, " 15 " bottom; *erase* "it".
" 139, " 15 " " for "screen" read "scree".

ERRATUM.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA,

VOL. XXII, PART 3.

Page 172, line 2 from bottom, for 16'59 read 19'69.

REFERENCE TO THE MINERALITE (*var. peridotite*), or "blue" (miner's term, not a blue clay) of the Cape diamond fields; and it is also said, but not authoritatively, that some of the diamonds of Wajra Karur have been found in it. A paper by Mr. Foote, bear-

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RECORDS
OF
THE GEOLOGICAL SURVEY OF INDIA.

Part I.]

1889.

[February.

ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA, AND OF THE
GEOLOGICAL MUSEUM, CALCUTTA, FOR THE YEAR 1888.

PENINSULAR INDIA.

MADRAS PRESIDENCY.—*Crystalline rocks,—Archæan.*—Accompanied by the Superintendent for Madras during part of one of my tours, I have again visited some of the diamond-producing areas in the Bellary and Kurnool Districts, more particularly with a view to the elucidation of the occurrence of these gems at Wajra Karur, where no outlier or remnant of the recognized diamond-bearing beds (*Banaganpillis* of the Kurnool series) exists. The original source, or parent rock for diamonds, has always been the object of our search; for it gradually became evident—to myself last of all among my colleagues—that the gems known to occur in the peculiar gravelly shales near the base of the Banaganpilli sandstones may really be only pebbles just as much as the waterworn detritus with which they are associated, and now it would almost seem as if we were on the eve of learning of such an original source occurring in volcanic intrusions in the crystalline rocks or gneisses of the Bellary District. I say, of learning, because if it eventually turn out that the diamonds of Wajra Karur do occur in the rock supposed to contain them at that place, then the discovery will be due to non-official or private exploitation of the country. The fact remains that diamonds are found in the surface soils and gravels of Wajra Karur (and at other places also in the Bellary District), on the summit of a low water-shed where at present there is no visible parent rock at a higher level whence they could have been derived. On the other hand, it is said, and has been reported in other papers as well as in the Records of the Survey, that a “neck” of igneous rock occurs among the gneisses there which bears some resemblance to the Kimberlite (*var.* peridotite), or “blue” (miner’s term, not a blue clay) of the Cape diamond fields; and it is also said, but not authoritatively, that some of the diamonds of Wajra Karur have been found in it. A paper by Mr. Foote, bear-

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ing on this so far curious and unique question, appears in the present number of the Records, in which it will be seen that he doubts whether diamonds can exist in this "neck" rock, and that he prefers rather to conclude that the diamonds of this place occur only as part and parcel of the superficial debris, having been derived from a long-disappeared upper portion of the same "neck" rock which had passed through some carbonaceous deposit which in past ages has also been worn off the face of the country. I prefer myself, as yet, to consider that these diamonds are from the debris of outliers of Banaganpalli sandstone which once existed near or at Wajra Karur; small outliers of such rocks having only lately been mapped by Mr. Foote much further south-westward of Kurnool than we had anticipated. In the meantime, we have not been able to detect any diamonds in the specimens of "neck" rock which have come under our treatment.

Transition, the Dharwar Series.—Mr. Foote has been engaged all the year on this economically important series of rocks; and his concluding observations on them, so far as they are fitted for preliminary publication in these Records, are given in the present number, the first instalment of them having appeared in the May issue. A map showing the distribution of the different bands of the series, and the known localities of gold occurrence, was also given in that number; so that the whole report should prove eminently useful in the further and, I may almost say, assured progress of the gold industry in the Madras Presidency. The area over which these bands of transition rocks occur in Southern India is enormous, stretching in a more or less north-north-west, south-south-east direction from about the 17th to beyond the 13th parallel of north latitude; and distributed over a breadth of 192 miles: while the number of spots in this huge tract which have been mined in past times and by a so far unknown people is very remarkable. The story of the struggles and ultimate success of the Kolar gold mines (which occur in the easternmost of these bands of Dharwar rocks) up to the present is well known: but if we may place any reliance on the geological relations of the series, and on the ancient working of that auriferous tract, the conclusion that other gold fields of equal if not superior richness are still lying fallow seems almost inevitable; indeed, the mere distinction of this series of rocks by the Survey has led to the recognition within the last year by Mr. Hughes of one of those in the Raichore Doab, where the extent of old mine workings, and the evidences of the means adopted for crushing the ore are marvellous.

I took the opportunity while still with Mr. Foote of re-visiting the Kolar tract as also this newly-found area in the Raichore Doab, when I was struck with the wonderful similarity in many features of the two regions; and at the same time was glad and indeed proud to recognize the *bond fide* scientific value and accuracy of the report of my colleague Mr. Hughes in his so much questioned though officially sanctioned connection with the Hyderabad Deccan Company.

Lower Gondwana.—The economic value of the extension of this formation down the valley of the Godavari river and on the drainage area between that river and the Kistna, has at last been brought into prominent notice by the successful exploitation of the Singareni coal-field by Mr. Hughes. The fact of the occurrence of

NIZAM'S DOMINIONS.
Coal-fields.

this outlying patch of coal-measures was made known so far back as 1872, and it is some satisfaction to the Survey, after so many years of waiting for its final development, that this should have been reserved for our colleague. At the close of Mr. Hughes' deputation with the Hyderabad Deccan Company, I revisited the tract under the further light which has been thrown upon it by shaft and incline workings, as well as to test—if there were any need of that—the value of the reports furnished by Mr. Hughes to his employers. This inspection has more than justified my original appreciation of the field, as also my later view of its possible capabilities in 1883 when I estimated that seventeen million tons of coal may be reasonably relied on. The borings which were put down by the Nizam's Government turn out, I regret to find, to be unreliable; nevertheless the new survey, borings, and workings show that the coal, though cut off at times by faults, is there in all its natural extension and quality. I do not think that Mr. Hughes over-estimated the conditions of the field when he reported as follows in 1887:—

- “(a) Its area is greater than that of the Umaria estate and the Karharbari field.
- “(b) The character of such of its coal as came within the range of inspection and practical trial has been declared by practical authorities. It is a good steam coal, has little or no clinker, contains only the average amount of ash, withstands weathering, and, from its texture, will bear handling.
- “(c) The entire series of coal measures is within easy reach of the surface, and there are the unknown possibilities of superior fuel occurring in the seams which have not been opened out.
- “(d) The field is beyond the range of detrimental competition, and it can claim the advantage of an assured consumption of 180,000 tons of coal per annum.
- “(e) The covering, cost of cutting, winding, and loading coal into wagons at the pit's mouth ought not to exceed Rs 2 a ton, when full raisings are established.”

Since then, or at the end of June 1888, the output of the colliery workings is recorded at 70 tons of round and 20 of small coal, or a total of 90 tons a day.

As to the powers of the coal, the Locomotive Superintendent of the Nizam's Railway reports in June 1888:—

“The condition of the trials as regards train loads and locomotive engine power were ordinary, and the results obtained may be taken as reliable data upon which to form an opinion of the quality of the Singareni coal supplied as a locomotive engine fuel. The coal was of average merit and not selected.

“The following were the averages:—

	B.
Coal per train mile	33'47
Water evaporated per pound of coal	6'36

Tertiaries of the West Coast.—Mr. Lake, having had his initiatory season of Indian geological work in company with Mr. Foote, was posted at the commencement of the present field season to the working out of the geology of the West Coast in the long tract of country between Cochin and Karwar. This is one of the few blank areas in the map of the

general geology of India which has remained unexplored; and already, though somewhat delayed by sickness, it is satisfactory to report that Mr. Lake's observational powers are of immediate value in so far as he has noted a possible relation between the existence of an oil shale among the strata underlying Calicut, and the movement of the mud bank at that place. This observation, though it does not as yet give any promise industrially, seems to throw further light on the smooth water tracts of Cochin and Alleppy to which I drew attention in 1884, in connection with the fact that the mud dredged from the banks underlying them had yielded a trace of oil.

A find of marine shells in the laterite of Malabar, and the recognition of two distinct levels of laterite, are important additions to our still very imperfect knowledge of this protean formation.

CENTRAL PROVINCES.—*Transition; Bijawars.*—The question of the exploitation of the manganiferous deposits at Gosalpur and other places in the Jubbulpore District having again been opened by the Central Provinces Government, Mr. Bose was deputed to make a thorough re-examination of the area. This was a close and intricate business, involving the making of several shallow pits and cross-cut trenches, and Gosalpur manganese ores. It occupied the whole of the working season; the result being two reports, the first of which, having to do with the practical bearings of the question, appeared in the August part of the Records, while the second (not yet published) dealt with the theoretical aspect of these unusual occurrences among the Bijawar rocks. Mr. Bose estimates the total quantity of *pyrolusite* (manganese ore) at Gosalpur at about 50,000 tons, while from the Sihora tract, and other neighbouring localities, about 26,000 tons may be reckoned on. The manganiferous hæmatites may be considered as practically inexhaustible.

The whole enquiry, however, remains very much as it was originally discussed by Messrs. Medlicott and Mallet; though there is no doubt that Mr. Bose's survey has added very materially to our knowledge of the region in the matter of details, while he has kept the problem regarding the origin of the *pyrolusite* well before him. The evidence, so far indeed, shows that the distribution of this ore may be very largely, if not entirely, attributable to sub-aerial influences which seem to have prevailed with greatest intensity during an early stage of the Recent or perhaps Post-pliocene period, one form of their action having been *lateritisation*, if we may so designate that chemical change or alteration resulting on weathering, concomitant with infiltration of iron peroxide (and rarely manganese oxide), which has certainly in some cases at least taken place on the transformation of certain rocks into laterite. A point of considerable interest in this connection is that it was in the Gosalpur neighbourhood that Mr. Mallet saw cause for suggesting the leaching out of the manganese from the adjacent manganese iron beds of the transition series, as accounting for the occurrence of what may be called a *manganese laterite* as distinct from the ordinary iron or ferruginous laterite: a distinction of some importance, leading as it does to the supposition that the few indications hitherto observed (not the least of them being that noted in the Bidar laterite by Captain Newbold so far back as 1844) of manganese ore among the laterites of the Madras Presidency may point to a wider occurrence of these ores than has hitherto been presumed.

Manganese laterite.

Since the commencement of the present field season, Mr. Bose has again resumed work in Balaghat among the Transition and Vindhyan rocks ; which in that region, and for the present, are classed under the local names of the Chilpi series and the Chattisgarh Vindhyan, though the former certainly bears in some respects a close resemblance to the Bijawar series in the Narbada Valley, and yet in other respects a much closer likeness to the Dharwar series of the Madras Presidency. For the present, however, a special economic relation between them and the Bijawars of the Narbada Valley lies in the existence of the Balaghat manganese, for the examination of which Mr. Bose's recent experience at Gosalpur must have well fitted him.

Deccan Trap Series.—Babu Kishen Singh has carried on the boundary of the Deccan Trap in the Chindwara District as far westwards as the Chindwara-Nagpore high road, where he has also followed the Lameta or Infra-trappean deposits as well as the much less continuously distributed Inter-trappean beds which are occasionally fossiliferous. His progress report is fairly interesting and full of details of the ground and of the specimens he has sent up to head-quarters, all of which will prove of increased value when this great formation of the Deccan comes to be more closely studied. Kishen Singh has now been placed with Mr. Bose for further training among the more intricate and difficult, as well as somewhat economically interesting rocks of Balaghat.

CENTRAL INDIA AND RAJPUTANA.—*Transition Series.*—My hopes regarding Mr. Hacket's being able to extend his observations sufficiently to the westward of Jodhpore to touch on the Gondwanas have not been fulfilled. His season's work lay to the westward of Mt. Abu, and the Aravallis, and it is laid down on sheets 74 and 75, and portion of sheets 93, 94, 95, 96, and 97 of the Topographical Survey maps: but partly from the increasingly complicated association of the different series of the very altered rocks in that region, and the disconnected way in which the ridges and outcrops of these show among the intervening sand wastes; and mainly, I fear, from broken health and failing energies, little further way has been made towards a solution of the geology of that region. Mr. Hacket's service was completed on return to head-quarters from the field, and he retired in July last.

A very peculiar and almost unique (for India) decomposition-form of certain quartzites belonging to the transition series has been long known under the name of "flexible sandstone," as occurring at Kaliana in the Jheend State; and enquiries having frequently come from Europe, and specially from America for specimens, opportunity was taken after he had finished the search for supposed petroleum in Ulwar, of Mr. Oldham being in the neighbourhood for obtaining specimens and ascertaining as much as possible concerning the stone and its occurrence in this hitherto unvisited locality. A note on the nature and mode of its occurrence, and the cause of its flexibility, is given in the present Records; and duplicate fragments of the rock are available for museums.

Mr. E. J. Jones and Sub-Asst. Hira Lal.

ENGLA PRESIDENCY.—*Crystalline Series.*—Renewed search for materials required for the increased development of the iron industry at the Barakar Works was taken up at the earnest solicitation of Ritter von Schwartz, and later on, to meet the demand raised

by Mr. Manneberg who came out to this country under an introduction from, or at the instance of, the Secretary of State for India, to the Government of Bengal in connection with these Iron Works.

Limestone for Bengal
Iron Works.

Mr. Jones was deputed for this enquiry, when he made a more rigorous and detailed examination of the dolomite of Dhelwa in Hazaribagh, and the limestones at Raniganj, Simaltala, and Pachete hill proving that stone of the pure composition demanded was available in sufficient quantity. He also pointed out sites for bore-holes, which have led to the knowledge of stores of coal which should raise the value of the estate proportionally.

Lower Gondwana.—Babu Hira Lal is still engaged in mapping the extensive coal tracts of the western portion of Chota Nagpur: his progress report for the last season being a description of portions of the Rampur, Sirgujah, and Lakhanpur coal-fields and parts of the adjacent area. All the coal outcrops have been examined and recorded, while assays have been made of such seams as were thought worth trying, some of them giving very fair results. His progress report, with accompanying portions of four sheets of the Chota Nagpur topographical survey, on a scale of one mile to the inch, are very creditable results of the season's work.

An attempt is at last about to be made by the Bengal Government to ascertain the capabilities of one of the coal-fields of the Rajmahal hills. The only effort hitherto in this way was, I believe, made on the eastern edge of these hills near the town of Rajmahal itself, which, had it been successful, would have opened up a most convenient source of supply for the deltaic system of railways. The boring was intended to have been run down 500 feet, but the attempt fell through before this depth had been attained. Attention is now being directed to the western side of the hills on what has been called the Hura coal-field, where outcrops of coal had been quarried long ago and a quantity of coal extracted, until the workings fell in and so obscured all further enquiry into the quantity or quality of the fuel. Boring is the only course to be followed out now for ascertaining anything further: and advice was given on this point. After a delay of some six months owing to the difficulty of getting any one to take up a contract for the boring, a further advance has been made: and, for the satisfaction of all parties, Mr. Jones was sent out in company with the District Engineer to select sites. He reports that such coal as could be seen or picked up is not of a very promising quality; but this cannot be taken as a fair indication of what the borings may show, and the field should not now be left with any doubt as to its value.

Chota Nagpur coal-
fields.

Rajmahal coal.

Delay in Boring ex-
ploration.

The present case is only a further instance of the unsystematic and indeed mixed way in which mining investigations are occasionally carried out by Government in this country, where such work has always been done directly by the Department of Public Works, and indirectly through advice from this Department. Much of the evil attending such a mode of procedure may be attributed to the notion that it is just as easy here in India, where mining work is as yet only very local,

How to meet the diffi-
culty of carrying out
borings.

to obtain skilled and experienced miners as it is in England: whereas the few men so trained, and on whom any reliance can be placed, are already fixed at the work which

suits them and requires them; the residuum of partially trained hands, or men of all trades with no special aptitude for any, being often worse than useless. There is, above all, the ever-recurring difficulty of finding boring plant, notwithstanding the fact that sets of such plant have been purchased over and over again, owing to loss or that they are stored at too great a distance from the new region of investigation.

Under such difficulties or disadvantages, I now repeat what I have often urged previously, that—in the present stage of mining in India—the Geological Survey Department is, or at least ought to be, best qualified for carrying out such preliminary exploitation. With sets of boring and certain mining plant stored at a convenient centre, and a mining manager with a small staff of subordinates—selected in some cases from men trained in an Engineering School like Sibpore College, I feel confident that mining questions would be settled more quickly,—and therefore at least more economically,—than has hitherto been the case. Indirectly also, by this means, a class of trained and reliable men would be gradually formed in the country from people of the country, ready to fill the many posts now occupied by highly paid men imported from England or the Continent.

EXTRA PENINSULAR INDIA.

BALUCHISTAN AND THE PUNJAB.—Tertiary.—So many varied reports, followed by enquiries, having arisen regarding the quality and extent of the coal outcrops and oil resources on the north-western frontier, I felt it incumbent on me to see what the actual condition of these developments are. At Khost,

Khost coal.

on the Sind-Pishin Railway, endeavours were being made by Mr. G. B. Reynolds, of the Public Works Department, to form a plan for working the thin seams of tertiary coal which, owing to the opening up of the railway, have lately assumed a very important aspect. The coal of this region, though not that of Khost itself, had been already briefly visited and reported on by Mr. W. T. Blanford in 1882, when, though the coal is good, the view taken of its extent and facility of being worked was not favourable. The Khost coal occurs, as far as I saw, in two thin seams cropping out at the foot and up the slope of the hills on the south-west side of the valley, a mile or so behind the railway station, dipping into the hill at an angle of 30 to 45 degrees. The outcrops have been grubbed at in all sorts of ways by digging at the surface as long as the ground would hold, or by driving galleries along the seam at a short distance inside the outcrop; and, so far, baskets of very good fuel are landed by coolies at the station at a very low rate, sufficiently so at least to satisfy the N. W. Railway administration. The more prominent seam varies from 2 to 3 feet in thickness, several inches of it being mere shale; so that there may be from 18 inches to 2 feet of good coal at times: it is badly crushed and squeezed, partly through being an outcrop-seam on the steep slope of the hillside, and it is very sulphurous from iron pyrites.

Of course, the happy condition of the coal being landed at present so cheaply on the railway platform must soon come to an end; so the problem before Mr. Reynolds was how to work a seam so disadvantageously placed. He proposed to run

an incline adit down on the dip of the coal as far as this could be conveniently carried, from the bottom of which horizontal drifts should be run with the seam on either side; the seam to be worked out upwards towards the outcrop. Haulage of coal to be up the adit to mouth and thence by incline down to railway. I have not heard that any progress has been made with this scheme: but in face of the very fitful continuity of the coal, and the extremely unstable character of the beds above and below, necessitating a costly form of holding up the workings, it seemed to me—although the only apparently feasible way of getting the coal—an essentially questionable adventure as far as profitable working went. Under these circumstances, and knowing as we do by Mr. Blanford's report and by what I myself saw in the neighbourhood of Sharigh, that there is horizontality, or nearly so, of the same series of beds with perhaps the same seam of coal; I really think that a close survey of the stratigraphy of the valley should be made before any further extensive scheme for working such untowardly disposed beds as those of Khost be tried.

There remains indeed the hope that the disadvantages connected with the exploitation of coal in Baluchistan may be met by the utilization of the petroleum which has been so successfully brought to the surface by Mr. R. A. Townsend at Khatan:

Khatan oil. but here again there is the difficulty of transport of the oil which militates strongly against the paying employment of this admirable fuel. As it is, the oil is too thick to flow any distance of its own accord, and it will have to be carried or forced over a very difficult country for some forty odd miles before it can be placed on the railway; while the place of the oil works themselves is about as desert a hilly tract, without supplies of any kind or even drinkable water, as can be imagined for the centre of such an industry. The pity of it is that this region should have been selected for Mr. Townsend's exploitation rather than others of much less inconvenient approach to the railway, where oil-shows were known. There can be little doubt that the oil in Baluchistan, within reach of ordinary boring, is of local occurrence, occurring in or among certain bands of the tertiary rocks, dependent too on particular stratigraphical features; so that it would be rash to bore at haphazard in any position among such beds as we know, for instance, underlie the great plain or 'pat' of Sibi and Jacobabad: but it struck me that as oil-shows are known in the neighbourhood of Shoran, where the rocks rise out of the place in an anticlinal undulation, the place also being more accessible, the Baluchistan oil explorations might be very advantageously directed to that side of the country. I now hear that operations have been commenced there.

I also visited the oil-shows in the Rawalpindi District, which certainly look poor enough, though the quality of the oil so far is superior to any yet seen in Baluchistan, or even in Assam. When, however, the poorness of these shows is compared with what I saw of the indications (pointed out to me by Mr. Townsend) of oil on the surface at Khatan, where, too, what may be called 'live oil' shows do not occur at all; I cannot divest myself of the idea that the deep boring proposed for the Rawalpindi region may yet yield a fair supply, though it too will no doubt have to be raised by pumping, the highly folded and shattered condition of the strata scarcely affording any expectation of a closely confined store of oil.

KASHMIR.—Mr. La Touche's deputation with the Kashmir Durbar has just come to a close; and on this duty he has been able to give valuable information not only on the special question before him, *viz.* the investigation of the occurrence and extent of the sapphire rocks in the Zanskar District, but also on the Jummu coal to which his paper on the Sangar Marg and Mehagala coal-fields, in the Records for May last, refers. At the request of the Durbar he also reported on the iron works and ores near the village of Soap, in the Kashmir Valley, with a view to their further development.

Mr. La Touche.

Sapphires.
Coal.
Iron.

A notice of his in the last part of the Records, on the rediscovery of nummulitic fossils in Zanskar, confirms a very interesting observation of Dr. T. Thompson made so long ago as 1852, which observation had been questioned by Mr. Lydekker in his Geology of Kashmir and Chamba. This is the more gratifying as Dr. Thompson's find had been utilised by MM. D'Archiac and Haime in their classical work on the Nummulitic Fossils of India.

He also on his return through Murree, endeavoured to meet the pressing question of an improvement in the water-supply; coming to the conclusion that, though the local supply might be increased to a small extent, the necessities of the case can only be met by bringing in water from a distance. A report on the question was furnished to the officer commanding the Rawalpindi Division.

Nummulitic fossils.

Murree water supply.

HIMALAYAS—*Archæan, Palæozoic, and Mesozoic.*—The tract of the Himalayas at present under survey consists of two parts or sections of the outer ranges: (1) the country extending north-westwards from Haldwani to the Ganges near Hardwar, in the hands of Mr. Middlemiss; and (2) the succeeding Dehra and Simla portion as far as the Sutlej, under Mr. Oldham, with whom, for the present, Mr. Datta is associated.

Messrs. R. D. Oldham, C. S. Middlemiss, and P. N. Datta.

Mr. Oldham, seeing that there has been no general review of our knowledge of the Geology of the Himalayas since the publication of the Manual of the Geology of India, and in the face of the progress made since then rendering necessary the amalgamation of the many isolated accounts of different portions of the range, put forward a valuable paper in the Records of August last, on the Sequence and Correlation of the Pre-Tertiary Sedimentary formations of the Simla region of the Lower Himalaya which ought to meet to some extent the world-wide demand for the latest information on the geology and structure of this special mountain region. His later paper in November on the Geology of the North-West Himalayas gives a further Record of observations in Spiti, Ladak, and Kashmir; such as can only be made, when opportunity offers for the carrying of geological traverses over the higher ranges.

Simla region and N. W. Himalaya.

Mr. Middlemiss contributed a further paper (No. III) on the study of the crystalline and metamorphic rocks of the Lower Himalaya, Garhwal, and Kumaun.

Tertiary.—The survey of the Haldwani-Hardwar tract is so far completed as to have enabled Mr. Middlemiss to send in the MSS. and maps for a finished Memoir, which will be issued early

Garhwal and Kumaun.

this year. It deals with the physical geology of the Sub-Himalayan belt of newer tertiaries, the pre-tertiary or Himalayan sub-groups being treated of incidentally.

Mr. Datta has only just commenced his Indian geological career this field season under the guidance of Mr. Oldham; so that a fair judgment can hardly yet be formed on the style of his work or the application to it of the excellent geological and observational attainments attributed to him in the recommendations for his appointment to the Survey. So far, however, Mr. Oldham's report of him seems to show that his chief patron, Professor James Geikie, must have formed a rather exaggerated if not enthusiastic appreciation of his pupil's attainments: or else it may be—and this is quite possible—that a kind of reactionary numbness or slacking off of the faculties of observation and generalization has followed on the strain of European training in a scientific profession as yet new to the Native of India.

ASSAM.—*Tertiary*.—At my suggestion, Mr. R. A. Townsend, Superintendent of Petroleum Works in Baluchistan, was deputed, during the rains, to look up the oil indications in the neighbourhood of the Naga Hills. The Survey had already

reported on these and their geological relations, in the Makum oil-field. Memoirs of Messrs. Medicott and Mallet: but it naturally seemed of the highest importance that the views of so experienced a specialist should be placed before us. Mr. Townsend divides the region into two portions for convenience of description,—Makum and Jaipur,—with the latter of which he only formed a slight acquaintance. The report on Makum is very encouraging: but promising as the oil may be in so far as quantity is concerned, it is well to call attention to the fact that there is no evidence (as far at least as the records in this office go) proving its capability of yielding a satisfactory proportion of burning oil on distillation. A sample brought by Mr. Townsend, which has been recently examined in the Survey laboratory, yielded (by volume) 92 per cent. of oil, which was collected in ten equal portions. The first, and lightest, tenth had a specific gravity of .833, and flashed at 139° F. (Abel's test); the specific gravity of the other portions being respectively .847, .858, .867, .875, .878, .870, .864, .861, .882.

This result is quite borne out by an analysis of petroleum from Assam (presumably Upper Assam) made by Prof. Boverton Redwood (Cantor Lectures on Petroleum and its products), who obtained—

	per cent.
Naphtha	None.
Burning oil	None.
Lubricating oil	94.2.

The analysis, again, of a sample from the neighbourhood of Makum (and very probably from a *bore hole* at Makum) gave 94.3 per cent. of oil, of which all but 2 per cent. (the specific gravity of which is not given) had a specific gravity ranging between .873 and .936. (Rec. G. S. of I., VII, p. 57.)

Mr. Townsend's sample was obtained at the surface from a natural oil spring; and, as he justly remarks, "the illuminating value of the crude oil can only be ascertained from samples taken from the oil measures below the surface which have not been exposed to atmospheric influences." But, until such petroleum from below has been examined, it will be as well not to assume what is as yet unproven.

BURMA.—The demand for further information regarding the resources of Burma necessitated the deputation of Dr. Noetling to that country; though he can be very ill-spared indeed from his proper post as Palæontologist of the Survey, an enormous and long-stored collection of fossils awaiting his examination and description. So far, however, his employment in Burma has had its value; so much so indeed that his services have been utilized to their fullest extent by the Chief Commissioner both in Mandalay and out in the districts during the working season and in the rains. I am hopeful, however, that arrangements may shortly be made which will allow of his returning to his more special work at the Museum in Calcutta.

Up to this, Dr. Noetling has examined and reported on the oil-fields of Youang-young, Thayetmu, and other places. He has also recognized Silurian rocks in the Shan Hills, with the limestones of which is associated a very important and extensive band of iron ore; and his latest expedition has been to the Ruby limestone tracts of Madya and Kya-uhyat, at which he has made some satisfactory investigations.

Mr. Hughes, since re-joining the survey, has been also posted to Burma; and so far has completed a special mission to Perak, associated with the Director of the Department of Land Records and Agriculture for Burma, for the examination of the system under which the various tin mines of that State are conducted. He is now in Tenasserim, where he is to arrange, if possible, for the thorough exploitation of the tin ores of that province.

Survey Publications.—The issues have been the usual current volume (XXI) of the Records, containing sixteen papers, five of these being of considerable economic interest; a Bibliography of Indian Geology compiled by Mr. R. D. Oldham, which will meet a very urgent want of geologists; and the concluding part of the Productus Limestone Fossils of the Salt Range by Dr. Waagen, forming Fasciculus 7, "*Calenterata—Amorphosoa—Protozoa*," of the Palæontologia Indica, published early in the year.

In connection with the issue of the Records, it is gratifying to note that, as heretofore, volunteer contributions have been sent in by Dr. Carter and Mr. Lydekker on the fossil finds which it is necessary for us to send home from time to time to specialists in palæontology, while our local contributors are represented by Dr. H. Warth and Commander Alfred Carpenter, R.N.

Library.—1,645 volumes, or parts of volumes, were added during the year: 1,067 by presentation or exchange, and 578 by purchase. The library is gradually becoming the resort of students and others, the issue of books on loan being allowed as far as is possible consistent with due regard to its proper consulting or reference use.

Museum and Laboratory.—Mr. Jones carried on these two sections of the Survey until the return of Mr. Mallet in October from sick leave. Numerous assays and reports on coal, oil, limestone, ores of iron, copper, lead, and other minerals have been made for private individuals and mining companies, in addition to the usual examination of rocks and minerals sent in by the officers of the Department. An interesting enquiry has been made on the constitution of the cobaltiferous "matt"

reported as being produced in Nepal : while a systematic series of experiments likely to lead to the utilization of some of the Indian soapstones in the gas industry at home has been made and reported on, in obedience to a requisition from the India Office.

The Museum record of additions by presentation, exchange, or purchase keeps pace with that of previous years.

Mining Records.—In response to a call which was sent out to the different coal companies, arising out of an indication in the public papers of a renewal of the question of mining inspection which I considered need hardly be opened as yet ; a very cordial co-operation was evinced by the promise of a fresh series of maps, sections, and other records from :—

Messrs. Apcar & Co.,
 Messrs. Bird & Co. for the Alipur Coal Co.,
 The Bengal Coal Co.,
 The New Birbhum Coal Co.,
 The East Indian Railway,
 The Ranigunj Coal Association,

the last two Companies and Messrs. Bird & Co. having already sent in their records.

International Geological Congress.—The Survey was represented at the gathering of this assembly of geologists in London in September last by Mr. Medlicott, the late Director, and by Dr. W. T. Blanford, President of the Geological Society. Mr. R. D. Oldham, also, had an opportunity while on privilege leave of exhibiting specimens of interest from India. The acknowledgments of the department are due to the Direction for presentation in advance of copies of Sheet 24 (CIV), and the Scale of Colours of the new International Geological Map of Europe, forwarded by Mr. Blanford.

WILL. KING,

Director, Geological Survey of India.

January 31st, 1889.

List of Societies and other Institutions from which Publications have been received in donation or exchange for the Library of the Geological Survey of India, during the year 1888.

- ALBANY.—New York State Museum.
 BALLARAT.—School of Mines.
 BALTIMORE.—John Hopkins University.
 BASEL.—Natural History Society.
 BATAVIA.—Batavian Society of Arts and Sciences.
 BELFAST.—Natural History and Philosophical Society.
 BERLIN.—German Geological Society.
 „ Königlich Preussische Geologische Landesanstalt und Bergakademie.
 „ Royal Prussian Academy of Science.
 BOLOGNA.—Royal Academy of Sciences.
 BOMBAY.—Bombay Branch, Royal Asiatic Society.
 „ Bombay Observatory.
 „ Marine Survey of India.
 „ Meteorological Department.
 „ Natural History Society.
 BORDEAUX.—Linnean Society of Bordeaux.
 BOSTON.—American Academy of Arts and Sciences.
 „ Society of Natural History.
 BRESLAU.—Silesian Society.
 BRISBANE.—Queensland Branch, Royal Geographical Society of Australasia.
 „ Queensland Museum.
 „ Royal Society, Queensland.
 BRISTOL.—Bristol Naturalists' Society.
 BRUSSELS.—Royal Geographical Society of Belgium.
 „ Royal Malacological Society of Belgium.
 „ Royal Museum of Natural History, Belgium.
 BUCHAREST.—Bureau Géologique, Roumain.
 BUDAPEST.—Hungarian Geological Society.
 „ Hungarian National Museum.
 BUENOS AIRES.—National Academy of Sciences, Cordoba.
 CAEN.—Linnean Society of Normandy.
 CALCUTTA.—Agricultural and Horticultural Society.
 „ Asiatic Society of Bengal.
 „ Editor, Indian Engineer.
 „ Editor, Indian Engineering.
 „ Indian Association for the Cultivation of Science.
 „ Meteorological Department, Government of India.
 „ Survey of India.
 CAMBRIDGE.—Philosophical Society.

- CAMBRIDGE, MASS.—American Academy of Arts and Sciences.
 „ Museum of Comparative Zoology.
 CINCINNATI.—Society of Natural History.
 COPENHAGEN.—Royal Danish Academy.
 DIJON.—Academy of Sciences.
 DRESDEN.—Isis Society.
 „ Royal Mineralogical Museum.
 DUBLIN.—Royal Geological Society of Ireland.
 „ Royal Dublin Society.
 „ Science and Art Museum.
 EDINBURGH.—Royal Scottish Society of Arts.
 „ Scottish Geographical Society.
 GENEVA.—Société de Physique et d'Histoire Naturelle.
 GLASGOW.—Glasgow University.
 GÖTTINGEN.—Royal Society.
 HALLE.—Kais. Leopoldinisch-Carolinische Deutsche Akademie der
 Naturforscher.
 HARRISBURG.—Second Geological Survey of Pennsylvania.
 HOBART.—Royal Society of Tasmania.
 KÖNIGSBERG.—Physikalisch-Ökonomische Gesellschaft.
 LAUSANNE.—Vaudois Society of Natural Sciences.
 LEIDE.—École Polytechnique de Delft.
 LEIPZIG.—Geographical Society.
 LILLE.—Société Géologique du Nord.
 LISBON.—Geological Commission of Portugal.
 LIVERPOOL.—Geological Society.
 LONDON.—British Museum.
 „ Geological Society.
 „ Iron and Steel Institute.
 „ Linnean Society of London.
 „ Royal Asiatic Society of Great Britain and Ireland.
 „ Royal Geographical Society.
 „ Royal Institute of Great Britain.
 „ Royal Society.
 „ Society of Arts.
 „ Zoological Society.
 MADRID.—Geographical Society.
 „ Royal Academy of Sciences.
 MANCHESTER.—Geological Society.
 „ Literary and Philosophical Society.
 MELBOURNE.—Department of Mines and Water-supply, Victoria.
 „ Geological Society of Australasia.
 „ Public Library, Museums, and National Gallery, Victoria.
 „ Royal Society of Victoria.
 MILAN.—Society of Natural Science.
 MINNEAPOLIS.—Minnesota Academy of Natural Sciences.

- MONTREAL.—Geological and Natural History Survey of Canada.
 MOSCOW.—Imperial Society of Naturalists.
 NAPLES.—Royal Academy of Science.
 NEWCASTLE-ON-TYNE.—North of England Institute of Mining and Mechanical Engineers.
 NEW HAVEN.—Connecticut Academy of Arts and Sciences.
 „ The Editors of the “ American Journal of Science.”
 NEW YORK.—Academy of Sciences.
 OXFORD.—Oxford Museum.
 PARIS.—Academy of Sciences.
 „ Geographical Society.
 „ Geological Society of France.
 „ Mining Department.
 PHILADELPHIA.—Academy of Natural Sciences.
 „ American Philosophical Society.
 „ Franklin Institute.
 PISA.—Society of Natural Sciences, Tuscan.
 ROME.—Geological Society of Italy.
 „ Royal Academy.
 „ Royal Geological Commission of Italy.
 SACRAMENTO.—California State Mining Bureau.
 SAINT PETERSBURG.—Geological Commission of the Russian Empire.
 „ Imperial Academy of Sciences.
 SALEM, MASS.—American Association for the Advancement of Science.
 „ Essex Institute.
 SAN FRANCISCO.—California Academy of Sciences.
 SHANGHAI.—China Branch, Royal Asiatic Society.
 STOCKHOLM.—Geological Survey of Sweden.
 STRASSBURG.—Heidelberg University.
 SYDNEY.—Australian Museum.
 „ Department of Mines, New South Wales.
 „ Linnean Society of New South Wales.
 „ Royal Society of New South Wales.
 „ Technological Industrial and Sanitary Museum.
 TORONTO.—Canadian Institute.
 TURIN.—Royal Academy of Sciences.
 VENICE.—Royal Institute of Science.
 VIENNA.—Imperial Geological Institute.
 „ Imperial Natural History Museum.
 „ Royal Academy of Vienna.
 WASHINGTON.—National Bureau of Education.
 „ Philosophical Society.
 „ Smithsonian Institution.
 „ United States Geological Survey.
 WELLINGTON.—Colonial Museum and Geological Survey of New Zealand.
 „ Department of Mines, New Zealand.

YOKOHAMA.—Asiatic Society of Japan.

„ German Naturalists' Society.

YORK.—Yorkshire Philosophical Society.

The Secretary of State for India.

The Governments of Bengal, Bombay, India, Madras, and Punjab

The Chief Commissioners of Assam and Burma.

The Resident at Hyderabad.

The Quartermaster-General of India, Intelligence Branch, Simla.

The Dharwar System, the Chief Auriferous Rock-Series in South India ;
by R. B. FOOTE, F.G.S., Superintendent, Geological Survey of India,
 (continued).¹

The first half of this paper which appeared in the second part of the *Records* for last year (1888) gave a general outline of the distribution of the different great bands and minor patches of this very important and interesting rock system, and a succinct account of the main geological features presented by the two great western bands, the Dharwar-Shimoga and the Dambal-Chiknayakanhalli bands. There remain then for description the numerous outliers (III) between these two great western bands; the Sandur hills and Copper Mountain tract in the Bellary country (IV); the great eastern, or Penner-Haggari band (V); the Maski band (VI), lying north of the last, and probably connected with, another schistose band, the Bomanhal band (VII), which lies north of the Kistna and stretches away northward till it is lost under the Bhima conglomerates and the Deccan trap to the north-west of Shorapur. Lastly, the band of the Dharwars forming the Kolar gold-field will have to be dealt with (VIII).

III.—THE OUTLIERS BETWEEN THE DHARWAR-SHIMOGA AND THE DAMBAL-CHIKNAYAKANHALLI BANDS.

These are fourteen in number and may be most conveniently enumerated by taking them from north to south—

1.—*The Kunchur outlier.*

This is a large outlier (8 miles west of Harpanahalli), of which, however, only the extreme north end has been visited. The hills forming the middle and southern parts are of considerable size, and, being very bare, allow of their character being recognised from long distances, e.g. the summit of Huchangi Drug. I could not make out, however, whether the Dharwar rocks forming the southern hills were directly connected with the northernmost extremity of the Halekal Gudda branch of the Dambal-Chiknayakanhalli band. Southward from Kunchur no outlier of Dharwar rocks occurs for 85 miles. Then in the immediate neighbourhood of the town of Banavar occurs,

2.—*The Karadihalli Outlier.*

This, as far as I traced it, consists of hornblendic and steatitic rock, resting on granite gneiss. It appeared to me of very small extent and from the aspect of the rock I am doubtful whether it should not be regarded as belonging to the gneissic rather than to the Dharwar system. Gold was obtained from its northern end by washing, and there are two or three reefs there deserving of closer prospecting.

¹ See Rec. G. S. of I., Vol. XXI, p. 40.

3.—The Tellavari Outlier.

Ten miles south of Karadihalli outlier lies another, consisting of hornblendic and chloritic schists, which, like those at Karadihalli, I only doubtfully regard as of Dharwar age. Its extent I am not quite certain about, as the northern and southern ends are covered by jungle, and I had no opportunity of tracing out its boundaries. To the north I believe the schists extend only a short distance, but to the south they may possibly be connected with another small patch of auriferous rocks, 6 or 7 miles to the south-south-east, to be described further on. One of the small old workings gave a fair promise of gold from scrapings of its side, but no good-looking reefs were noticed.

4.—The Gollarahalli Outlier.

This very small outlier, lying $2\frac{1}{2}$ miles N. N. W. of Gandasi,¹ has been accidentally omitted from the map. Very little rock is to be seen except small outcrops of hornblendic schist, which may or may not be of Dharwar age. The old workings are of great superficial extent and mostly very shallow, but the eastern side appears to deserve much deeper prospecting than had been carried out up to the time of my visit in 1887.

5.—The Belgumba and Jalgaranhalli Outlier.

This small outlier of Dharwar rocks, which is a very elongated ellipse in shape, measures about 5 miles by half a mile, as far as seen. The rocks seen are chloritic and hornblendic schists, which to the east of Belgumba village are traversed by two large quartz reefs, running nearly parallel with the strike of the schists, which is about S. S. E.-N. N. W. Several old workings lie on the west side of the reef ridge; they are of good size, but no reef was traceable in connection with them (in 1887), and the results of washings made there were far from promising.

At the southern end of the outlier lies the old Jalgaranhalli workings, which consist of a small and shallow pit. The surface here is very flat, and covered with an unbroken spread of soil, and the only outcrop of rock seen is a very small one of a singular hornblendic rock, of stellately felted structure. No reef was seen in the one old working, but the scrapings, when washed, gave so good a show of gold as to induce me to recommend much fuller and deeper prospecting than had already taken place.

6.—The Mallanhalli Outlier.

This outlier lies $3\frac{1}{2}$ miles further S. E. by S. and is separated from the foregoing by a spread of gneissic rocks underlying the Dharwar hornblende schists which form it. The hornblende schist is overlaid by a green micaceous gneissoid schist, and scattered about is a good deal of débris of quartzite of distinctly Dharwarian aspect. To the south the rocks are hidden by jungle and soil, and their extension has yet to be worked out.

¹ A large village (with a 3rd class traveller's bungalow), 15 miles S. W. of Tiptur railway station, on the Dharwar-Bangalore line (S. M. Railway).

The old workings consist of a large pit (unconnected with any visible reef), washings of the scrapings of which gave a moderate show of gold. A little to the north of the pit is a large reef of rather good-looking bluish and white mottled quartz, which shows for nearly a hundred yards, with a thickness of from 12 to 15 feet at the surface. No accessory minerals are seen in the quartz at the surface, but the reef certainly deserves to be well tested in depth.

7.—*The Taggadurbetta and Nugihalli Outlier.*

This patch of Dharwar rocks, which is of some size and importance, shows as a distinct ridge for some miles, and near its centre culminates in the very conspicuous hill after which it is named and which forms a good landmark for a long distance all around. The rocks here seen are chloritic schist, with intercalated hæmatitic bands. Two of these latter, of very massive character and considerable richness in iron, form the crest of the Taggadurbetta. Their northern extensions continue for a mile as low but conspicuous mural outcrops; they are then lost under the valley of a local stream. Their further extension has not been followed up, and it is not improbable that they may run considerably further, or even join the Mallanhalli outlier, just described, some 8 miles to the N. N. W. To the south of the summit the hæmatite beds are speedily lost sight of, as they sink down rapidly and the locally flattened top of the ridge is obscured by thick cotton soil. The summit beds have given rise to a very extensive talus of rounded and angular masses of hæmatite, which covers thickly the eastern slope of the ridge in that part. In this talus are to be seen the old workings, which consist of several very shallow pits or rather broad trenches. The few reefs seen here are of no great length or thickness. They run in the strike of the "country rock," which consists, as above mentioned, chiefly of chloritic schist. The general strike of the rocks is north and south. The reefs are very poor-looking, and the results of washing were the reverse of encouraging.

To the west of Nugihalli only chloritic schists are to be seen, but further south are beds of hæmatite schist, intercalated with the chloritic beds. Whether they are representative of the two great beds further north remains to be settled by further examination. Various pits and excavations in this part of the outlier have been regarded as old gold workings; but, I think, on perfectly insufficient evidence. Some were certainly nothing more than quarries. What appears to be the southern extremity of this outlier is a low broad knoll of chloritic schist, overlaid by a thin bed of hæmatite schist, which latter forms a wide-spread talus. Between this and the auriferous patch I call the Kempinkote outlier there is a broad belt of gneissic rocks, but it is possible that the Dharwars make a sweep round to the west, and thence trend again to the south-east, and thus join the Kempinkote patch. This, however, requires confirmation.

8.—*The Kempinkote Outlier.*

I have called this patch of Dharwars an outlier because it appeared to me on my hasty visit to be surrounded on all sides by gneissic rocks—still it may be connected to the west and north-west

with a possible extension of the Taggadurbetta Dharwars. The rocks seen here consist of hornblendic and steatitic schists in which the great pit made by the old miners was sunk. No reef was to be seen exposed in it at the time of my visit, and but very few fragments of quartz, so few that I examined all carefully but could not find any trace of free gold, which was said to be a special feature of this old mine. A quantity of the material, scraped from the west side, where the rock is a steatitic schist gave a very rich show of gold, of fine grain and excellent colour. Judging from the great size of the mine it must at one time have been, or promised to be, very remunerative, but no evidence exists to explain why mining was discontinued. To the north-east of the great pit is a show of chloritic schists abounding in minute cubical cavities, full of reddish limonite, a product of pseudomorphism after iron pyrites.

South of the Kempinkote outlier lies a broad band of gneissic and granitoid rocks, with occasional trap dykes. The granitoid rises into the well-known Shravan Belgola hill, remarkable for having its summit carved into a huge figure of a man, 60 feet high.¹

9.—*The Bellibetta Outlier.*

This outlier, the northern end of which lies some 15 miles south of Kempinkote, forms a long narrow band extending southward for about 8 miles along the east side of the valley of the Hemavati river. The principal rocks seen are chloritic schists, which form the mass of Bellibetta hill (3,029'), which gives the name to this auriferous tract. The chloritic schists of Bellibetta hill are underlaid on the east by steatitic schists, on which stands the small village of Katargatta. To the north of Bellibetta hill a curiously felted hornblendic schist, with a small admixture of chlorite, occurs. The eastern side of the band of Dharwars consists mainly of talcose hornblende schists. Beds of quartzite occur here and there. The band of Dharwars forms ridges on each side of itself; both ridges are here and there broken through by the cross drainage of the country, and especially so is the western ridge. The name Bellibetta seems to include all the old workings, which are very numerous all up and down the outlier, but the principal ones are on the northern slope of the main hill, which forms the highest part of the western ridge. To what this auriferous tract owes its name of Bellibetta is not at present very clear, for no ore of silver occurs there now in quantity, or has left any traces of itself among the débris of the old workings. In Canarese, Bellibetta means the "Silver hill," and this seems to have suggested the stories which are afloat of the fabulous wealth of the place in that precious metal. I examined the old workings very carefully, but got hold of no trace of silver in any shape, though the indications of gold were decidedly favourable. The name may, I think, be rendered as "white hill" equally well as "silver hill." Several of the great brecciated quartz runs in the Bellary and Karnul Districts are called Bellagal or

¹ The figure represents Gomateswara, one of the Tirthankaras, or principal Jain Saints. The figure is said to be quite 1,000 years old, but is in excellent preservation, being most carefully guarded by the Jains. It is very remarkable that this conspicuous figure, standing some 500 feet above the surrounding plain, with no object of equal height within several miles distance, should have escaped destruction by lightning. A fine gateway a little way below the summit and cut out of the solid rock was struck, and the lintel badly sprung.

“white rock,” and in the case of Bellibetta the name may merely have reference to the white colour of the great quartz reefs on the hill which are still conspicuous and must have been very much so before reduced by the extensive workings of the old miners. If silver ore ever did abound it is curious that none has remained visible at the present day. The old workings which I believe were made in quest of gold seem to have been extensive, but are so much filled up that it would appear to have been done purposely. The whole place appeared to me worthy of deep prospecting on a large scale to really test its value.

The Dharwar rocks seem to extend southward for some distance beyond the Bellibetta hill, but I had no opportunity of following them further south, and their further course in that direction is not distinctly indicated by features sufficiently strong to be traceable by sight to any great distance. Their extension has yet to be worked out.

The next auriferous tract to be considered lies about 23 miles south of Bellibetta; and about 14 miles west of Mysore city. On the map accompanying Part I of this paper I have shown three little patches (outliers?) of the auriferous rocks; but it is possible they may be connected and this connection hidden by the thick scrubby jungle which covers nearly all that part of the country. My conclusion was based on the shape of the ground, but my view of it was but very cursory. The question will have to be determined by a regular survey.

Of the three outliers just alluded to the most northerly is—

10.—*The Nadapanhalli Outlier.*

This is a small patch of pale greenish brown chlorite schist, of which very little is to be seen, because of the thick soil deposits and extensive scrubby jungle. The old workings for gold occur at a point $\frac{1}{4}$ of a mile north-east by east of Nadapanhalli village. They occur mostly as shallow trenches or pits, running approximately north to south. In the southern pits the reef has been entirely removed as far as can be seen. In the northern, a good-sized reef remains but the quartz is not very promising in character. In colour it is white, but contains a fair number of cavities filled with earthy limonite probably derived from the decomposition of enclosures of chloritic mineral. Iron pyrites is of great rarity, and no other sulphides were to be found, while the washings of scrapings from the pit sides and of crushed quartz gave but a small show of gold, though it was of excellent quality.

11.—*The Karimuddenhalli Outlier.*

This patch forms, as far as I could judge, a narrow strip, about two miles long, on the top of a flattish ridge, east of Karimuddenhalli village. The rocks seen consist mainly of pale pink felspathic schists of very gneissic aspect, but associated with hornblendic and hæmatitic schists, bearing a fair resemblance to typical Dharwars elsewhere. The workings, which are very numerous, are mostly very moderate in size, but a few are large; and all seem very old, for the sides are very greatly weathered, and many good-sized trees have grown up in the bottoms, or on the sides. Many reefs are to be

seen running N.—S., E.—W., N. E.—S. W., &c., &c. Some are of good size, but all are white and hungry-looking, and of very poor promise; while the numerous washings I had made were equally unsatisfactory.

12.—*The Sonnahalli Outlier.*

This outlier which lies to the east of the foregoing is separated from it by a small valley, in which appears a band of unquestionably older gneissic rock, overlaid by a very trappoid hornblendic rock, the base of the Dharwars in this place. On this trappoid rest chloritic and other schists, in which are the numerous old workings which have caused this outlier to be reckoned a highly promising gold-field. The workings, judging by the extremely weathered character of the rocks forming their sides, would seem to be of great antiquity. They are also greatly overgrown with jungle. None of them are of great size or extent, and in many cases the lodes have been so entirely removed that it is only possible to guess what was the mineral mined for. The results of the numerous washings I made were not encouraging; still the real value of the place cannot be known till much deep prospecting has been carried on, and the old pits cleared out thoroughly, to show the condition of the reefs they were sunk down on.

Three large reefs are to be seen near Sonnahalli village, but none of them looks promising; the first two, which strike N. 5° W., lie half a mile east of the village, the third which runs nearly W. by N. to E. by S. lies on the north-eastern slopes of the Sonnahalli hill. This latter has been worked to some extent and apparently abandoned because of the exceeding massiveness of the reef, which is very hungry-looking.

13.—*The Holgere Outlier.*

This, the last of the series of outliers, will be found some 22 miles south-east of the group just described, and is formed of hornblendic schists, which may possibly be of Dharwar age and are faulted down among the surrounding gneissics. The schists are very badly exposed on the high ground south of Holgere village. In a small nullah running east into the village tank a rather fine bed of grey sub-crystallised limestone is cut across and exposed, but only for a few yards, both ends being hidden by the surface soil. The old workings are very small, and so are the visible quartz reefs, which have a nearly north to south strike. Several washings were made, but all yielded results which at best were but very middling. The recently sunk trial pits yielded no more favourable results than did the old ones, and the whole place seems worthy of but little attention.

The shortness of my visit to Holgere prevented my ascertaining the northerly and southerly extensions of the auriferous rocks; and the country is too much covered by scrub jungle to allow of any geological features being recognised at long distances, the rocks presenting no striking outcrops.

In the last number of the Quarterly Journal of the Geological Society (Vol. XLIV, Pt. 3, August 1888) appears a short paper by Mr. G. Attwood, F.G.S., A.M., I.C.E., "Notes on some of the Auriferous Tracts of Mysore Province, Southern India."

Mr. G. Attwood's notes on some of the Auriferous tracts of Mysore.

which describes, all too briefly, two small areas belonging in part to the southern end of the Dambal-Chiknayakanhalli band of the Dharwar, and gives some "general observations, on the auriferous tracts from numerous traverses." The chief point on which I do not agree with him has reference to the geological age to be assigned to the rocks associated with the true auriferous strata. Mr. Attwood included the whole of the schistose rocks in the tracts that he examined in one great series which they certainly appear to be as seen in that part of Mysore. It is only much further to the north that the unconformity between the Dharwar schists and the older gneissics and granites can be made out; and, as I have pointed out elsewhere, some of the Dharwar schists are so gneissic in appearance that it is often extremely difficult in many sections to know where to draw the line between the two. Especially difficult is this the case in the tract occupied by the line of outliers just reviewed. Mr. Attwood, in the little sketch map at the beginning of his paper, includes in his Banavar-Honsur auriferous band many schistose rocks which I regard as belonging to the old gneissics, and he thus represents a broad continuous band where I see a discontinuous one. I am too slightly acquainted with the two areas he describes to follow his sections, which are very diagrammatic in their construction. He points out the highly broken and disturbed character of the gneissics and schists of the Mysore plateau, and then speculates on this being possibly due to the great pressure caused by the gradual elevation of the Eastern and Western Ghats; but, as the President, Dr. Blanford, pointed out in the subsequent discussion, the Western Ghats are simply a ridge left by denudation, and the same may safely be said of the section of the Eastern Ghats which forms the eastern side of the Mysore plateau. Another point requiring notice and further elucidation is Mr. Attwood's ascription of a Tertiary age to the porphyrite dykes which he met with in his "Seringapatam area." Unfortunately he has given no reasons for assigning such a comparatively recent origin to these intrusive rocks. The only porphyritic intrusion I came across in Mysore was a very beautiful warm brown, or chocolate coloured, felspar porphyry forming a large and important dyke some miles to the westward of Mr. Attwood's examples. This dyke traverses the hills immediately east of the Kattar Gatta temple, which overlooks the east end of Seringapatam Island. There was no evidence of any kind as to the age of this dyke beyond the fact of its being irrupted through the Dharwar schists after they had been brought into their present positions. It is much to be regretted that Mr. Attwood has not indicated the exact localities whence he procured the specimens microscopically examined and described by Professor Bonney in the Appendix to Mr. Attwood's paper.

A fact of some interest relating to the Dambal-Chiknayakanhalli band of the Dharwar has been the discovery by Mr. Mervyn Smith (lately announced in "*Indian Engineering*") of lodes containing argentiferous galena in the neighbourhood of Chittal Drug. He specifies three: the first at the 119th milestone of the Bangalore high road, the second at the 121st milestone, on the north-eastern spur of the Jogi Maradi hill, and the third on the western slope of the same hill near the town of Chittal Drug. The galena obtained from these lodes, in the quartz of which it is distributed in patches, varies greatly in its richness of silver, some specimens being very rich. It is much to be hoped that the lodes will turn out rich enough to be worth working

Mr. Mervyn Smith's
galeniferous lodes near
Chittal Drug.

profitably. It has been reported, but not on very satisfactory evidence, that both sulphide of antimony and sulphide of bismuth have been obtained in this neighbourhood. There can be no doubt that the tract around Chittal Drug is metalliferous and deserving of a very close survey.

IV.—THE SANDUR HILLS AND COPPER MOUNTAIN TRACT.

This tract, which is of so very strange and irregular a shape that it cannot be called a band, must be considered as composed of two distinct synclinal folds, which are bracketed together, so to say, near their respective middles. Both stand out high above the general level of the country in their central parts, but sink much lower at their respective extremities, while the band of rock connecting them has also been planed away greatly by eroding forces.

The Sandur and Copper Mountain synclinals.

The two great synclinals form respectively the Sandur hills and the Copper Mountain range, which constitute such picturesque features in the landscape for many miles to the south of the railway between Bellary and Gadag. Both synclinals run nearly north-west to south-east.

The Sandur hills, which constitute the western of the two great synclinals, form a remarkably flat-topped mass, as seen either from the south-west or north-east, but at either end of the synclinal (which in plan may be compared to a broad leaf tapering rapidly towards either extremity) is approached, the ground becomes broken and to the north the hills decrease rapidly in height, and are finally lost in the plain; at the south end, the hills decrease considerably in height and the Dharwar basement beds thin out and lie raggedly on the granitic hills, which here attain some elevation. The centre of the synclinal is occupied by a considerable valley, on either side of which rise high flat-topped ridges of very nearly equal heights, though probably the western is slightly the higher and attains an elevation of 3,256 feet at the Raman Drug sanitarium. The height of the two side ridges is so equal that when looking at them from most points outside of the synclinal it is impossible to imagine the existence of the median valley by which they are separated.

The Sandur synclinal.

Just at the broadest part, the synclinal is cut across by the Narihalla stream flowing from the south-west and continuing north-eastward to the Tungabhadra. The stream has cut two deep gorges through the great west and east ridges, which afford fine sections of the rocks forming them, and are very beautiful approaches to the town of Sandur, which lies nearly in the middle of the central valley. A third pass at the northern end of the synclinal also allows of easy access to the valley, but fails to give a useful section of the rocks in that part.

The structure of the synclinal is not so simple as it appears at first sight, for considerable inversion of the beds on the eastern side of the valley has taken place, and it is difficult to say how far westward such inversion has extended. What are probably the uppermost axial beds of the synclinal appear to dip under what are really much lower members of the system. The examination of the central valley and of the southern end of the synclinal ellipse has not yet been fully completed. To the south of the Narihalla stream the central valley is divided in two by a high rocky ridge, known as the Devadara hill, rising steeply out of the plain and running

south-east some four miles, when it joins the southern part of the western ridge, by a neck considerably lower than its own average elevation.

The following section will give a correct idea of the sequence of formations met with along the Narihalla stream, beginning from the western, or Oblagundi gorge, and ending outside the eastern one, or Bhimagundi. The length of the section is a trifle over 8 miles—

1. Schist, dark-green, hornblendic (?)
2. Schist, gritty, brownish green.
3. Hæmatite rock, very thick.
4. Schist, green.
5. Hæmatite rock.
6. Schist.
7. Hæmatite rock.
8. Argillite schist, ferreous,—red, brown, and chocolate.
9. Hæmatite rock; *the gorge bed.*
10. Trap, contemporaneous.
11. Hæmatite rock.
12. Trap, contemporaneous.
13. Clay schist.
14. Trap, contemporaneous. Sandur flow.
15. Schist.
16. Hæmatite rock and schist. } Devadara hill beds.
17. Schist. }
18. Trap, contemporaneous. Hoshalli flow.
19. Hæmatite rock.
20. Schist.
21. Hæmatite rock. Bhim Tirth bed.
22. Schist.
23. Hæmatite rock; *the gorge bed.*
24. Schist, with contemporaneous trap.
25. Hæmatite rock.
26. Schist.
27. Hæmatite rock.
28. Schist.
29. Hæmatite rock.
30. Schist, with contemporaneous trap.
31. Hæmatite rock. Long cliff bed.
32. Schist, with contemporaneous trap.
33. Hæmatite rock. Brecciated bed.
34. Schist.
35. Hæmatite rock. Ettinahatti bed.
36. Trap, contemporaneous.

As yet it is not possible to correlate the beds on the two sides of the synclinal, but this may be possible when they shall have been followed up round the southern extremity of the basin.

The great hæmatite beds give rise to many steep mural scarps, several of which, along the eastern side of the eastern ridge, are of great height and length, and from their vivid red colour form a splendid contrast to the patches of rich green forest remaining at their base.

This section will suffice to give a good general idea of the series of rocks forming the Sandur synclinal. The details of several other sections were given in my paper on the Geology of parts of Bellary and Anantapur Districts, and several others

will eventually be described in the forthcoming Memoir on the Bellary District. The only beds not included in the Sandur section which deserve special notice are some remarkable conglomerates exposed on the north-eastern flank of the synclinal some six or seven miles due north of Sandur town. They are of two kinds, conglomerates formed chiefly of quartz pebbles, imbedded in a tough chloritic matrix, and conglomerates of pebbles in a siliceous matrix varying in character from sandstone to perfectly jaspideous quartzite. This latter variety has been subjected to extraordinary brecciation on a great scale. In many sections the conglomerates are very distinct and fresh-looking; but as they are followed towards the north-west end of the synclinal and the beds have been tilted to higher and higher angles, a great change comes over the mass, the rock becomes strongly laminated, and the pebbles enclosed are elongated to a very remarkable extent, so much so as to look like thick and rather flattened pencils of stone. This may be specially well seen to the east of Jambanat-konda, the fine peak to the eastward of Hospet.

Conglomerates in the Joga ravine.

Alteration of conglomerates by pressure.

The most remarkable feature of the Sandur synclinal is the immense development of the hæmatitic beds and their extraordinary richness in iron of excellent quality. Only the fuel is wanting for this region to become one of the great iron-yielding centres of the world. The richness in iron of the hæmatite beds varies greatly, the beds varying from almost pure quartzites with hardly any hæmatitic laminæ to massive, almost pure steel-grey, metallic rock of intense hardness. An example of the latter on a great scale is to be seen south of the hamlet of Kummataravu (Combudhurroo of sheet 59) about six miles north-west of the extreme south of the synclinal. At other places the beds run into a poorly or richly ferruginous argillite, as the case may be; at others again the rock is highly jaspideous in character. This jaspideous variety is specially developed on the north-eastern side of the synclinal at and around the little ruined hill fort of Timappaghur (Timanghur of sheet 58) and in the Ramgor ravine and several others opening out to the northward. In the Ramgor ravine splendid ribbon jasper—banded vivid red and rich grey—forms huge cliffs 200 feet, or possibly more, in height. Superb specimens of this wonderfully beautiful rock are to be procured of almost any size. Along the western edge of the synclinal this highly jaspideous character of the rock is less strikingly displayed; the hæmatite is of a more earthy character, and in its weathering gives rise to much local pseudo-lateritic breccia, which is very characteristic of the plateau on which the little sanitarium of Raman

Ribbon jasper rock.

Ferruginous surface breccias.

Drug stands.

Schists and argillites are more commonly seen here, and one or more of these latter, which are exposed in the cuttings made by the ghât which descends the western slope from Raman Drug to Narraindeverkerra, contains manganiferous concretionary nodules in considerable quantities. The more earthy nature of the hæmatites on this side of the mountains has given rise to a huge talus along their base, so great as completely to conceal the boundary between the Dharwars and the granitics for some 13 miles. Much of this talus is of very rich quality, but no use is made of the ore.

Schists and argillites.

The hæmatite ore smelted at Kamalapur and then made into the large bowl-shaped sugar-boilers, so largely used in sugar manufacture in the Tungabhadra Valley, is quarried on the spur north-west of Jambanát Konda.

The ore is a very rich reddish-grey metallic variety, and yields iron of excellent quality, and the Kamalapur sugar-boilers are highly esteemed in that region.

I came across no old workings or mines, but such may exist nevertheless hidden in the jungle which obscures the hillsides greatly in some places.

As seen in the section given above the lowest bed of the Dharwar system east of the synclinal is a contemporaneous trap which spreads across the space between the Sandur and the Copper Mountain, and forms a considerable tract mainly occupied by rounded hills, rising to 300 or 400 feet above the surrounding plain. The whole is not one unbroken flow, for here and there small deposits of schist, hæmatite, and in one case—to the south of Toranagal (Tornagul)—of crystalline limestone, show that intervals must have occurred when sedimentation began to occur again between the outpouring of the several flows.

The trap, macroscopically viewed, is a diorite of medium texture and black colour. Here and there it is coarse-grained in texture. A slight tendency to prismatic jointing is not uncommon, but the prisms are rarely more than a foot in length and rude in shape. This trap forms the base of the greater part of the south side of the Copper Mountain synclinal, but is over-lapped at the ends, *e.g.* to the north-east of Toranagal, where a hæmatite bed rests directly and undisturbedly on the very hummocky surface of the coarse porphyritic granite.

The Copper Mountain synclinal offers a much less interesting succession of rocks than does the Sandur synclinal. This is partly owing to the fact that the sections are much less perfect, rendering it far from easy to correlate the several members of the two synclinals, or even to feel perfectly certain as to the identity of the principal beds at the opposite ends of the synclinal. This is a difficulty which always exists in areas where the strata have been much contorted and fractured, and contain neither fossils nor minerals whose distribution is sufficiently special to admit of their being used to determine horizons.

The most interesting section across this narrow and greatly squeezed-up synclinal is to be traced from the great tank at Avinmudagu Central section. north-eastward for a distance of about $5\frac{1}{4}$ miles very nearly about the middle of the synclinal. The succession obtaining here is as follows:—

South-west Wall of Synclinal.

Hæmatite quartzite.
Schists, hornblendic, &c.
Hæmatite quartzite.
Schists, hornblendic, &c.
Hæmatite quartzite.
Schists, hornblendic.
Hæmatite quartzite.
Schists, hornblendic, &c.
Trap.
Schists.
Granite gneiss.

North-east Wall of Synclinal.

Hæmatite quartzite.
Schists, hornblendic.
Hæmatite quartzite.
Schists, hornblendic.
Hæmatite quartzite.
Schists, hornblendic.
Hæmatite quartzite.
Schists—black and green hornblendic, &c., a great thickness, base not seen locally.

The beds forming the north-east wall of the synclinal are slightly inverted, while those of the centre are vertical and those of the south-west wall have a very high northerly dip. I cannot help thinking that only the basal part of this exceedingly deep synclinal fold now remains; the upper part, which included many of the beds represented in the Sandur synclinal having been bodily denuded away; in fact only about half of the whole series has been allowed to remain. The hornblendic schists alternating with the hæmatite beds appear to represent the contemporaneous traps which form so striking a feature in the north-eastern wall of the Sandur synclinals. Owing to their having undergone far greater pressure in the Copper Mountain synclinal, the trap-flows would appear to have been converted into hornblendic schists.

At the eastern end of the synclinal, where the compression was much less, as shown by the much smaller angle of dip of the hæmatites, the traps have only been partially schistified (if such a word is allowable), and appear variously as nearly unaltered trap, as a trappoid of semi-schistose character, and as true schists, but generally cut up into small masses by an infinite number of small joint planes often at right angles to the great cleavage planes.

The argillitic form of the hæmatite is rarely seen in the Copper Mountain synclinal; so also the jaspideous and bright coloured variety of the quartzitic form. The beds on the whole are poor in iron as compared to those in the Sandur synclinal.

Argillites and jaspers rare.

The name of the synclinal is that by which its highest summit is known to the European residents of Bellary, and was derived from the fact that copper mines were said to have been opened on the south flank of the mountain by Tippu Sultan, but to have been speedily abandoned because unproductive. I did not see them myself, and my guides on both occasions that I climbed the mountain knew, or affected to know, nothing of them; but I hope to re-examine the south flank much more fully than I have yet done and shall probably hit upon the small pits then excavated.

The highest summit of the Copper Mountain, known to the natives as the Sugadevi-ammabetta after a local goddess, attains a height of 3,140 feet. It is covered by a local breccia of pseudo-laterite, derived from the decomposition of the great hæmatite beds which compose it.

The northern extremity of the synclinal is very obscure; of the great hæmatite beds which alone admit of clear stratigraphical determination, the eastern series dies out—or more probably is cut off by an obscure fault at the north end of the line of hills which they form; the western series thins out rapidly and is lost to sight about a mile to the north of Daroji village, and the underlying hornblendic schists have been so much eroded that they are only to be traced as a thin narrow band, which stops short about 5 miles south of the Tungabhadra river.

The eastern end of the synclinal extends some 10 miles east by south of the Copper Mountain itself and then ends abruptly, the whole series having been denuded away. It will, I expect, be found that a band of Dharwar rock re-appears some 7 or 8 miles further to the south-east in the unsurveyed area east of the Haggari river; for I noticed

Northern end of synclinal.

Eastern end of synclinal.

(from a hill a few miles west of Uruva Konda) a tract of slightly elevated ground stretching away south, which had a distinctly non-gneissic aspect.

V.—THE PENNER-HAGGARI BAND.

It will be seen on reference to the map that there is a trifling break in the central part of this band; this was not known when I chose the name for the band, but the break is so trifling, and the connection of the beds on either side so absolutely distinct, that I will not change the name.

For convenience of description, however, I will speak of the north-western part of the band as the Hunugunda division and of the south-western as the Penner division.

The extreme north-westerly outcrop of this band of Dharwar occurs at Todihal, a village on the right bank of the Kistna, as a show of hornblendic schist with intercalated beds of pale, pinkish white talcose schists. The southern side of this Dharwar outlier is bounded by the overlying basement quartzites of the lower Kaládgi series, which here forms the Bilgi hills. The Kaládgi beds here form a synclinal fold, beneath which the Dharwar rocks are hidden, but re-appear about 8 miles to the south-east and form a deep bay between two diverging scarp of the lower Kaládgi quartzites and conglomerates.

Yerkal bay.

The bay, which I will call the Yerkal bay, has been formed by the denudation of the western end of an important anticlinal fold of the Kaládgi series, which rested on the upturned edges of the chloritic, hornblendic, and hæmatitic beds here composing the Dharwar series. The chloritic and hornblendic series have been greatly denuded themselves and a deep valley excavated in them, out of which several beds of hæmatitic quartzite and hard schist stand out as prominent ridges, but which gradually sink down to the eastward. This erosion valley is itself crossed nearly at right angles by the Ghatprabbha river flowing northward to the Kistna. The river flows through two gorges cut through the south and north scarps of the Kaládgi basement quartzites and conglomerates.

The southern gorge¹ is of no special interest, but the northern, or Yerkal gorge,² is noteworthy from the great cliff of hæmatite schist formed by the northernmost bed of that rock just south of the Kaládgi scarp, which has locally sunk into a low saddle. The Dharwar rocks are very ill-seen in the centre and on the south side of the erosion valley, but on the northern side they are fairly exposed for some 5 or 6 miles, when the hæmatitic ridges sink down and are lost under the general spread of cotton soil which covers everything for miles around. They rise over the surface in low hills here and there near Byramatti and Hamblikop, and then sink down again and are lost sight of as they approach the Malprabbha river. They make no show in the bed of the river and do not re-appear again till 5 or 6 miles further on, when they crop up conspicuously in the Hunugunda ridge, which is about two miles in length. Here they are schistose in character and not rich in iron. A little to the south-east

¹ The southern gorge lies about two miles north-east of the important town of Bagulkota, and is traversed by the Eastern Deccan railway.

² The rock forming the cliff at Yerkal is much more a jaspideous quartzite than a schist, into which however it passes both to the east and west.

of the town they again sink down under the cotton soil spread to re-appear another five miles to the south-east near Tumbigi, from which they may be traced in a line of poorly ferruginous rather argillaceous schistose hills past Kandagal out of the Bombay Presidency into the Raichur Doab, the portion of His Highness the Nizam's dominion lying between the Kistna and Tungabhadra rivers. Here the character of the country changes and the nearly dead level plain is replaced by an undulating and in parts hilly tract. The sections become much better and several other outcrops of hæmatitic rock appear to the north of the Hunugunda series we have been following south-eastward from Yerka! gorge. Near Meyrudodi, 6 miles north-north-

Meyrudodi and Iadi-
gudda hæmatites.

west of Tawaragiri, the hæmatitic rocks rise into a high and conspicuous ridge of richly ferruginous quartzite which continues for several miles, when the beds become poor and soft, and are lost sight of for a few miles, but again become rich in iron and form well-marked ridgy outcrops, which rise finally into the high ridge of the Iadi-gudda, the highest point in that region, and fully 800 or 900 feet above the surrounding plain. The beds here are very rich in hæmatite; and in former times, when charcoal was cheap, before the destruction of the forests was complete, much iron was manufactured and found a ready sale to the Hyderabad armourers, being of very excellent quality. The reckless destruction of the forests raised the price of charcoal so greatly that the iron-smelting industry was utterly ruined many years ago. Within the present year the prospecting officers of the Hyderabad (Deccan) Company have discovered some very extensive old mines on the Iadigudda, which are supposed to have been made in quest of gold. About 3 miles south-east of Iadigudda the beds have again become poor and the series cannot be traced any further.

We must now retrace our steps some 40 odd miles to the west-north-west, to the most easterly point of the main Kaládgi area. Here, about
Amingarh hæmatites. $2\frac{1}{2}$ miles west of the village of Amingarh, is a remarkable group of hæmatitic beds of great beauty and deserving of attention from the great amount of contortion they have undergone. They show a subsidiary degree of minute crumpling besides the great curves into which they have been squeezed by great lateral thrusts, resulting in the production of numerous "vandykes," in which the variations in colour of the different jaspideous and ferruginous laminæ are beautifully displayed. The slightly ferruginous jaspideous laminæ vary in their colour from pinkish to almost pure scarlet, and form striking contrasts with the white or pale drab of the non-ferruginous siliceous laminæ, or the purplish, semi-metallic grey of the richly hæmatitic laminæ.

The siliceous laminæ are very fine grained in texture and often as semi-vitreous as very fine grained quartzites, and frequently weather to a glossy jaspideous surface, instead of becoming dull and earthy looking. The contortions are best seen to the west of the small ghat by the high road to Kaládgi, which crosses the hills $2\frac{1}{2}$ miles west of Amingarh. The rocks here are generally very rich in hæmatite and the red jaspideous bands are very numerous, so that the great curves and minor vandykes in which the beds stand out from the hillsides present a very remarkable, and, when lit up by the morning sun, a very beautiful appearance.

There are other displays of hæmatitic beds both west of that just described and

to the S. and E. S. E. of Amingarh, but they offer no specially noteworthy features. As a rule, they are much less rich in iron than the above described.

Another group of hæmatitic beds of some importance lies to the south of the main ridge at Jamalapur some 4 miles south-west by south of Meyrudodi Trigonometrical station hill above referred to (p. 30).

The intimate geological structure of the Hunugunda division of this great Dharwar band was not worked out as fully as desirable; the time at my disposal did not admit of it. The country was traversed in rapid marches just close enough to ascertain the existence or non-existence of possible outlying basins of the Indian carboniferous rocks which might have been spared by the denuding agencies that played such havoc with the Lower and Upper Gondwana formations on the eastern side of the peninsula. The schists were regarded as belonging to the great gneissic group, to a close examination of which time was not to be devoted unless any special metallic wealth demanded it. The connection between the schistose bands and any of the auriferous tracts was not known till a couple of years later, when I had visited and explored the auriferous northern end of the Dharwar-Shimoga band and the Dambal goldfield of the Dambal-Chiknayakanhalli band, but after that no opportunity occurred of my revisiting any part of the north-western, or Hunugunda, division of the Penner-Haggari Dharwar band.

The greater part of the Hunugunda division, consisting, as it does, of comparatively soft chloritic and hornblendic schists has been worn down to a level plain, the greater part of which is obscured by cotton soil. Chloritic schists are to be seen largely exposed in a few localities, as at Timapur (Teemehpoor), 3 miles north-west of Hunugunda (Bijapur District), and at Somulapur, 10 miles south-west of Mudgal, in the Nizam's territory. The colour of these schists is predominantly a delicate pale green; dark green varieties are less common, but are also to be met with. The chloritic schist tracts are characterised by the absence of all hills of any size or elevation, but are much cut up on a small scale by watercourses.

Hornblendic schists are also common in parts of the band, as to the south-west and south of Hunugunda at distances of 10 and 5 miles respectively; and elsewhere are associated with, and strike parallel to, the more conspicuous hæmatitic bands.

To the east of Iiadigudda the hæmatites become very much less important, and many strongly hornblendic massive spreads of rock appear, presenting all the appearance of being truly contemporaneous trapflows. From Tawaragiri the width of the band of Dharwars decreases rapidly. At Kulumangi (7 miles to the east-south-east) it measures only 3 miles, as against 6 at Tawaragiri. It goes on decreasing in width as followed south-eastward, and about $5\frac{1}{2}$ miles from Kulumangi has narrowed away completely and disappears about a mile south-west of Mailapur (Mylapoor).

Four miles to the E. by S., traces of Dharwars re-appear but form only an extremely narrow spit at first; this widens, however, as followed south-eastward past the large village of Karatugi. The northern boundary of the band runs on hence to, and across,

Penner division of the band.

Trap flow area at east end of Hunugunda division.

Jamalapur hæmatites.

Survey of Hunugunda division insufficiently close.

the Tungabhadra in an east-south-east direction, while the southern boundary trends south-east and south in a wavy line to the river, which it crosses in a south-west direction and joins on to a very irregular patch of Dharwars lying on both sides of the river and extending up its valley as far as the town of Kampli (Kumpli).

The sinuosity of the boundary of this patch is such that where the main band crosses the Tungabhadra at Naddavi it is barely $2\frac{1}{2}$ miles wide.

The principal rocks seen on the Doab side of the Tungabhadra are trappoids and traps, which form the greater part of the low-lying parts of the bands, but are very ill seen, owing to the thick and continuous spreads of cotton soil obscuring the surface nearly everywhere. Two or three poor beds of hæmatite are exposed in the line of low hills which run just within the northern boundary, and curve round east-south-east into the small hill west of Nandihalli and north of Naddavi, at which village they cross the Tungabhadra. Argillites, with some flaggy sandstones, here and there approximating to quartzite, occur in the centre of the valley north of the Murigudda (Moorygooda) ridge, a bold ridge with fine cliffs on its southern scarp rising some 600 to 700 feet above the plain.

The flanks are nearly everywhere thickly covered by talus; but at one place, a little to the south-west of the Trigonom-
 Murigudda brecciated quartz run. metrical station hill, a rain gully cuts into beds of green and pale green chloritic schist.

The main mass of the ridge consists of beds (apparently two in number) of massive quartzose rock, with much quasi-brecciation. On the northern side of the ridge this rock, when seen from a little distance, bears a great likeness to a true quartzite, its thick bed dipping northward, but close at hand the rock has a close resemblance to the ordinary brecciated quartz characteristic of so many of the great runs traversing this part of the Southern Deccan. I hope to be able to get some light on this point by a microscopic examination of sections from different parts of the ridge. A very similar rock, probably an extension of the Murigudda ridge, forms a small hill, 2 miles east of Karatugi. Here again the rock looks in many respects more like an altered quartzite than a true vein quartz.

The rock forming the patch extending up the Tungabhadra valley towards
 The Kampli patch. Kampli consists largely of trap, trappoid, and hornblendic and chloritic schists, with a few small hæmatitic beds. The schists are in many places cut through by intrusive veins of pegmatoid granite. Some of these are particularly well seen in the left bank in the Yeemingannur nullah, 6 miles east of Kampli town. Some of the granites occurring among the

schists in this quarter appear to be contemporaneous. Good
 Contemporaneous granites. examples of such are to be seen in the banks of a small nullah draining the high ground immediately north-east of Kampli; also, on a somewhat larger scale in the banks of a nullah, which falls into the Tungabhadra, $4\frac{1}{2}$ miles north-east of Kampli. These granite flows are best seen where the road from Kampli to Itugi crosses the nullah.

To return to the place where the band crosses the Tungabhadra, the beds seen
 Naddavi hæmatite. here are chiefly dark hornblendic schists and trappoids, but immediately west of the village of Naddavi is a fair band of hæmatite schist, which is doubtless a southerly continuation of the band forming the crest of the Nandihalli hill above referred to. The beds show much lateral

contortion to have taken place. The strike is parallel with the general course of the band.

For many miles south-south-eastward from the river, the course of the band is greatly obscured by the continuous cotton soil spreads which cover the country. It is only here and there that an unusually hard bed of rock stands up over the surface and forms an outcrop. As a rule, the presence and nature of the rocks can only be ascertained by laboriously hunting for outcrops in the larger streams draining the surface. Among the few features of interest in the course of the band between the Tungabhadra and the Haggari are the two important hæmatite bands forming

Sindigiri hæmatites. the Sindigiri hills. They are fairly rich in iron, and here and there quite jaspideous in texture. Two miles south-east of their southern extremity rises a ridge of very slightly hæmatitic quartzite, which, though low (about 100' high over the plain), is remarkable for its bare and rocky character and very artificial appearance, due to the peculiar nature of the jointing. The last noteworthy feature to be seen west of the Haggari is a low bare hill of very black trappoid, immediately north of the Bellary branch of the Southern Mahratta Railway and about 4 miles east of Bellary. All the rest of the band is hidden under cotton soil, a few nullah sections excepted. No outcrop of the Dharwars shows through the alluvium of the Haggari, and on the east (right) bank of the river the country resumes the same character of a nearly level plain, out of which only a few low hills rise at long intervals. Two lines of high ground occur here; the northern one consist-

Bevinhalli trappoid hill. ing of poor hæmatitic beds, with associated schists and argillites, which form three hills, two at Joladarashi and a third, $1\frac{1}{2}$ mile to the south-east, on which stands the village of Chel Gurki (Chailgoorky).¹ The strike of these beds is south-easterly, but at a very little distance east of Chel Gurki they sink down and are lost under the cotton soil.

The southern line of hills is divided in two by a broad saddle. The hills are low (100'—150') and rocky, and would not deserve mention, but that they consist of a diorite (?) of extraordinary character. This rock shows a green hornblendic matrix, full of whitish pink, or whitish enclosures of felspar (Orthoclase?) approximately spherical in shape, and generally from $\frac{3}{4}$ to 1 inch in diameter. The number of enclosures, which never show any crystal faces, is very great and must often form fully a 4th of the whole mass, which is intensely hard and tough. At a little distance the rock often resembles a puddingstone, for which indeed I mistook it at first sight. The mass of the hills is made up of three great dykes of this very remarkable form of trap. A small dyke of the same kind is also to be seen along the south side of the Madras-Bellary high road, a couple of miles east of the ford over the Haggari.

Dykes of coarse diorite. When exposed in nullah sections the main mass of the band is seen to be made up of hornblendic and chloritic bands.

Chel Gurki hæmatites.

Penner division mostly schistose.

About 8 miles south-west from Bantanahal railway station is a low ridge, in

¹ South of Virapur Railway Station.

which beds of chloritic schist alternate with beds of jaspideous hæmatitic quartzites. These disappear to the east under the cotton soil, but it is not unlikely that to the west they may really be continuous with the Chel Gurki beds above referred to. Further to the south-east little is seen because of the cotton soil, but where outcrops occur they mostly show trappoids or hornblendic schists. The character of the country continues unchanged till the basin of the Haggari is left, but then the slowly

undulating plains are replaced by broken rocky country, traversed by numerous large and important dykes of diorite.

Hilly tract in the Penner basin. The band consists here mainly of hornblendic and chlorite schists, which extend to and across the Penner, beyond which the band has been followed for a distance of 15 miles by my colleague Mr. Lake, who found them forming a clear and simple synclinal just south of the river, consisting of alternations of trap flows and schists. To the eastward of the main band lie a considerable number of outlying patches of Dharwars which show signs of having been greatly broken up by the agencies which crumpled up the whole system. Its further course

appears to be southerly, and its connection with yet more southerly occurrences of Dharwars has to be worked out.

Probable extensions of the Penner Haggari band. Schists, apparently of Dharwar age, are reported from the south of the Anantapur District, and also from Pargarh in Northern Mysore.

A show of schists of Dharwar aspect was met with by Dr. W. King a little to the south of where the Chitravati river cuts through the hill ridge forming the base of the Kadapa basin, 30 miles south-east of Anantapur town, but was not followed any further. This schist patch is said to be the extreme north extension of the Kolar goldfield band, a statement which will, I expect, very probably be verified when the tract of country lying between the two points comes to be surveyed.

I did not meet with any old workings of any sort in the Penner division of the band, nor did I hear of any on enquiry, but I came across no one likely to give me any useful information on this point.

VI.—THE MASKI BAND.

This important band is called after the large village of Maski (Mooski of sheet 58), which stands on the western side of its southern half. No other place of any importance or note stands on this band of Dharwars after its extent and shape. which it could have been more fitly named. The band is very irregular in shape, and a much better idea of it will be got from inspecting the map which accompanied Part I than by any description that could be given. Its southern extremity lies about 3 miles north-west of the Tungabhadra in Lat. N. $15^{\circ} 42''$ and its northern lies about 43 miles to the north by 5° west, in Lat. N. $16^{\circ} 21''$, and about 4 miles south of the Kistna. There is some reason to believe that its extreme north-western extremity continues up north and crosses the Kistna; this point, however, requires further examination, for there is in the immediate vicinity another band of hornblendic schists belonging to a gneissic series older than the Dharwars. When I visited that quarter in 1870 I was not in a position to distinguish between the two series.

The northern half of the Maski band is essentially hilly, the hills being mostly low and rounded like downs, with a generally smooth surface, extensively covered with cotton soil, which is rather unusual, for cotton soil, as a rule, affects only level tracts of country and disappears from all but the very gentlest slopes.

The southern half is very flat and can boast of only a couple of hills. Except on these two hills very few outcrops are seen anywhere over the southern half. The predominating rock throughout the band is a schistose, black, hornblendic trappoid, passing contemporaneous trap or into true hornblendic schist, as the case may be. A few rather poor hæmatitic bands occur in the southern part of the northern half, and again in the southern half to the north-north-east of Sindunur. Near Wandalli, in the centre of the broadest part of the north half is a noteworthy example of an altered conglomerate, with a siliceous matrix. The enclosed pebbles, which are not very numerous, have been squeezed into long and rather flattened cigar, or pencil-shaped bodies. Chloritic schists are well developed locally but to nothing like the same extent as the hornblendic schists.

In most parts of the band the bedding of the rocks is parallel to the strike of the band, but local deviations of strike occur, especially in the broad part of the northern half, and the deviation in this latter case has been followed by the quartz reefs, which there occur in numbers.

This Maski band is at the present time being energetically prospected by the prospecting staff of the Hyderabad (Deccan) Company, headed by Mr. W. P. Stephenson, assisted by Messrs. W. K. Cherry, Molony, and Temby. They have discovered very large numbers of old workings, many of them of considerable size and depth, proving beyond a doubt that a large and important gold mining industry existed here a long time since, probably in the peaceful times before the Mussalman invasions. Many of the workings had evidently been deliberately filled up, probably to conceal them from the enemy.

Dr. King and I paid a flying visit to this goldfield quite lately and were shown several very important old workings near Wandalli and Topuldodi to the north of Kavital (Kautala of the country people), besides numbers of lesser ones. The workings have in many cases been followed down to between 40 and 50 feet, but then water comes in and prevents further exploration till pumps can be rigged up to drain them. This will be done very shortly, and the old workings will then be bottomed, when it will become possible to reach the undisturbed lodes and ascertain their real value. In the meantime encouraging shows of gold have been obtained from crushings of bits of the lodes left as props to the shaft walls.

We saw two good groups of "mullockers," or the small mortars in the rock in which the old miners pounded up the ore, or "mullock." One of these, close to the Topuldodi camp, showed the ordinary small mortars rather larger and deeper than half a cricket ball, with several larger ones, like inverted dish-covers. The other group, about a mile north-west of the

"Mullockers."

Wandalli camp, shows large shallow saucer-like hollows in the solid, tough trappoid, Granite crushers. In these the ore was crushed, not by hand, but by working great rounded granite crushers, between half a ton and a ton in weight. The size of these crushers is so great that they must have been worked with some kind of framework by which to get leverage to move them easily. A considerable number of these great crushers are to be seen, and several lie in their proper hollows. They must have been brought from several miles distance and at no small expenditure of labour. It is abundantly evident that a great mining industry was once in progress in this Dharwar band; and there are at present good grounds for hoping that the reefs to be reached may, as in the case of several of the Kolar mines, turn out really rich enough to be profitably worked in European fashion.

The mines just referred to are all in the broad part of the northern half, but numerous other workings occur in the southern part of the northern half near to, and south of, the Lingsugur-Raichur high road. Some of these also are important from their size and depth, and may lead down to valuable lodes. I came across only one of these workings, near Boodimir, and that contained water at a depth of about 20 or 30 feet down on an incline. I could not get hold of any lode to find out the nature of the mineral looked for, nor could I find out on enquiry of the people what the mine had been sunk for.

A curious proof of the utter oblivion these mines seem to have fallen into among the people around is the fact that their existence was unknown to Colonel Meadows Taylor, who resided near for many years, and gave up much time to the geology and archæology of the country, and was moreover a perfect master of the vernacular, and on the most friendly terms with the inhabitants.

Two or three miles westward of Maski town lies a short and narrow band of schistose rock, which from its position would appear to be an outlier of the Maski band; but which I feel a little doubtful about because of the schists which form it being associated with one or two beds of poor magnetic iron. Magnetic iron is a decidedly uncommon rock in this part of the country, though extremely common further south and east in the Salem, Coimbatore, and Nellore Districts, and in all these cases the magnetite beds are distinctly gneissic in their age and association. The hornblende schists associated with this magnetic iron are not unlike some of the Dharwar, and gold was obtained from them by the Deccan Company's prospectors at Billudumurudi, the highest hill in the little band. If these beds be really of Dharwar age it is the only case to my knowledge of a magnetic iron belonging to that system; all other iron beds associated with it being hæmatitic.

Billudumurudi outlier magnetite bed.

VII.—THE BOMANHAL SCHIST BAND.

This band stretches from near the left bank of the Kistna west of Shorapur in a N. 5° W. direction some 20 odd miles, till it is lost sight of under the great cotton soil spread which lies on the divide between the basins of the Kistna and Bhima. The southern end is hidden by the alluvium of the large Bomanhal nullah. I call this band after the village of Bomanhal, which stands on its southern end, and is noted for having been a favourite abode

Why so named.

of Colonel Meadows Taylor, C.S.I., the distinguished author, when Resident with the Rajah of Shorapur. His house on the top of the hill overlooking the great tank commands a fine view all along the band of schists, the eastern half of which occupies the valley of the Bomanhal nullah, while the western half forms a well marked succession of hills and downs. The band has an average width of about 3 miles. The schists composing it are mainly hornblendic, and there can, I think, be no doubt as to the Dharwar age of this band. This question will soon be decided, as Mr. Stephenson and his prospecting officers are to attack the band ere long. From the general impression of the band as a whole which remains in my mind I shall be surprised if it does not turn out an important mineral region.

Between 10 and 12 miles east of the Bomanhal band is another band of hornblendic rocks which I did not show in the map in Part I, being rather doubtful whether it should not be regarded as belonging to the older gneissics, like the hornblendic band immediately north of Lingsugur. A further

The Saggur band. study of my field maps, however, leads me to think it should be regarded as of Dharwar age and should as such have been shown in the map. If this is right, it should be called the Saggur band, or outlier, from the small town of that name which stands on it. The main mass of it lies between Saggur and Shorapur town. A narrow band of hornblendic beds, probably a continuation of the Saggur bands, was mapped by Dr. King as curving round the small granite gneiss massif of Shahpur, which lies immediately north-east of Saggur town.

VIII.—THE KOLAR GOLDFIELD BAND.

Last in the order of description, but first really in practical importance, is the narrow band of Dharwars known as the Kolar goldfield, which lies some 40 miles east of Bangalore. The great success attained at a good number of the mines now being worked there has proved beyond all cavil that gold does exist in richly paying quantity in many of the lodes running through the Dharwar schists, and I for one firmly believe that lodes of equal richness will be found in other tracts in which similar geological conditions prevail. It is remarkable what good judgment the old miners had in these matters; possessed of no real scientific knowledge they nevertheless succeeded in gaining great practical experience as to the nature of the rocks and conditions of position most favourable to successful extraction of the gold when found. Where their old workings were most extensive and deep, there their modern successors have also, as a rule, been most successful, when they descended to levels the old miners were unable to reach from the insufficiency of their mechanical appliances.

In many parts of the other schistose bands it is impossible, either from the obscure and confused position the rocks occupy or from the very small show they make on the surface, to say how they really lie. In the Kolar band near the mines, this is not so, for there it is clear that the schists are disposed in a deep narrow synclinal fold. This fold rises in parts somewhat over the general level of the surrounding granitoid country and, nearly throughout the western side of the band, occupies a higher level than the eastern.

The dip of the rocks forming the basement of the band and therefore the boundaries of the synclinal, is easily traced on both sides ; but not so the dip of the axial beds of the fold, the uppermost members in fact, for they have been so altered by the great pressure which gave rise to the synclinal that an irregular cleavage system was set up which entirely masks the original planes of bedding. Extensive minute jointing has also supervened to increase the alteration changes. The lines of bedding are completely obliterated, and it was (at the time of my visit) impossible to decide from the sections seen whether the central axis of the synclinal represents one great acute fold or a series of minor ones in small vandykes. The great petrological similarity of the strata forming the axial part of the synclinal makes it all the harder to unravel the difficulty. The various sections in the shafts being sunk at that time (1881) threw no light on the subject, and I do not know whether subsequent observers have been able to settle this point.

The basement bed of the fold appears to be the hæmatitic quartzite which forms on the western side of the synclinal and rises into the Walagamada hill ridge. The bedding of this is often vertical and much contorted in places. The texture of the rock varies from a highly, jaspideous quartzite to a schisty sandstone. The beauty of the vandykes, crumplings, and brecciations of this rock in the Walagamada Konda is very remarkable. On the eastern side of the fold the hæmatite quartzite is much less clearly developed, except in the south-east part of the goldfield, where it forms the main mass of the Yerra Konda Trigonometrical station hill. Overlying the Walagamada quartzites are chloritic schists, on which rests a great thickness of hornblendic schists and trappoids, which make up the central mass of the synclinal. To the south of the goldfield tract the synclinal becomes pinched and dies out in long narrow strips which run down into the Krishnagiri taluq. These have been investigated by Mr. Bosworth Smith, Mineralogist to the Madras Government, but his report on them is not yet available.

The Kolar band has been examined by me only for a little distance north of the goldfield, but several prospectors claim to have followed it up north for a long way and speak very highly of its promising appearance. One prospector informed me he had traced it continuously northward till it passed under the basement of the Kadapa rocks near the gorge of the Chitravati. If this be so he must have joined it on to the schistose patch discovered by Dr. King and mentioned above at page 34. Another, but less reliable, observer told me the band stretched away more to the east of north and passed close to Maddanapalli in the Kadapa District. It is hardly probable that the band maintains itself as a simple synclinal fold for many miles north of the goldfield, and it will be curious to ascertain what position the beds then assume.

It should be mentioned, in conclusion, that the position of the rich reefs in the goldfield is rather to the eastward of the axis of the synclinal. In this respect the mines lying in the same line as the Mysore, Urigam, and Nandidrug mines are much the best off ; the reefs further east have so far been less productive and those to the west of the axis seem to be decidedly poorer. The best quartz is decidedly blue and contains but little pyrites. In only one mine were arsenical pyrites said to be injuriously common, and to necessitate special treatment of the ore.

It is not in accordance with mining experience elsewhere that every venture should succeed, but the results already obtained are abundantly good enough to encourage sensible people to proceed with care and forethought to open other mines in the Dharwar rocks.

Eruptive Rocks in the Dharwar areas.

Many intrusive rocks occur in the Dharwar areas, but the most remarkable are the dykes of what may be called the great Peninsular trap system, from its general development all over South India, in many parts of which it forms the most remarkable feature in the country, for example in North Arcot, South Kadapa, and the east part of Anantapur. Such an extraordinary network of dykes of dioritic trap of all sizes, but mostly very large, is, I believe, quite unparalleled elsewhere, but certainly so in India. The majority of these dykes were intruded after the formation of the Dharwar rocks, and many of them are to be seen cutting through the schists and quartzites. They belong to the period intervening between the crumpling up of the Dharwars and the deposition of the Kadapa beds. The few dykes found intruded into the Kadapas belong to a newer and different looking series.

Large veins of pegmatite cut the Dharwars here and there, as at the place where the extension of the Sundur synclinal crosses the Tungabhadra and in the Kampli patch before referred to (page 32).

The porphyrites occurring in the Dharwars in the neighbourhood of Seringapatam are also noteworthy intrusive formations.

Lastly come the brecciated quartz runs, such as that forming the Murrigudda in the Penner-Haggari band, close to the Tungabhadra; their true nature and their relation to the Dharwars have yet to be worked out.

Notes on the Wajra Karur Diamonds, and on M. Chaper's alleged discovery of diamonds in pegmatite near that place; by R. BRUCE FOOTE, F.G.S., Superintendent, Geological Survey of India.

Fresh attention having been drawn to the subject of the occurrence of diamonds at Wajra Karur in the Anantapur District by the starting not very long since of a Joint Stock Company to work the supposed matrix there, it may not be inopportune to offer some further remarks on the subject, as they appear to throw some more light upon this very interesting question. I wish also to make some comments on an alleged discovery near Wajra Karur by a French Mining Engineer, M. Chaper, of diamonds in a pegmatite rock in association with sapphires and rubies.

What has attracted so much attention to Wajra Karur on the part of professed experts in diamond mining, M. Chaper excepted, has been the discovery there of a bluish tuff-like rock, which presents a strong superficial resemblance to some of the Kimberley "blue rock," that has

The "Blue rock."

proved so marvellously rich in diamonds in the South African mines. My acquaintance with the South African diamond matrix is limited to one specimen of the Kimberley "blue rock" which I saw in our Museum in Calcutta in 1883. Very shortly after, on returning to Madras, I was shown specimens of the Wajra Karur "blue rock," and was so much struck by the great resemblance between the two that I immediately remarked on it to Mr. R. G. Orr (of Messrs. P. Orr and Sons), who had shown me the Wajra Karur specimens. The source of the South Indian diamonds seemed likely to be ascertained beyond a doubt, and one of the most interesting questions in South Indian geology on the eve of being answered.¹

Whether the specimen of the Kimberley rock I examined was a good and typical one I cannot say, but it strongly resembled the Wajra Karur rock that I saw so soon afterwards. The latter, which is soft and crumbly, and full of cracks, lined with films of carbonate of lime, is from excessive weathering in such bad condition as to be quite unfit for microscopic examination. It is to be hoped that ere long much harder specimens, susceptible of grinding and polishing, will be procurable; for it is of the highest interest to ascertain whether this rock is also a variety of porphyritic peridotite, such as that forming the diamond matrix at Kimberley. The Kimberley matrix rock has been very fully described by the late Professor Carvill Lewis,² by whom it was regarded as a distinctly new rock type and appropriately named "Kimberlite."

The Wajra Karur "blue rock" occurs in a "neck" in the epidotic granitoid which forms the high ground north and west of the village. The Wajra Karur neck. Owing to the immense quantity of quartzose débris, derived from the surrounding granitoid, which is scattered over the face of the country, the exact extent of the neck is not clearly seen, but it measures several acres in area.

Owing to its soft nature, the "blue rock" has weathered much quicker than the surrounding hard hornblendic gneiss, and has thus come to be worn into a hollow, which forms the head of the small stream flowing south-eastward through the village and falling into the Penner some 10 miles further on. The high road

¹ My first visit to Wajra Karur was after this, and the views I arrived at after a close examination of the diamond-yielding tract, were embodied in my paper "On the Geology of parts of the Bellary and Anantapur Districts," which appeared in the Records of the Geological Survey of India (Vol. XIX, pt. 2, 1886).

² In a paper read before the British Association at Manchester in 1887, an abstract of which was published in the Geological Magazine for March last. Unfortunately this does not give a full macroscopic description of the rock, by which to judge more fully of the external resemblances to the Wajra Karur rock.

P. S.—I have thought it better, in the interests of this enquiry, to append to this paper a reprint of Prof. Lewis' Note. The suggestion in it of *serpentine* in the form of a decomposed eruptive peridotite, as the original matrix of the diamond is of value in connection with the fact that the *Banaganpalli* group of the Karnul formation rests on, and is unconformable to, one group of the Kadapah formation which is largely made up of volcanic rocks, and some serpentine beds. We do not know of a centre or source from which these volcanic rocks may have risen; but at present there is nothing against such a source being related to the Wajra Karur "neck," or other volcanic vents which may eventually be recognized in the Bellary District.—W. K.

running south from Guntakal village and Timancherla Railway station passes across the eastern side of the neck, and the blue rock is to be seen here and there in the road-side ditches, while in a small road-metal pit close to the village it is seen in contact with the epidotic hornblende gneiss. As far as I have been able to ascertain the first explorer that noticed the "blue rock," was Mr. J. Brukowsky who visited Wajra Karur after seeing the Kimberley mines.

At the time of my two visits in November 1884 and January 1885, the neck was being largely and deeply prospected by Mr. A. Copley, a practical diamond miner of Kimberley experience, on behalf of Mr. R. G. Orr, of Madras, and others.

At the time of my final departure from Wajra Karur, Mr. Copley had either met with no success, or did not write and inform me of any subsequently, as he had promised me he would do. Such being the case and no tidings of the discovery of diamonds having reached me, I could but conclude that none had been found, either in the matrix, or by means of the very elaborate and perfect washing machinery

Assumed absence of diamonds how accounted for. largely used to test the nature of the local "blue rock." As diamonds are insoluble and resist weather action more successfully than any other mineral, the inference was obvious

that no diamonds existed in the Wajra Karur rock so far as it had been tested, though the testing had been carried to considerable depths in several shafts and largely over the surface of the neck: furthermore no discoveries of diamonds were reported from the banks of the stream running down south-eastward to the Penner river nor from the deeply eroded lower ground through which it flows. It is manifest from the position of the neck that the great mass of material removed by denudation in forming the hollow in which it is seen exposed, must have been washed down the stream in question, and had diamonds occurred in that mass it is highly improbable that none should have been left in the bed and banks of the stream where their existence would certainly have been discovered by the old diamond seekers in former generations, who would have "shoaded" up the stream and have inevitably reached the neck.

My conclusion as to the absolutely negative results of Mr. Copley's research would appear to have been based on imperfect information, for a new company called the "Madras Presidency Diamond Fields Limited Company" was some months since started with the object of working what in their prospectus is set forth as a very promising field.

The remarks which I made on the subject of Mr. Copley's work in my paper "On the Geology of parts of Bellary and Anantapur Districts,"¹ were to the effect that he had been unsuccessful; and I ventured to put forth a hypothesis in explanation of the (supposed) absence of diamonds from a rock from which so much had been expected owing to its external resemblance to the Kimberley diamond matrix. My hypothesis was that the absence of diamond must be ascribed to the fact that the intrusive rock filling the neck had risen up through rocks containing no carbon in any form; which, as far as my knowledge of the surrounding epidotic hornblende gneiss extends is the essential character of that rock. The Kimberley peridotite on the contrary had passed through a great thickness of highly carbonaceous shales, the carbon derived from which (in whatever combination whether as CO

¹ Records, Geological Survey of India, Vol. XIX, part 2.

or CO_2) was occluded in the irruptive rock and gave rise to the innumerable crystals of pure carbon, as the heated mass cooled down. If this hypothesis be correct, the lower parts of the Kimberley and other peridotites in West Griqualand below the level at which the supply of carbon from the carbonaceous shales was obtainable should prove barren of diamonds; and it will be exceedingly interesting to watch the progress in depth of the diamond pits, as they should, in that case, in due time descend below the level at and above which diamonds were formed by the crystallising of the occluded carbon. If the Wajra Karur neck should on further examination prove barren in diamonds I shall consider my hypothesis as established.¹

Before I ever visited the Wajra Karur diamond field and only knew of it by report, I had often speculated (the existence of the neck of "blue rock" being then unknown) on the possible existence there, or in the neighbourhood, of outliers of the Kadapa or Karnul conglomerates from which, and especially from the latter, the diamonds might be derived by subaerial denudation: I therefore examined the country all around very closely, but failed to find any trace of a remnant *in situ* of the former extension over that region of members of either of those rocks series. That such extensions of those two series did once exist I cannot but firmly believe, although the tremendous denuding agencies that have been at work have left no visible traces *in situ* of the rocks in question. The only traces of those rocks now remaining are the few diamonds found scattered over the surface of that neighbourhood. They escaped the general destruction of the rocks they had been enclosed in owing to their intense hardness and durability and remained behind when every other trace of those rocks had vanished. A vastly greater number than those which were left was doubtless swept away with the general mass of débris and found its way either into the valley of the Perner, or from the more northern parts of the extensions into the valleys of the Tungabhadra and Kistna, and furnished in part the supply of diamonds obtained from the alluvial beds in the lower parts of those river valleys, but in far greater part were washed out into the Bay of Bengal, at the bottom of which diamond-bearing conglomerates have doubtless been formed. The mass of material removed in the destruction of the extensions I suppose to have formerly existed was doubtless vastly greater than what the whole existing alluvia of both river valleys now represent. When writing on Wajra Karur blue rock in my paper on the Bellary Anantapur country I was exceedingly loth to give up the idea that it was the source (or at least one great source) of the South Indian diamonds, but the entire absence of diamonds (as then supposed) from the rock then exposed in the neck was a difficulty I saw no way out of. Since then, however, while speculating on the subject, I have hit,

¹ The finding in the wash dirt of a limited number of small crystals and chips of diamond will not suffice to invalidate my hypothesis, as they might easily have been washed down from the surface through the innumerable cracks traversing so highly decomposed a material as the "blue rock." The finding, however, of a single crystal *in situ* in any undisturbed part of the "blue rock" would constitute it a true matrix and at once upset my hypothesis. As a matter of fact, I shall not at all regret having to relinquish my hypothesis, for then one source of the formation and occurrence of diamonds in India will have been established to the great gain of Geological Science.

upon what I think is a fair and legitimate solution of the problem, and it is this:

How the "Blue rock" gained its carbon. when the "blue rock" was irrupted from below, that region was covered by a great thickness of sedimentary rocks, of which some were sufficiently carbonaceous in character¹ to furnish the carbon required to allow of the "blue rock" becoming charged on cooling with the carbon crystals, as was the case at Kimberley and in the other South African peridotite "necks." The "neck" rose to a great height above what now remains: in the course of time denuding agencies attacked the diamond-bearing portion of the neck of "blue rock," and the gems thus set free were washed away and imbedded in conglomerates, forming at a distance at lower levels from the materials

Age of oldest diamond conglomerate undetermined. of the neck and of the sedimentary rocks through which it had risen up. What was the age of the conglomerate of

Old workings near Huvin Hadagalli. which the diamonds first formed part is a question that has yet to be worked out. The oldest conglomerate known to the Geological Survey in which diamonds actually occur is the basement conglomerate of the Karnul series, the Banaganpilli beds of Dr. King's excellent classification of that series. Old workings for diamonds were however carried on in apparently much older conglomerates belonging to the underlying Kadapa, and I met with one old set of workings² in the western part of the Bellary District which were in an unquestionable Dharwar conglomerate, which is of course of vastly greater antiquity. In the present state of our knowledge it is impossible to fix the age of the first conglomerate in which the diamonds of the Wajra Karur neck may have been included, for it is uncertain whether the old mines just referred to in the Dharwars and Kadapas really yielded diamonds or were only unsuccessful trial pits made, because of the petrological resemblance of the rocks they were made in to the unquestionably diamond-bearing pebbly conglomerates of the Karnul series.

The diamonds occurring in the Banaganpilli beds are just as much rolled pebbles as the jaspers, quartzites, quartzes, granites and gneisses, Banaganpilli diamonds true pebbles. &c., which make up the Banaganpilli conglomerates. It is very difficult to obtain diamonds still imbedded in the conglomerate matrix, but I succeeded in procuring a couple of very small ones: unfortunately the fragment of matrix was much too small to make a decent hand

¹ The existence of such a series of carbonaceous rocks may be very reasonably postulated, though singularly enough none of the sedimentary rocks whose extensions may be supposed to have been penetrated by the "blue rock" neck and thus to have furnished the carbon requisite show any traces of carbon in their remaining areas.

² This old working which presented all the features characteristic of a diamond working occurs on a small hill of pebble conglomerate about 3 miles south of Huvin Hadagalli in the western part of Bellary District. The conglomerate forms part of the Dambal-Chicknayakanhalli band of the Dharwar rocks. The surface of the hill is riddled with a number of little pits identical in appearance with those frequently seen in the Karnul diamond district. Between the pits were here and there little platforms of earth with stone revetments, exactly like the sorting tables seen at the Banaganpilli diamond mines. I could see no trace of any other mineral in quest of which these little pits could have been made, and the peculiarity of the conglomerate immediately suggested their having been diamond pits. The civil authorities at Huvin Hadagalli were ignorant of their existence, and I have been unable to find out anything about them by subsequent enquiries.

specimen, though large enough to show what local rock the gems occurred in. One of the two diamonds was a mere broken fragment when imbedded.

The Wajra Karur neck is the only one as yet known in South India, but it is not unlikely that others of similar character may be found in other parts. It is difficult to understand the wide distribution of diamonds over the peninsula, if they were all derived from a single centre, but if other necks existed to the north, or north-east especially, this difficulty would entirely vanish. It is quite probable that the remains of such other necks may occur in the wide spreads of granitic and gneissic rocks—lying between the Kadapa and Karnul basins on the east and the Kaládgi and Bhima basins to the north-west. None were met with in such parts of the granitic area as were examined by the Geological Survey, but a great part of that area remains unsurveyed, while much of the surveyed tracts could not be gone over exhaustively. Should the Wajra Karur neck turn out productive of diamonds, the whole of that tract should be closely prospected, for a neck might well exist without any traces showing of a kind to have attracted the attention of native prospectors, for they had certainly not recognized the Wajra Karur neck as a source of diamonds. The prospecting will have to be carried out by a process of most minute "shoading," especially where the cotton soil spreads occur. Even with the most searching process of shoading it will be impossible to effect an exhaustive examination of much of the country, for there are tracts measuring many thousands of acres in extent where no streams cut through the cotton soil, and the sub-rock not being exposed no "shoad stones" can be seen to guide the prospector.

It is only lately that I became aware of the existence in the Bulletin de la Société Géologique de France, for 1886, of a paper by M. Chaper, a French mining engineer, on "A diamondiferous pegmatite in Hindustan."¹

The only notice of this, if true, very remarkable discovery I had seen was a very brief paragraph in (if I remember rightly) the "Madras Mail," making the barest mention of it and without any particulars as to the locality, or circumstances, of the find. Mr. Chaper's paper, from which I give some extracts further on, is unfortunately unaccompanied by any map or plan showing the exact locality of his find, and the written account of it is so vague that I do not think it would be possible to determine the spot even if on the ground. This is very much to be regretted as it prevents his discovery being put to a crucial test by tracing out the pegmatite vein whence he derived his diamonds, sapphires, and rubies. Could this be done, the validity of his claim could speedily be decided by mining the vein in question. If his gems really came out of the vein, it is most unlikely that others would not be found in it, and it would be possible, and probably easy, to determine to which of the many series of veins traversing the older crystalline rocks of that region that particular vein belonged.

According to his own showing however, he regarded his results as most unfavourable from a practical point of view, and as holding out but very poor hopes of the pegmatite proving a remunerative source of diamonds. His arguments for believing

¹ "Note sur une Pegmatite diamonifère de l'Hindustan."

the pegmatite to be the matrix in which carbon crystallised into diamonds will be examined further on. I will merely state here that to my mind his views are quite mistaken, and that he utterly fails in substantiating his supposed discovery. Such being the case, I shall give but a brief review of his lengthy paper, for, although I took the trouble of translating nearly the whole of it, it is not worth reproducing in print.

From his description of the place I cannot identify it with any I visited, and it lies far to the east of the most easterly place pointed out to me as having yielded diamonds on the surface. Had his description been less vague and imperfect, I should have made a point of returning to the place and hunting it up. Unfortunately I never heard the whereabouts of his work till long after I had finished mine around Wajra Karur.

He begins his paper by long notes about the country at and around Bellary town, perfectly irrelevant to the matter in hand. Eventually he gets to Wajra Karur and begins to examine the country round about. He recognised correctly the change in the characters of the country on either side of the divide between the drainage basins of the Tungabhadra and the Penner, but failed to recognize the presence of the neck and the blue rock in it. Unless the high road then existing ran differently from what the road does now, he must have actually travelled across the east side of the neck and have overlooked the blue rock exposed in the road side ditches. He must also have examined that side

Did not find the blue rock. of the village very superficially; presumably he let himself be influenced by the accounts given by the natives of the different localities where diamonds of note had of late years been collected.

Of the many spots pointed out to me as having yielded notable diamonds within late years, none lay in the hollow occupied by the neck, but all on the surrounding higher grounds to the north-north-east and east, all of which consist of epidotic granitoid. Several were in the fields some distance eastward of the village. According to his own showing M. Chaper devoted himself mainly to the exploration of the tract east of Wajra Karur, as will be seen further on—

“It was therefore to the eastward of Wajra Karur that my reseaches had to be directed with the object of establishing the wealth in diamonds of this tract.

“It has in fact produced them from time immemorial; this fact appears to me established beyond a doubt by all the evidences that I collected. Numerous depressions which are still to be seen to-day around Wajra Karur may have originated from ancient workings, anterior probably to the English domination. But since a very long time all work of this kind has ceased. The statements of the people are quite in agreement with this; it is from the surface of the country that the diamonds are collected now-a-days. After storms people of the lowest class (chucklers) wander about over the fields in rocky and uncultivated places; the more rainy the season has been and the more violent the storms have been the better their chances of remunerative finds. The best are but very modest according to the witnesses I heard, and would be far from remunerative if the time devoted to them were not in other respects of no value to the searchers.”

M. Chaper was wrong in this, as some of the stones found thus on the surface have been of considerable value. Amongst them, though not at Wajra Karur itself but at some distance to the north-west (if I was rightly informed), was the “Gor-do-Norr” valued at from 10,000 to 15,000 pounds.

He accordingly gets to work at Wajra Karur and examines especially the tract eastward of the village, and after a time concludes that "in all the neighbourhood of Wadjra Karur there are no traces of transported matter.¹ The surface of the ground is entirely composed of the products of disaggregation and decomposition of the underlying rock."

This point he insists upon strongly, as it supports his contention that the gems he found (apparently) in the soil at foot of some rock containing pegmatite veins could only have been derived from the decomposition of some vein in closest proximity; they could not have been brought thither from any distance.² The rock is cut up in every direction by small veins of injection which weather more slowly than the general mass and thus stand out in a conspicuous network—

"In the divisions of this network all the elements dissociated from the rock are in a condition of juxtaposition excepting those of the surface, which the foot of an animal or the root of a plant have been able to disturb."

M. Chaper observed four principal rocks in the course of his study of the tract east of Wajra Karur, and says: "The predominant rock is an amphibolic rock," and then proceeds into a petrological disquisition why it should not be regarded as a "hornblendic gneiss," the definition given to it by M. Fouqué, the French petrologist, who examined M. Chaper's specimens microscopically. The rock forming the country to the east of Wajra Karur is most distinctly and typically a hornblendic gneiss, though most extraordinarily cut up by small veins of several ages to such an extent in many places as to mask the true lamination of the gneiss.

M. Chaper prefers to call it a "hornblendic diorite," a name which is probably quite applicable to a certain boss of hornblendic rock, varying considerably in its character within narrow limits, which rises some 5 or 6 kilometres to the east-south-east of Wajra Karur.

The next rock in importance is a pegmatite, according to both his own and M. Fouqué's determination. It consists of orthose or microcline of a bright salmon pink, pale oligoclase, limpid quartz, and epidote; the latter forming a network of strings and veinlets of all sizes, and being an original constituent of the rock, not a subsequent product of infiltration. Its colour makes it a conspicuous rock.

The third rock "of probably metamorphic sedimentary origin," which appears only to have been seen in occasional fragments in his excavations, he regards as a "Metamorphic felspathic grit."

The fourth rock, a grey or blackish grey, fine grained granitoid, consisting of orthose, white and white and black micas and quartz, M. Fouqué terms a *granulite*, a definition which M. Chaper adopts.

¹ This is a very near approach to the truth. After several days close searching I could only find a couple of true water-worn brown quartz pebbles, specimens of not the least earthly use as indications of the age of the formation they were derived from. These and, according to my hypothesis, the diamonds themselves here occurring, are the only survivals of the first or second conglomerate which I suppose to have been denuded away bodily.

² This is rather a hazardous contention in view of the torrential character of occasional rainstorms in those regions.

He arranges the four rocks according to their age as follows:—"Granulite, hornblendic diorite, epidotic pegmatite, metamorphic felspathic grit," the first being the oldest. He does not, however, make their relations to each other at all clear, but leaves one to infer them. It does not appear whether the pegmatite occurs in bosses, or veins, or what; merely that it is met with near the hornblendic boss referred to before, though the fact of its being a later arrival is established. It is, therefore, presumably an intrusive rock, but not necessarily of very vast antiquity, for it occurs largely in the Dharwar system, both in veins and in lenticular masses.

According to M. Chaper the injection veins which form such a wonderful network in the hornblendic gneiss (diorite *selon lui*) are referable to two types—a granulitic and an andesitic with augitic porphyrite; the former being subdivisible into a purely granulitic, an epidotic granulitic, and a syenitic (granulitic?).

He next refers "to the single mineral vein," which exists 7 or 8 kilometres south of Wajra Karur and describes it. It is nothing more than a great run of exceptionally white brecciated fault rock, consisting of nearly pure quartz, which forms a considerable rocky ridge known as the Tellakonda (hill).

He then proceeds as follows:—

"It is certainly superfluous to say that the places where the natives find and collect the diamonds are not situated indifferently on one or other of the above-named rocks. In this matter they have the teachings of an experience not very enlightened, it is true, but of great antiquity, which admits little room for error. Finally, one may recapitulate their ideas on this subject by saying that the soils which they consider the most productive are those derived from the weathering *in situ* of the coarse grained rocks in which the salmon coloured orthose predominates and of the metamorphic rocks. The granite and the hornblendic diorite would then, according to them, be sterile. I could devote but little time to the verifying of these latter purely negative indications. I had, above all things, to go to the point as directly as possible, that is to say, to verify the existence of diamond where it was alleged to occur.¹ For this purpose I had many excavations made at places situated most diversely with reference to the underlying rocks, but preferably on the first. M. deMorgan, who was my associate in this expedition, and I watched the extraction and washing of the materials derived from these excavations, and we performed the picking over, the produce being two diamonds, two sapphires and three rubies. We are both of us convinced that these gems came quite authentically from the excavated material, and had not been introduced by fraud. All were found at the very moment of being turned out, and during the using of pick and shovel. The fastidious and weary labour of washing and picking over resulted in nothing."

This is all the evidence offered by M. Chaper, and he then proceeds to recapitulate the results, on which he remarks:—

"The interest of the results would have been singularly increased could I have brought back with me diamond and corundum in their gangue. I regret more than any one can not having been able to produce and submit to all comers such a material fact, which would prevent all doubt and discussion."

¹ Whose allegation was this? As far as I could gather there is no such thing, as a systematic search for diamonds by any class of professional searchers, who certainly could have discovered this association did it exist, and had they done this would in all probability have gone further and have broken up and pounded the rocks in search of diamonds, as they did at Banaganpalli, and in other places where diamonds are found in a matrix. The spots indicated to me as having furnished diamonds on the surface were none of them connected with pegmatite or felspathic sand, but were on the surface of the hornblendic-epidotic gneiss. In the parts I examined there were no pegmatites of any importance or I should certainly have mapped them.—R. B. F.

His arguments in favour of the occurrence of diamonds in pegmatite will, I think, convince very few people. He met with great incredulity on the part of the people in Madras, who were interested in his exploration, where he was believed to have been tricked. Nobody else seems ever to have found rough sapphires and rubies, or indeed corundum in any shape near Wajra Karur, and several experts considered that one of his rubies showed signs of cutting!

There was evidently no attempt to "salt" the ground to make it attractive in order to have it favourably reported on, but it is very likely that Was he tricked? the few little stones that were found might have been introduced despite his careful watching by some one interested in making him continue his exploration.

His results were certainly very discouraging to his principals, for they were as poor as poor could well be. To my mind it is surprising that with such exceedingly slender theories only, instead of facts, he should have ventured to write a paper and lay it before such a highly scientific body as the Société Géologique de France.

APPENDED NOTE.

"*The matrix of the Diamond.*"¹ By PROFESSOR H. CARVILL LEWIS.

A microscopical study of the remarkable porphyritic peridotite which contains the diamonds in South Africa demonstrates several interesting and peculiar features.

The *olivine*, forming much the most abundant constituent, is in porphyritic crystals, sometimes well bounded by crystal faces, at other times rounded and with corrosive cavities, such as occur in it in basaltic rocks. It rarely encloses rounded grains of glassy bronzite, as has been observed in meteorites. The olivine alters either into serpentine in the ordinary way, or into an aggregate of acicular tremolite crystals, the so-called '*pilit*,' or becomes surrounded by a zone of indigo blue bastite—a new variety of that substance. The olivine is distinguished by an unusually good cleavage in two directions.

Bronzite, *chrome diallage*, and *smaragdite* occur in fine green plates, closely resembling one another. The bronzite is often surrounded by a remarkable zone, with a centric, pegmatitic, or chondritic structure, such as occurs in certain meteorites. This zone is mainly composed of wormlike olivine grains, but a mineral having the optical characters of cyanite also occurs in this zone.

Biotite, a characteristic constituent, occurs in conspicuous plates, often twinned, generally rounded, and distinguished by its weak pleochrism, a character peculiar to the biotite of ultra-basic eruptive rocks. It alters by decomposition into the so-called *Vaalite*.

Perovskite occurs in very numerous but small crystals, which optically appear to be compound rhombic twins.

Pyrope is abundant in rounded red grains. Titanic iron, chromic iron, and some fifteen other minerals were also found. Rutile is formed as a secondary mineral through the alteration of the olivine into serpentine, being a genesis of rutile not heretofore observed.

The *chemical composition* shows this to be one of the most basic rocks known, and is a composition which by calculation would belong to a rock composed of equal parts of olivine and serpentine, impregnated by calcite.

The *structure* is at the same time porphyritic and brecciated, being one characteristic of a volcanic rock which after becoming hard had been subjected to mechanical movements. It is a volcanic breccia, but not an ash or tuff, the peculiar structure being apparently due to successive paroxysmal eruptions. A similar structure is known in *meteorites*, with which bodies

¹ Report, Brit. Assoc. for the Advancement of Science, 1887, Manchester; p. 720.

this rock has several analogies. A large amount of the adjoining bituminous shale is enclosed, and has been more or less baked and altered. The occurrence of minute tourmalines is evidence of fumarole action.

The microscopical examination supports the geological data in testifying to the igneous and eruptive character of the peridotite, which lies in the neck or vent of an old volcano.

While belonging to the family of peridotites, this rock is quite distinct in structure and composition from any member of that group heretofore named. It is more basic than the picrite-porphyrites; and is not holocrystalline-like dunite or saxonite. It is clearly a new rock-type, worthy of a distinctive name. The name *Kimberlite*, from the famous locality where it was first observed, is therefore proposed.

Kimberlite probably occurs in several places in Europe, certain garnetiferous serpentines belonging here. It is already known at two places in the United States: at Elliott County, Kentucky, and at Syracuse, New York; at both of which places it is eruptive and post-carboniferous, similar in structure and composition to the Kimberley rock.

At the diamond localities in other parts of the world diamonds are found either in diluvial gravels or in conglomerates of secondary origin, and the original matrix is difficult to discover. Thus, in India and Brazil the diamonds lie in a conglomerate with other pebbles, and their matrix has not been discovered. Recent observations in Brazil have proved that it is a mistake to suppose that diamonds occur in itacolumite, specimens supposed to show this association being artificially manufactured. But at other diamond localities, where the geology of the region is better known than in India or Brazil, the matrix of the diamond may be inferred with some degree of certainty. Thus, in Borneo, diamonds and platinum occur only in those rivers which drain a serpentine district, and on Tanah Laut they also lie in serpentine. In New South Wales, near each locality where diamonds occur, serpentine also occurs, and is sometimes in contact with carboniferous shales. Platinum, also derived from eruptive, occurs here with the diamonds. In the Urals, diamonds have been reported from four widely separated localities, and at each of these, as shown on Murchison's map, serpentine occurs. At one of the localities the serpentine has been shown to be an altered peridotite. A diamond has been found in Bohemia in a sand containing pyropes, and these pyropes, are now known to have been derived from a serpentine altered from a peridotite. In North Carolina a number of diamonds and some platinum have been found in river sands, and that State is distinguished from all others in Eastern America by its great beds of peridotite and its abundant serpentine. Finally, in Northern California, where diamonds occur plentifully and are associated with platinum, there are great outbursts of post-carboniferous eruptive serpentine, the serpentine being more abundant than elsewhere in North America. At all the localities mentioned chromic and titaniferous iron ore occur in the diamond-bearing sand, and both of these minerals are characteristic constituents of serpentine.

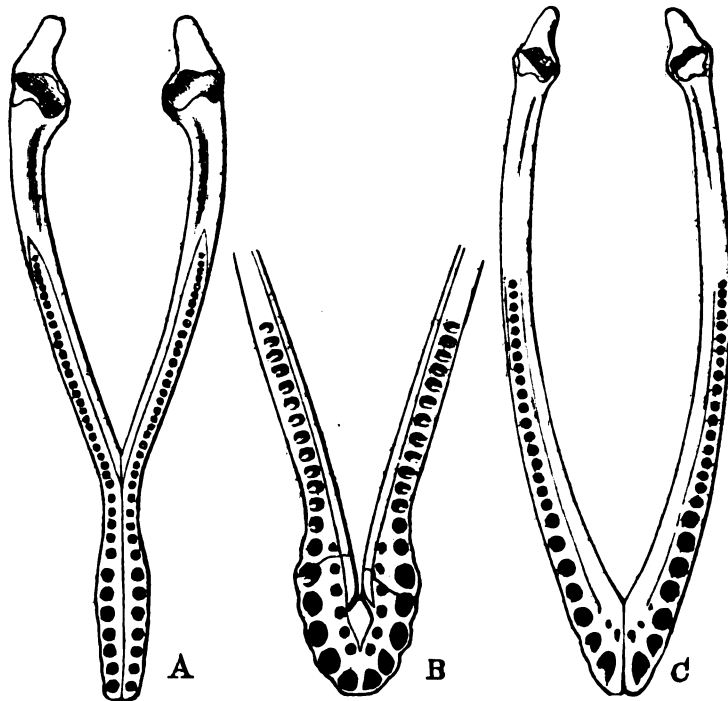
All the facts thus far collected indicate *serpentine*, in the form of a decomposed eruptive peridotite, as the original matrix of the diamond.'

On the Generic Position of the so-called Plesiosaurus indicus, by R. LYDEKKER, B.A., F.G.S.

In describing the symphysis of a Sauropterygian mandible from the Umia stage of the Gondwanas of Kach in the 'Palæontologia Indica' (Ser. iv, pt. 3, p. 28, pl. vi, fig. 1), to which I applied the name of *Plesiosaurus indicus*, I remarked upon its apparent close resemblance to the imperfect mandible of a Sauropterygian from the English Lower Lias figured in Buckland's 'Geology and Mineralogy' (Bridgewater Treatise), pl. ix, fig. 3. I was, however, at that time, owing to the want of literature,

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unaware that the English specimen had been made one of the types of *Plesiosaurus arcuatus*, Owen. Thanks to the Director of the Survey, I have recently been able to make an actual comparison of these two specimens, the result of which not only justifies my previous comparison, but also shows that the differences I have pointed out are merely due to the English specimen having been somewhat flattened by pressure. So far, indeed, as I can see, there is not even any specific distinction between the two specimens; but as the wide difference in their geological horizons (the Umia stage being correlated with the Upper Jurassic) probably indicates that the two forms are specifically different, I propose to retain my specific name for the Indian one. In *B* of the accompanying woodcut the Kach specimen is figured, with



Three types of Sauropterygian mandibles. *A. Peloneustus philarchus*; from the Oxford Clay of Northamptonshire, †. *B. Thaumatosaurus indicus*; from the Umia stage of Kach, †. *C. Plesiosaurus dolichodeirus*; from the Lower Lias of Somersetshire, ‡.

a restoration of the missing part of the dentary from the English example. And it will be seen from this figure that the mandible is characterised by its spoon-shaped symphysis, which is of considerable length, and has five dental alveoli of much larger size than those of the rami. The posterior border of the oral surface of the symphysis is also marked by a diamond-shaped prominence.

The other specimens drawn in the accompanying woodcut are intended to show the difference of this type of mandible from those of other Sauropterygians. The mandible on the right hand of the figure (*C*) is that of *Plesiosaurus dolichodeirus*—

the type of the genus—from the Lower Lias; while the one on the left (*A*) is that of a Sauropterygian from the Oxford Clay to which, in a paper recently communicated to the Geological Society, I have applied the generic name of *Peloneustus*. The former, it will be observed, has a short V-shaped symphysis, without any marked enlargement of the anterior teeth; while in the latter the symphysis has become extremely elongated and narrow.

In the paper above-mentioned I have brought forward evidence to show that the so-called *Plesiosaurus arcuatus*, together with the allied *P. megacephalus* of the same beds, and *P. cramptoni*, of the Upper Lias, should be referred to the genus *Thaumatosauros*, originally described upon the evidence of vertebræ and teeth from the Great Oolite of Würtemberg. The species of that genus, in addition to certain peculiar features of the pectoral girdle, are characterized by their relatively large skulls, having a spoon-shaped mandibular symphysis, and large anterior teeth; by the neck being relatively short and thick; and by the cervical vertebræ having very short centra, with nearly circular and deeply cupped terminal faces, and double costal facets. To this genus must also be referred the Kach Sauropterygian, under the name of *Thaumatosauros indicus*.

This genus appears to have its last English representative in the Kimmeridge clay, — the approximate equivalent of the Umia stage,—but that species seems to have been of very rare occurrence. Some signs of affinity with *Peloneustus* are shown by *Thaumatosauros*; but the former is readily distinguished by the characters of the pectoral girdle, by the extremely long mandibular symphysis, and the ellipsoidal contour and slight cupping of the terminal faces of the cervical vertebræ, while in many of its characters it makes a marked approach to *Pliosaurus*.

On Flexible sandstone or Itacolumite, with special reference to its nature and mode of occurrence in India, and the cause of its Flexibility: by R. D. OLDHAM, A.R.S.M., F.G.S., Deputy Superintendent, Geological Survey of India. (With 2 plates.)

The existence of a peculiar flexible form of rock, afterwards called Itacolumite, appears to have been known as far back as 1780 when specimens were brought from Brazil by the Marquis de Lavradio, Viceroy at Rio de Janeiro. But, though known to science for more than a century, it appears never to have attracted much attention, and, to this day the descriptions in textbooks are, for the most part meagre and inaccurate. Not infrequently it is said to be the original matrix of the diamond, and with only one exception, so far as I am aware, the flexibility is always said to be due to the presence of mica.

The first of these myths appears to have been the outcome of a survival of mysticism and to a belief, no weaker for being unexpressed, that so valuable and rare a gem as the diamond could not be of common origin: and, when in the same district that yielded diamonds there was found a peculiar and mysterious rock in

which the diamond appears to have been occasionally observed, this was enough to give rise to the belief in an intimate and necessary connection between the two. But a similar rock has since been found in other parts of the world unaccompanied by diamonds, nor does there seem to be any reason for supposing that in Brazil the diamonds are other than of derivative origin and that their association with itacolumite is other than accidental.

The second statement, that mica is the cause of its flexibility, can be traced to the authority of Von Eschwege,¹ who is also responsible for the fancy name of Itacolumite. But the fact that mica seldom, if ever, forms a large proportion of the rock, and is in some cases entirely absent suffices to prove that the flexibility is, in some cases at least, not due to the presence of this mineral.

Besides the usually small proportion, and occasional absence, of mica in the rock, the nature of the flexibility it possesses is very different from that of mica or any of the other flexible minerals. If one of the flexible specimens be examined it will be found to yield with the greatest readiness to any force applied, and can be stretched, compressed, or bent in any direction with the greatest ease, up to a certain limit at which, to use a slang but expressive term, it "jams", and no further application of force will cause it to yield except by actual fracture. The extent to which some of the softer specimens will bend, when cut into thin slabs, is remarkable; one specimen, 17 inches long and three quarters of an inch thick, allowed its end to be lifted 7 inches vertically from the table on which it lay before the other end moved. This great degree of flexibility is only shown by very soft and decomposed specimens, and there is every gradation from them to hard pieces whose flexibility is only noticeable when cut into thin slices, but in every case the flexibility is the same in kind and differs only in degree.

Another fact, which does not lend any support to the mica theory, is that the flexibility is invariably exhibited by decomposed specimens only. At Kaliána² the flexible stone occurs on a hill composed of vertically bedded glassy quartzites; it is confined, so far as my investigations and enquiries went, to one single spot where, for about 20 feet across the strike and for about 30 yards along it, the rock has become flexible; near the margin of this area the flexible stone passes downwards into the ordinary quartzites, but in the centre the decomposition had extended downwards to the floor of the quarry, a depth of fully 15 feet; here, too, the rock was much softer, more decomposed, and flexible than nearer the margin.

The same connection between decomposition and flexibility has been noticed in Brazil by Von Eschwege, who says that the more decomposed and iron-stained the rock becomes, the more flexible it is. He also notices that the stone yielded by one and the same bed is flexible at one place, at another not, and that the peculiarity is not confined to one particular bed, but may be found affecting several distinct, superimposed beds. Mr. Tuomey in his report on the geology of S. Carolina notices that the Itacolumite of that State "passes even in the same mass into compact quartz, to be distinguished from common quartz only by its stratified structure," and at another place that "the passage from the arenaceous to the compact variety is gradual, and it is in this passage that it assumes the form of *itacolumite*." The same

¹ Poggendorf, *Annalen* LVII, 100, (1817); LIX, 136; (1818).

² 4 miles from Dádri in Jhind.

observations are conspicuously applicable to Kaliána, and I attribute the fact that flexible stone has only been recorded from one locality, to the extent to which this hill has been riddled with quarries that have been worked for centuries to supply building and quern stones, while elsewhere the same rocks are, as a rule, almost untouched. Did these rocks contain mineral wealth that would encourage prospecting it is probable that other localities for flexible stone would be discovered.

From these considerations we may conclude that the flexibility of the rock is due, not to the flexibility of any of its constituents, but to some peculiarity in the mode of aggregation of the individual grains of quartz and other material of which it is composed. This conclusion is not now enunciated for the first time, for I find that, in 1785, the Chemist, M. H. Klaproth, published a description of the "Flexible quartz of Brazil," in which the following passage occurs: "I am inclined to think that the elasticity of this fossil originates solely from the form of its aggregation; for, as may be distinctly seen at the first glance in the entire stone, all those longish lamellæ are interwoven in one single direction, and implicated in such manner that each junction resembles a vertebra or hinge. With this idea also corresponds the particular kind of the flexibility of the stone, which is not tough or coriaceous."¹ This, though not a complete explanation, is far more correct and satisfactory than that which has been repeated in all manuals and text-books, with the exception of that by Prof. S. Haughton, who says "occasionally, in some rare cases—which, as far as I have any knowledge of them, are confined to Brazil, South Carolina and Delhi—you have a rock composed of particles of sandstone which are not in contact with each other but lie in a paste of felspathic clay, which paste permits a certain amount of motion between the particles of the mass." An explanation which is incomplete only in so far as it does not explain how a rock so constituted could hold together.

It now remains to determine the nature and origin of the structural peculiarity to which the rock owes its remarkable character.

If a slice of flexible stone is examined under the microscope, by reflected light, it exhibits a structure most conspicuous in all the specimens of flexible, and equally conspicuous by its absence from all specimens of non-flexible, stone I have examined. The rock consists of irregular aggregates of grains of quartz separated from each other by fissures and crevices which extend deep into the stone and give one the impression of ramifying through its mass further than they can be actually traced. Should one of these aggregates of quartz grains be touched with a needle it will be found loose and easily moveable from side to side, but it cannot be displaced without fracture, either of itself, or of the surrounding particles. In fact, the rock consists of a number of irregular aggregates of quartz which hold together by projections on one fitting into hollows in another, while the clear space between them allows of a certain amount of play.² I have attempted to portray this structure in fig. 1, but it is extremely difficult to represent in any mere delineation, which does not allow of a demonstration of the mobility of the individual aggregates.

The descriptions of Von Eschwege exhibit the Brazilian stone as belonging to a

¹ *Schrift. Berl. Ges. Naturf. Freunde*, VI, 322, (1785). The original not being accessible, I have quoted from "Analytical essays towards promoting the Chemical Knowledge of Mineral Substances by Martin Henry Klaproth," 8°. London (1801), p. 410.

² Since writing the above I have met with a short paper by O. Mügge in which the same view of the flexibility of the stone is declared.—*Neu. Jahrb.*, I Band, 1887, pp. 195-197.

highly metamorphosed formation, and even the decomposed flexible specimens from the Brazils and Georgia show some signs of the metamorphism they have undergone. They are both much more finely laminated than the Kaliána stone and the surfaces of the laminæ, along which the rock splits with ease, are covered with fine plates of silvery mica, which are all drawn out in one direction. The presence of this mica doubtless gave rise to the idea that it was the cause of the flexibility of the stone, but in those specimens accessible to me they are not confluent and form but a very small proportion of the stone. Their arrangement with the longer axis of each pointing in the same direction can hardly be due to their original deposition in this manner; it seems more probable that the rock has been subjected to great pressure and at the same time to the softening influence of heat and superheated water, and, under the influence of these, has been squeezed or drawn out in the direction marked by the lengthening of the plates of mica. Possibly, too, what has been described as lamination may in fact be an imperfect cleavage structure.

However this may be, there can be no doubt that the quartzites of the Kaliána hill have been subjected to intense metamorphism. Under the microscope the individual quartz grains are seen to be compressed together and to interlock with each other in the most elaborate manner. The general indications of metamorphism and even incipient fusion have been sufficiently described by Colonel McMahon¹, and it is unnecessary to dwell further on them here.

In the Kaliána rock there is, besides the quartz and accessory minerals, a certain proportion of felspathic paste, more conspicuous in sections cut transverse than in those cut parallel to the bedding. This paste does not surround the individual grains of quartz, but occupies spaces between aggregates of several grains, and it is to the decomposition and removal of this paste that the flexibility of some decomposed specimens is due. In such a rock the development of a flexible structure depends on the proportion and mode of distribution of the felspathic mud; if absent or only present in a very small proportion, decomposition will not extend deep into the rock, the quartz grains will be detached and fall off, leaving the undecomposed rock with a mere film of weathered stuff on the surface: if it is too evenly distributed, the quartz grains will not be in sufficiently intimate contact with each other, and as the rock weathers it will decompose into grains of sand easily detached and removed: if finally it should be suitably distributed, but too large in amount, the voids left by its removal will be so large that the quartz aggregates will not interlock with each other. The number of conditions that must be fulfilled accounts satisfactorily for the rarity of flexible sandstone and to a certain extent for the capriciousness of its distribution in rocks which are of the same age and have to all appearance the same composition and structure.

The only method of proving the hypothesis maintained above, would be the discovery of a flexible rock in which a similar structure was due to a different cause, and such evidence is fortunately provided by the discovery, by the late Mr. F. Fedden, of a flexible sandstone near Chárlí² south of the Penganga river in Berar. It is an ordinary soft sandstone of rounded grains of quartz, with a little felspar, held together by a cement of carbonate of lime, which forms 35·9 per cent. of the whole

¹ *Rec. Geol. Sur., Ind.*, XVII, 101—18, (1884).

² *Vide Mem. Geol. Surv., Ind.*, XIII, 16, (1877).

mass. Here there is no comparatively soluble material whose removal leaves the rest of the rock as a mass of irregular aggregates interlocking with each other, for on removal of the cement, by solution, the rock falls into sand. But if the fractured surface of the rock is examined, an abundance of sheeny patches point to a crystallisation of the cementing matrix, and these crystals offer a number of planes in various directions along which solution proceeds with greater rapidity than elsewhere, and as a result the rock becomes divided into irregular interlocking aggregates of sand and calcite.

We have then two distinct rocks of vastly different ages, the Chárlí rock being Permian or upper Carboniferous at the oldest, while the Kaliána rock is certainly at the newest lower palæozoic; one exhibiting a high degree of metamorphism, the other showing no traces of it, one highly disturbed, contorted and compressed, the other lying almost flat and undisturbed, one almost pure quartz, the other containing a large proportion of carbonate of lime, agreeing only in two points, that both occasionally decompose into a mass of irregular interlocking aggregates, separated by empty spaces, and that where this has taken place, both exhibit a peculiar and remarkable flexibility of precisely similar character. It is impossible to avoid the conclusion that there must be an intimate relation between these two peculiarities, and that the flexibility is the direct result of the unusual structure of the rock.

We have then an hypothesis which allows of the observed fact that thin slabs can be bent further than thick ones; for the same absolute lengthening or shortening of the opposite surfaces will result in a greater angular displacement when they are close together than when far apart. It accounts for the rock being always a product of decomposition; for the structure postulated could not be innate, and could only arise from the partial removal of a once solid rock. And, lastly, it is in perfect accordance with the peculiar nature of the flexibility of the rock.

Flexible sandstone is accordingly a rock in which incipient decomposition has resulted in its division into a number of irregularly-shaped aggregates, whose irregularities interlock and hold them together, while the intervening free spaces allow them individually a certain freedom of movement, and to the rock as a whole a certain degree of flexibility within limits governed by the size of the individual aggregates and of the free spaces between them.

Note.—It may not be uninteresting to record here the localities where flexible stone occurs.

In America besides Mexico, there are the localities in North and South Georgia and South Carolina. In Europe it is said to have been found in the Rhine valley (*Nou. Jahrb.* 1841, p. 566), in Galicia it occurs *bien caractérisé* (*Bull. Soc. Géol. France*, 1834, p. 416) and it is said to be found in the Ural mountains (*Zeits. Deut. Geol. Ges.* 1849, p. 484), but the term here appears to be used as synonymous with a micaceous quartzite containing diamonds; at p. 487 Baron von Humboldt quotes Jacquemont as an authority for the occurrence of Itacolomite in India, but he refers to the diamond bearing Vindhyan sandstones of Panna, and not to the flexible stone referred to above, with which Jacquemont does not seem to have been acquainted.

In Asia I know of none but the two localities mentioned in this paper.

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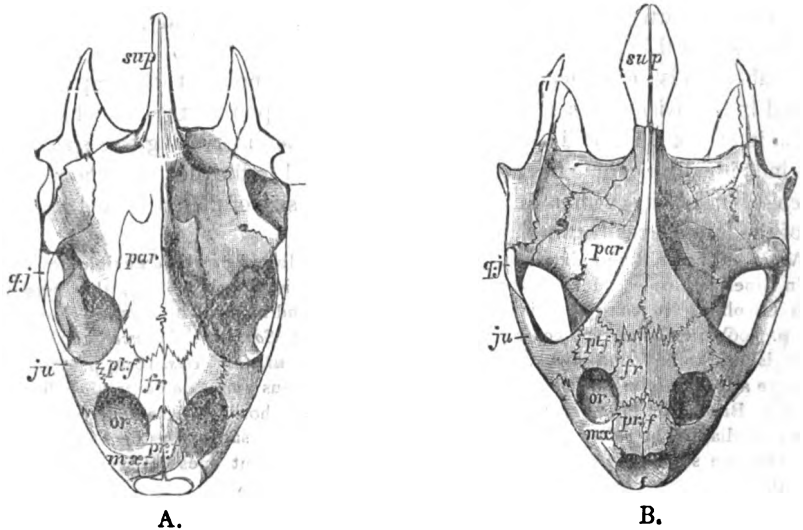
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Notes on Siwalik and Narbada Chelonia, by R. LYDEKKER, B.A.,
 F.G.S., &c.

Since it is always desirable in describing fossil Chelonia to have the evidence of the skull as well as that of the shell, I am glad to take the opportunity of figuring the skull of an *Emyda* from the Siwaliks of Perim Island acquired a few years ago by the British Museum, since we have hitherto known this genus in a fossil state solely by the shell. In order to exhibit the points in which the skull of *Emyda* differs from that of *Trionyx*, I have figured, side by side with that of the former genus, a cranium of *Trionyx gangeticus* from the Pleistocene of the Narbada valley—



Frontal aspect of the skulls of (A) *Emyda* (*cf.*) *granosa*, and (B) *Trionyx gangeticus*; restored and reduced to the same scale. *Sup.* supraoccipital; *par.* parietal; *pl.f.* postfrontal; *fr.* frontal; *pr.f.* prefrontal; *mx.* maxilla; *ju.* jugal; *qj.* quadratojugal; *or.* orbit.

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(x 27)

Fig. 2. Flexible Sandstone from Chārli, cut
transverse to bedding.

R D Oldham, del.

Lith^d by Lala Bindulall.

GEOLOGICAL SURVEY OF INDIA.

R.D. Oldham.

Records. Vol: XXII



(x 7)

Fig. I. Flexible Sandstone from Kaliāna, cut
transverse to bedding.

R.D. Oldham, del

Lith^d by Laia Bindulali.

It will be seen by an inspection of the figures, that the skull of *Emyda* is distinguished from that of *Trionyx* by the much greater deflection of the beak, the larger orbits, the relatively narrower interorbital and postorbital bars, the larger postfrontal and the generally longer and narrower contour of the entire skull.

The fossil skull agrees in all respects with that of full-grown individuals of *Emyda granosa*, and therefore serves to confirm the identification of the Siwalik shell figured by myself in the 'Palæontologia Indica' with that species. It should, however, be observed that I am unable to distinguish *Emyda granosa* by the characters of the skull alone from the closely allied *E. vittata*; and it is accordingly by no means certain that the skull may not belong to the latter. I refer it, however, provisionally, to the former species, as being the one of which we have definite knowledge in the Siwaliks.

In describing the Siwalik and Narbada Emydines in the "Palæontologia Indica" I have in many instances much difficulty in deciding whether to refer the fossil forms to the existing species to which they were evidently closely allied, or to consider them as representing distinct species. After much hesitation I came to the conclusion to adopt, in most cases, the latter alternative. In the same memoir, owing to the unsatisfactory nature of the definitions of the numerous genera of Indian Emydines proposed by the late Dr. Gray, I decided to employ the generic terms *Clemmys* and *Batagur* in the wide sense in which they are used by Mr. Sclater in his "List of the Animals in the Zoological Society's Gardens."

In recently revising the classification of the Chelonia, the results of which will appear in his forthcoming British Museum Catalogue, Mr. G. A. Boulenger has seen reason to adopt a larger number of genera for the Indian Emydines, and has also arrived at the conclusion that most of the Siwalik forms to which I have applied distinct names are not really separable specifically from their existing allies. As my friend has been good enough to communicate his conclusions to me with permission to publish them, it appears advisable that they should be noticed in the publications of the Survey; since it is useless to retain in our literature so-called species which cannot be defined.

I may add, that when I was describing the Siwalik Chelonia, none of the recent Chelonian shells in the British Museum were stripped of their epidermal shields, so that it was extremely difficult to compare them with those fossils in which only the sutures between the component bones were displayed. Mr. Boulenger has now stripped at least one shell of almost every genus, so that for the future the Palæontologist will have the opportunity of much more exact comparison, and the consequent probability of arriving at a correct conclusion.

Firstly, with regard to the Batagurs, Mr. Boulenger proposes to restrict the term *Batagur* to *B. baska*; and to adopt Gray's names of *Hardella* and *Kachuga* for the other types represented in the Siwaliks which I have included in *Batagur*. There is, consequently, no Siwalik representative of the latter genus. The shells which I have described as *B. falconeri* and *B. caulleyi* are regarded as indistinguishable from the existing *Hardella thusgi*; while Mr. Boulenger also considers that the smaller shell which I described in the 'Quarterly Journal Geol. Soc.', Vol. XLII, p. 540, pl. XV, under the name of *Clemmys watsoni*, and considered to be a totally

¹ Series X, vol. iii, part vi (1885).

different form, is really a male of the same species; there being a great difference in the size of the two sexes. I have great hesitation in separating the form I have described as *Batagur bakeri* from *Batagur kachuga* of Gray; and these are now united by Mr. Boulenger as *Kachuga lineata*. There appeared to me to be such a marked difference in the form of the vertebral shields of the shell described as *Batagur durandi* from the allied *B. dhongoka* that I had no hesitation in separating the two forms; but my friend does not consider these differences as of specific value, and accordingly classes both as *Kachuga dhongoka*. The genus *Pangshura* is now included in *Kachuga*, and the species described by Dr. Günther as *P. flaviventus* identified with *Kachuga teetum*: consequently, the fossils which I have referred to *P. flaviventus* should be named *K. teetum*.

For *Clemmys hamiltoni* Mr. Boulenger retains Gray's name of *Damonia*, and if he is right in considering the Siwalik specimens I have figured as *C. palæindica* as not specifically separable from that form, they must be known as *Damonia hamiltoni*. In the group now regarded as generically distinct under the name of *Bellia*, I have described several shells which I referred to four distinct species, under the generic designation of *Clemmys*; Mr. Boulenger informs me, however, that I have regarded sexual characters as specific, and that while the depressed shells are males the vaulted ones are those of female individuals. Under these circumstances, and taking the contour of the nuchal and vertebral shields as affording specific characters, it is probable that we have only two Siwalik species of *Bellia*; viz., *B. sivalensis* = *Clemmys hydaspica*; and *B. (Clemmys) theobaldi* = *C. punjabiensis*. The form which I have compared with *Clemmys trijuga* will be distinct from the genus *Clemmys* as now restricted.

Finally, in the land tortoises, the observations of Mr. Boulenger tend to show that *Colossochelys* is not generically separable from *Testudo*; while among the Trionychoidea, I am now disposed to regard the unnamed *Trionyx* represented in plate XXVIII, fig. 3, of the Memoir in the 'Palæontologia Indica' as probably belonging to a variety of *T. hurum*.

In the following table the synonymy of the fossil forms according to the above-mentioned views is clearly indicated:—

Batagur	. falconeri, Lyd.	} =	Hardella thusgi.
————	. cautleyi, Lyd. .		
Clemmys	. watsoni, Lyd. .	} =	Kachuga lineata.
Batagur	. bakeri, Lyd. .		
————	. durandi, Lyd. .	} =	Kachuga dhongoka.
Pangshura	. flaviventus, Lyd. .		
Clemmys	. palæindica, Lyd. .	} =	Damonia hamiltoni.
————	. hydaspica, Lyd. .		
————	. punjabiensis, Lyd. .	} =	Bellia theobaldi, Lyd.
————	. punjabiensis, Lyd. .		

RECORDS
OF
THE GEOLOGICAL SURVEY OF INDIA.

Part 2.]

1889.

[May.

*Note on Indian Steatite, compiled by F. R. MALLET, Superintendent,
Geological Survey of India.*

In October, 1887, a "Memorandum regarding the supply of steatite" was drawn up by Mr. J. R. Royle, C.I.E., at the India Office, with special reference to the possible resources of India. Mr. Royle had been applied to by a well-known firm of gas engineers, asking if he could assist them in obtaining from India a material suitable for the manufacture of gas-burners, as they were at that time dependent entirely on Germany for their supply, and the German steatite was then fetching the high price of £17 per ton. The firm in question had, some years ago, received one consignment from India, which answered their purpose perfectly, but they had been unable to obtain any further supply. As it was known, therefore, that good steatite did exist in India, and, further, as the material would be employed in England for many other purposes besides that mentioned above, if a sufficient quantity could be obtained, it was suggested by Mr. Royle that the Government of India should be requested to have samples of good Indian steatite forwarded to London, with particulars as to the supply obtainable, and the local cost.

A copy of the above memorandum was in the following month sent by the Secretary of State to the Government of India, with the suggestion that the necessary samples, and information respecting them, should be collected and sent home to the India Office. The matter having been referred to the Director of the Geological Survey, Dr. King drew up a preliminary note, embodying the information then available. Acting on this, the Governments of Madras, the Central Provinces, and Burma, and the Agents to the Governor General in Central India and Rajputana, were asked to furnish as complete information as could be obtained locally, together with samples of the stone.

Altogether, about 50 specimens (mostly 6 inch cubes) have been received from 38 different localities scattered over 19 districts. Concerning all of these, more or less full information was sent at the same time. The samples and papers having been forwarded to the Geological Survey Office, the work has been assigned to me

B

of making a preliminary examination of the former and systematizing the information obtained.

As it would be useless to send to England stones that are unfit for employment in any of the uses to which steatite can be applied, all those have been rejected which are obviously worthless. Of these a few are sandstones, the rest being potstones, and steatites so impure as to be valueless, except for such coarse purposes as potstones can be applied to. These rejections include about 30 specimens, leaving 22 specimens from 15 localities in 12 districts. Of these districts, 7 are in the Madras Presidency; the remainder being in the Central Provinces, Rajputana, and Burma.

The specimens last mentioned vary greatly in quality, but none are so bad as to have been deemed worthy of summary rejection. Although the final decision as to which of them are suitable for the purposes of gas engineers must be left to the engineers themselves, an attempt has been made to form some idea on this point in the laboratory here. It appears, from Mr. Royle's memorandum, that the latter stages in the manufacture of gas-burners are performed with circular saws, running at 1,700 revolutions per minute, and that the most minute particles of grit would suffice to destroy both the burners and the saws. As one of the most necessary qualities in the steatite, then, is the capability of being cut into sufficiently small pieces without injury to the saw, it appeared that it would be a fair test to reproduce the actual conditions of manufacture as nearly as could be. A saw two inches in diameter was not obtainable, but one of four inches was used, which was run at about 1,300 revolutions per minute, giving therefore a circumferential speed even greater than that of the two-inch. But this, in as far as injury to the saw itself was concerned, was probably more than balanced by the fact that the larger saw was probably of thicker steel and had stronger teeth. A straight-edge was placed parallel to the saw on one side, and adjustable in its distance, so that slices of steatite of any required thickness could be cut. As a matter of fact, however, all the specimens were tested as to their capacity of being cut into slices $\cdot 03$ inch thick. Slabs measuring about 4 inches $\times 1\frac{1}{2}$ " $\times \frac{1}{2}$ " were taken, and slices cut from these of 4" $\times \frac{1}{2}$ ". From some specimens, slice after slice of this kind could be cut without breaking. Others, again, gave slices which generally broke in two, while the most brittle samples gave slices which broke up into three or four pieces. These grades are distinguished roughly in the notes below as:—

Cut easily in slices.

Cut in slices.

Cut with difficulty in slices.

At the same time the presence of grit could be detected by the peculiar noise made by the saw, and the feel of the slab in the hand as it was pushed forward.

Previously to their being sent to Calcutta the Madras specimens were tested by Mr. Bosworth-Smith, Mineralogist to the Government of that Presidency, in as far as the means at his disposal allowed.

"It appears," he writes, "that the stone is principally wanted for cutting into caps for gas-burners, but as the demand for stone for such a purpose would of necessity be very small, the economic value of the mineral for other purposes should be given. There are several minor uses to which steatite is put, such as 'marking-

chalk' for tailors, &c. It has been proposed to use the mineral in a fire-proof paint, but with what success I am not aware. Its most general use, however, is as a lubricant, and as this quality can be fairly well tested by rubbing the powdered mineral between the finger and thumb, I have given, in the remarks upon each specimen, a note upon its quality as a lubricant. In determining its capabilities of being cut, but little can be done away from the cutting machine; but as it is clear that grit and a heterogenous structure would be absolutely fatal to its use, I have classed all those specimens that contain grit, and which are not homogeneous, as unfit for cutting. In determining the grit, the method used was to take an ordinary office penknife and cut a small plane on one of the corners of the specimen; then, if on drawing the edge of the knife *backwards* up this streak there were particles of grit loosened, these will scratch the surface of the cut. Such a specimen I have called 'gritty.' If the grit particles could be felt with the edge of the knife when cutting *forwards*, I have termed such a specimen 'very gritty.' On cutting one specimen the grating effect was so great that only the term 'sandy' would apply." Mr. Bosworth-Smith's remarks on the various specimens are quoted in the following notes.

MADRAS PRESIDENCY.

AI.—*From Maddawaram Village, Nandyal Taluk, Kurnool District.*—The specimen from this locality is white, and faint reddish, in color, with a compact structure. Cuts very freely: cuts easily in slices. Mr. Bosworth-Smith says—"This specimen seems the best of those sent in for the required purpose. It does not seem too hard, neither is it over soft. It appears to be remarkably free from grit." The present Director of the Geological Survey, Dr. W. King, who has examined the rock *in situ*, writes,—“Further north still, between Moodwaram (Maddawaram) and Yenkatgerry, the shales of this series¹ are very magnesian, some of the layers being nothing else but fine grey and greenish steatite. There are also seams of the finer form, or French chalk, which is here called, and known over South India, as 'Bulpum.' This Bulpum is largely used by the people as a chalk for writing on their blackened boards, or small folding books of blackened paper or canvas. The associated bands of steatite and steatitic shale, which are of various shades of brown, green, and purple, are carved at Kurnool into paper-weights, &c., * * * This is the quarrying place for steatite in the district.”²

In the preliminary note alluded to above, Dr. King remarks that “any amount of it (the steatite) can be easily obtained, as it occurs in well-marked bands, or thin beds.” “This locality is 22 miles due south of the town of Kurnool.” It is four miles distant from the Bethumcherla Railway Station. The Collector of the district gives the “dimensions of the quarries” as one square mile (doubtless meaning that they are scattered over that area), and estimates the cost of delivery at Madras per ton at 20 to 30 rupees, the equivalent of which in sterling is about £1-7 to £2-0.³ To this must be added the sea-freight. This varies greatly, but at the time of

¹ *i. e.* the Paupugnee beds of the Kadapah formation.

² Memoirs, Geological Survey of India, Vol. VIII, p. 166.

³ Here, and elsewhere, the rupee is taken as equal to 1s. 4d.

writing, would be, by steamer, about 40 shillings per ton (by weight), making the cost of the stone in London about £3-7 to £4-0.¹

A2.—*Same Locality as A1.*—Color pale green; slightly crystalline in structure. Contains occasional dark red, highly gritty specks of some size, which are minute garnets. Harder to cut than A1, but cuts tolerably freely except where specks are met with, which are *very* gritty: cuts in slices. Mr. Bosworth-Smith remarks that this specimen “does not seem so suitable for cutting as the above; for, on cutting it, the powder seems to clog somewhat. It makes a good lubricant and ‘French Chalk’ powder.”

B1.—*From Pendakallu Village, Ramallakot Taluk, Kurnool District.*—Color pale green; very slightly crystalline in structure. Cuts freely: cuts in slices. “This seems free from grit, is soft and easily cut; does not clog much. Its powder is very greasy and would make a good lubricant” (Bosworth-Smith). The locality is seven miles from the Railway Station. The quarries are stated by the Collector to have the dimensions of (to be scattered over?) 10 acres, and the cost of delivering the stone at Madras is estimated at 20 to 30 rupees (£1-7 to £2-0) a ton, which would be equivalent to about £3-7 to £4-0 in London.

B2.—*Same locality as B1.*—Pale green; somewhat crystalline in structure. Cuts tolerably freely: cuts with difficulty into slices “Very much like the above, but not quite so homogeneous, and therefore not likely to cut so well” (Bosworth-Smith).

G1.—*Somalapuram, Bellary District.*—Pale green; somewhat crystalline in structure. Cuts freely: cuts in slices. “A soft stone; fairly well free from grit; giving a very greasy powder. Seems homogeneous and free from included crystals” (Bosworth-Smith). The Collector of the district remarks that the place is 37 miles from Bellary, and that there are five quarries, of which the smallest measures 8' × 12' × 7', and the largest 12' × 24' × 10'. This, and the two following specimens, were probably obtained from different quarries, but it is not so stated. The Collector estimates the cost of delivering the stone at Madras at Rs. 25-1 (£1-13) per ton, to which must be added about £2 for freight to London.

G2.—*Same locality as G1.*—Similar to G1 in color and structure. Cuts freely: cuts in slices. “Similar to above, but in two places tried there was a fairly large piece of grit. Gives a greasy powder” (Bosworth-Smith).

G3.—*Same locality as G1.*—Pale green. Somewhat crystalline in structure, and slightly schistose. Cuts freely: cuts in slices. “A good soft stone free from grit: will make an excellent lubricant and should cut well” (Bosworth-Smith).

Narjampalli of Gulumarri Village, Tadpatri Taluk, Anantapur District.—Yellowish-white and greenish: compact in structure. Cuts very freely: cuts easily in slices. “This is very similar to A1 * *. If not too hard for the cutting machine, it will probably make a serviceable stone, as it is compact and free from grit. It gives a fair lubricating powder, but it is inferior to the softer stones in this respect” (Bosworth-Smith). The quarry is situated in a hill called Balapurangi Gutta. The stone, according to the Collector, may be had in abundance, but it is not regularly worked. It may, apparently, be inferred from this that pieces are to be obtained much larger than that sent, which only measures 6" × 1" × 1". The Collector esti-

¹ With reference to this, and the following estimates, see remarks on p. 67.

mates the cost of delivering it at Madras at Rs. 28-12-4 (£1-18) a ton, but adds that this is "merely an approximate estimate." It would make the cost in London about £3-18.

L1. *From Pathur Village, Chittoor Taluk, North Arcot.*—Pale green: nearly compact in structure, but traversed by thin veins of crystallized talc, which constitute lines of weakness along which the stone breaks more easily than elsewhere. Rather hard to cut, but free from grit: cuts easily in slices. "This seems a fairly good stone for cutting, as it is free from grit, and seems compact and homogeneous. Its lubricating qualities are only moderate" (Bosworth-Smith). There is one quarry at present. No estimate is given of the cost of delivering the stone at Madras, but the cost of delivering stone from Gangadaranellur, in the same taluk, is put down by the Collector at Rs. 7-8-0 (10s.) a ton, to which must be added the sea-freight.

C1. *From Eswaramalai Hills, Atur Taluk, Salem District.*—Pale green: finely crystalline in structure: contains disseminated crystals of dolomite, which are occasionally as much as $\frac{1}{4}$ inch long. Gritty in cutting: cuts with difficulty in slices. "This specimen is found slightly gritty on cutting. It contains some calcite. Its powder, when free from grit, makes an excellent lubricant" (Bosworth-Smith). The Collector states that there are three quarries, the smallest of which measures 9' \times 9' \times 9', and the largest 33' \times 21' \times 42', besides several smaller pits at the foot of the hills. He estimates the cost of delivery at Madras at Rs. 20 to 25 per 50 Madras maunds, or a little over half a ton—say Rs. 40 to 50 (£2-13 to £3-6) a ton, which would make the cost in London about £4-13 to £5-6.

C2. *Same locality as C1.*—Pale green: finely crystalline. Contains numerous, small disseminated crystals of a chloritic mineral, and minute acicular colorless crystals (tremolite?). Gritty: cuts with some difficulty in slices. "Similar to above but rather more gritty" (Bosworth-Smith).

E2. *Edamaranahalli village, Kollegal Taluk, Coimbatore District.*—Pale green: finely crystalline: contains minute chloritic crystals. Rather gritty in cutting: cuts in slices. "Distinctly sandy to the cut. Powder greasy, but with gritty particles" (Bosworth-Smith). The stone is obtained in the hills near the village. No estimate of cost is given.

E3. *Kollegal Taluk, Coimbatore District.*—Reddish-white and greyish: finely crystalline. Cuts tolerably freely: cuts easily in slices. "Gritty to cut. The powder is very greasy, and would make a good lubricant if grit were removed. The specimen is thin, and not up to the required size" (Bosworth-Smith). It is not clear whether this specimen is from the same village as E2, or from a different one, and it is not stated whether pieces thicker than that sent ($1\frac{1}{2}$ inch) can be obtained.

K4. *Manavalike village, Nerankimagane, Uppinangadi Taluk, South Canara District.*—Pale buff, with reddish specks in places: schistose. Cuts very freely: cuts easily in slices parallel to the foliation, but not across it. "A rather hard stone, free from grit and may do for cutting, but will not do for lubricant" (Bosworth-Smith). The specimen sent is a small one, about 2 inches thick, and it is not stated whether larger ones can be obtained. The Collector puts down the dimensions of the quarry or quarries as 600 square yards, and estimates the cost of delivery at Madras at Rs. 20-2-0 (£1-7) a ton, which would be equivalent to about £3-7 in London.

CENTRAL PROVINCES.

No. 6.—*Kanheri Village, Sakoli Tahsil, Bhandara District.*—Color buff: crystalline in structure, and intersected by occasional thin veins of crystallized talc, along which the stone breaks easily. Cuts very freely: cuts easily in slices if free from veins: powder very greasy. The local authorities say that there is a large quarry which is extensively worked, the stone being largely used for making vessels. The cost of quarrying is roughly estimated at Rs. 2 a ton, and that of the cartage to the railway (27 miles) at Rs. 6. The railway charge to Bombay would be Rs. 25-12, giving a total at the port of Rs. 33-12 or £2-5. To this must be added the sea-freight, which, at the present time, would be, by steamer, about 30 shillings per ton (by weight), making the cost in London about £3-15.

No. 1.—*Marble Rocks, Jabalpur District.*—White, with pale reddish blotches here and there: somewhat schistose. Cuts very freely: cuts easily in slices with the foliation, but with difficulty across it: powder very greasy. Dr. King writes—"I know of this steatite myself, and have seen the people grubbing it from the pockets in the Marble Rock dolomite and schists. The rocks about there are much crushed and twisted, the steatite having, in this way, been stretched and squeezed into irregular pockets, which of course, in case of more extended exploitation in depth, will be difficult to get at. At present there seems quite enough of the material, either at the surface or close to it, for the purpose required." According to the local authorities—"The extent of supply cannot be given with certainty. The steatite is found in irregular pockets, imbedded in limestones and schists. As the local demand is inconsiderable, the quarries have not been as yet worked on any large scale, but it is said that some thousands of maunds¹ can be made readily available. If the specimens now sent are up to commercial standard, the only doubt which can arise is, not whether the local supply is sufficient, but whether (having regard to the peculiar formation) it will be feasible to extract blocks of the size required." The cost of quarrying is roughly estimated at Rs. 2 a ton, and that of cartage to the railway (3 miles) at Rs. 1-12-0. Adding to this Rs. 28-7-0, for railway carriage, gives a total at Bombay of Rs. 32-3-0 (£2-3), or, with sea-freight, about £3-13 in London.

RAJPUTANA.

Mora Village, 15 miles north-west of Hindaun, State of Jaipur.—Pale green: very finely crystalline, and somewhat schistose, in structure. Cuts very freely: cuts easily in slices parallel to the foliation; more difficultly across it: powder very greasy. This is the material so much used at Agra for manufacturing elaborately carved ornamental articles. Mr. C. A. Hacket describes the stone as occurring in a bed (intercalated with quartzites of the Arvali series) which varies in thickness, but averages 2 feet, and which dips at about 30°, the outcrop being on the side of a hill, 150 feet above the plain. The quality of the material varies, but cubes of pure stone of 12 to 18 inches can be obtained. It is not excavated from open quarries, but from rude mines, the entrances to which are inclines following the dip of the bed. The mines are only worked in the dry season, and then intermittently, when the merchants from Agra arrive with orders, the total of which amounts on an average to 1,500 maunds

27·2 maunds = 1 ton.

(55 tons) per annum. The cost per maund of delivering the stone at Mora (1 mile from the mines) was given by the head villagers to Mr. Hackett as follows:—¹

	a. p.
To the khatis or miners	1 0
Carriers from mine to Mora	2 0
Zamindar of Mora	2 0
Sonar, or broker (financier)	0 6
Chowkidar of village	0 6
Chowkidar on guard	0 6
Putwari for weighing	0 6
Village charities	0 3
Maharaja of Jaipur (royalty)	3 0
Total cost delivered at Mora	10 3

According to information given to the Executive Engineer of Jaipur, the cost at the mine is 2 annas a maund, but this apparently refers to the cost of extraction only. The rate for cartage to Hindaun Road railway station is estimated at 6 annas, the railway charge to Bombay being R1-7-1. Adopting Mr. Hackett's figures this gives—

	R a. p.
Cost at Mora	0 10 3
Cartage to Hindaun Road Station	0 6 0
Railway carriage to Bombay	1 7 1
Cost per maund at Bombay	2 7 4

which is equivalent to R66-15-0 or £4-9 per ton, or to about £5-19 in London.

Raiwala (or Raialo) Village, 15 miles north of Jatwara Railway Station, Jaipur State.—White, with occasional reddish markings: nearly compact (slightly crystalline) in structure. Cuts very freely: cuts easily in slices: powder very greasy. According to information obtained for the Executive Engineer of Jaipur, there are 3 quarries, with the following dimensions—

Length.	Breadth.	Depth.
800'	30'	15'
300	30	?
450	50	?

It is added, however, that "these quarries are apparently of dimensions stated, but, not having been opened out, it is impossible to speak with certainty as to extent or quality." "We have never worked these quarries; the information is therefore necessarily imperfect." It would appear from this that the figures given must refer to the supposed extent of the soapstone deposit, not to that of existent quarries. As the place is some 7 or 8 miles nearer the railway than Mora, and involves about 30 miles less railway carriage, the charges for delivering the stone at Bombay may probably be taken as about the same, or slightly less.

Gisgarh Village, Jaipur State.—Green: highly schistose in structure. Rather gritty in cutting, but cuts easily in slices, except across the direction of foliation.

¹ Manual of the Geology of India, Part III, p. 443.

According to information obtained for the Executive Engineer of Jaipur, the quarry is 200 feet long, 3 feet wide, and 2 feet deep, from which it may be inferred that it extends along the outcrop of a bed having a rather high dip. Slabs can be obtained of large size, but not more than $2\frac{1}{2}$ or 3 inches thick. The cost per maund of delivering the stone at Bombay is estimated as follows—

	R	a.	p.
Cost at Gisgarh	0	4	0
Cartage to Bandakari Station	0	4	0
Railway carriage to Bombay	1	6	6

Cost at Bombay	1	14	6

This is equivalent to Rs 1-14 (£3-9) per ton, or to about £4-19 in London.

BURMA.

Myingudé Mountain, Yoma Range, Kyaukpyu District.—Pale green, but contaminated a good deal with ferruginous impurity: compact in structure. The purer pieces cut freely: cuts easily in slices. The Native Extra Assistant Commissioner at An writes—"I have the honor to report my visit to the soapstone mines at the Myingudé Mountain, which (the mines) are evidently on our side of the Yoma Range, and on a small hill joining the Myingudé Mountain. Last year the Burmese from Upper Burma dug six mines on our side and two on theirs. As these soapstones are to be found between other stones, it is very difficult to know the approximate yield of the mines. I am, however, informed that the Burmese who dug the mines last year received about 5,000 viss.¹ A hundred viss of first quality will fetch at An Rs. 70 or Rs. 80 at least; of the second Rs. 50 or Rs. 6c. The greatest depth of the mines dug last year is 8 cubits. Having discovered soapstones all over the hill, I hope to find more mines, but the discovery, and the production of them, entirely depend on the amount of labor employed." The specimens sent to Calcutta are only about an inch square by 4 or 5 inches long. It is not stated whether larger can be obtained, but as Mr. Theobald, speaking of the steatite of the Arakan Hills generally, says that the veins are usually of small dimensions,² probably the pieces in question are fair samples of what can be procured. The rates given above are equivalent to—

	Rs.	Rs.	£	s.	£	s.
First quality, per ton,	429	to 491	or	28	12	to 32
Second " "	307	" 368	" 20	9	" 24	11

To this has to be added carriage from An, by river, creek and sea to Akyab (estimate for which is not given), and freight from Akyab to London, so that the stone would be far more expensive in England than that from Germany.

It may be suspected that the very high prices quoted are due in part to much of the stone being of inferior quality, so that only a small portion of that extracted is saleable. The remote position of the mines or quarries, and the high rates paid for labor in Burma, also tend to raise the cost.

¹ About 8 tons.

² Memoirs, Geol. Survey of India, Vol. X, p. 336.

Hills behind Pa-aing, Sidóktaya Township, Minbu District.—Pale green: compact in structure: cuts freely. The pieces sent are only $\frac{1}{4}$ or $\frac{3}{8}$ inch square by 2 or 3 inches long, and it is not stated if larger can be obtained. Concerning this stone the Deputy Commissioner writes—"It is not exactly known how much there is, but the revenue paid for the quarry license this year was Rs. 2,300, so probably there is a good deal. We have been such a short time in the country that we have not been able to investigate the quarries, which are right up in the hills away from villages, I understand. It is procurable at Sidóktaya at Rs. 80 to Rs. 85 a 100 *vis* (365 lbs.), and has then to be carted about 50 miles to the river. This would cost another Rs. 5 or so. The steamer charges to Rangoon (about Rs. 15 a ton of 50 cubic feet) have then to be borne." The price at Sidóktaya given above is equal to Rs. 491 to Rs. 521 (£32-15 to £34-15) a ton, a rate which would be quite prohibitive, in as far as export to England is concerned.

Although, as previously remarked, the final selection of the most suitable material must be left to the gas engineers themselves, it will, I think, be found that the variety like A1, from Maddawaram in Kurnool, and the stones from Gulumarri in the Anantapur District, and Raiwala in Jaipur, are amongst the best, while several other samples appear to be very promising. But it has been pointed out by Dr. King in his preliminary note that a difficulty is likely to arise in the first instance with reference to the due selection of the best stone. "It is this difficulty of selection which must introduce a considerable factor in the cost of the stone as placed in the English market, for I fear that for some time the native quarrymen and contractors cannot be depended on for sending well-selected stone." Dr. King adds that a European, and preferably one from the German quarries, in charge, would be highly desirable, were it not that owing to the comparatively small demand now existing for steatite in England, the nascent industry would not be able to support the expense. As a practicable alternative, therefore, Dr. King suggests that natives might be obtained from some of the existing quarries, who, after some training, would be competent to make a proper choice. Mora, in Jaipur, would probably be the most likely place to seek such overseers. The steatite there varies in quality, but the demand at Agra for the best material has led to the acquirement of the necessary skill in selection on the part of those engaged in the work.

It is not clear whether the estimates for quarrying given by the various District authorities include manual labor only, or whether provision is made for supervision. Royalty, also, does not seem to be allowed for. An addition ought further to be made to the estimates, on account of expenses connected with breaking bulk at the railway, and at the ports of shipment and delivery, as well as, perhaps, on account of some incidental charges. But even if a liberal allowance be made under such heads, it appears clear that the steatite from every locality mentioned, except those in Burma, can be delivered in London at prices far below that now paid for continental stone. When the gas engineers have made their final selection, the export of a trial consignment will lead to more closely accurate information than is available at present, as to the cost of delivering the material in England.

Distorted pebbles in the Siwalik conglomerate ; by C. S. MIDDLEMISS, B.A.,
Geological Survey of India. (With one plate.)

A curious case of pebble distortion in the soft Upper Siwalik conglomerate has just come under my notice. It occurs near the axis of a small synclinal about one mile up the Raiála gád, Sara N., in E. Kumaun. The conglomerate here is composed, as generally, of a very large percentage of quartzite pebbles, grey and white in colour, with a few (more numerous, however, than I have elsewhere noticed) granite and trap pebbles. All these rocks, which are well-rounded and somewhat smaller than a cricket-ball, are closely packed together in a slightly coherent sandy matrix, not harder than what is ordinarily known as sand-rock. There is no cementing calcareous material here, as is present in many places.

The diagram forming the upper figure of the accompanying plate represents a nearly horizontal plane of division, having much the appearance of a slickensides, which cuts through the Siwalik conglomerate in this one place where I have observed it. But the remarkable attendant fact concerning it is that many of the pebbles above and below the slickensides have been crushed or drawn out in the direction of the plane of division. At the left upper side of the diagram there is first a quartzite pebble, split and shivered into plates and needles, and drawn out into a finely tapered process of pounded quartz. Next to that is one of granite, an ordinary typical granite, of the kind found *in situ* immediately to the north of the main-boundary (reversed fault between the Tertiary and Himalayan rocks) and which was in company with the trap erroneously ascribed by General Strachey¹ as intrusive in the Tertiaries in the Gola R. This pebble displays a process tailing off into a very thin filament, as long as the pebble itself. The next quartzite pebble is very dense and is merely in a fractured and splintered condition. Next to this come three pebbles, two of quartzite, with one of trap between them. Each of these has been crushed and drawn out into wavy, sinuous bands, resembling those of a puckered schist. A similar set of pebbles beneath the plane of division shows analogous features, the drawing out, however, being in the opposite direction.

This somewhat extraordinary local shearing appears at first sight easily explained. Even the youngest members of the Sub-Himalayan series have been folded and reflexed to a very great extent, as I have depicted in a forthcoming memoir. It seems rational, therefore, to impute the above feature to the action of the forces which brought about that folding and reflexing of the rocks. But against this is to be set the fact that it is a very rare feature, not by any means universal, as is much of the overfolding of the Sub-Himalayan zone. The Siwalik conglomerate is not cut through by numberless sets of these divisional planes, and it can hardly, therefore, be placed in the same category as those foliated granites, traps, and other rocks of the older Himalaya which evince dynamic metamorphism on a microscopic scale through great thicknesses of the rock.

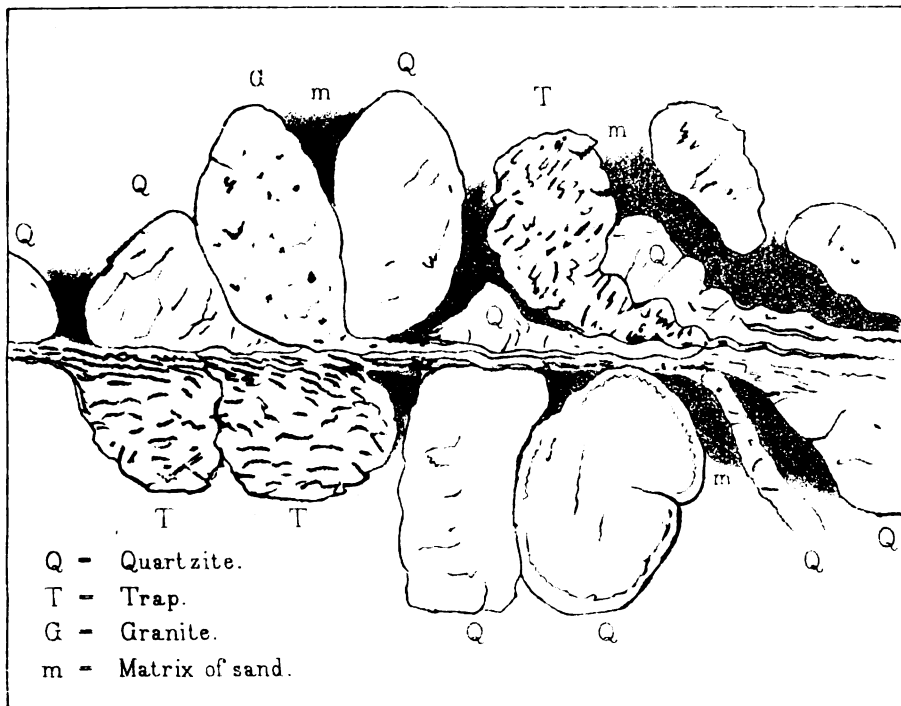
The first effect of dynamic metamorphism of rocks of this kind we should expect to be a compacting and hardening of the finer material, a conversion of the

¹ Q. J. G. S. Lond. 1851, Vol. VII, p. 296.

GEOLOGICAL SURVEY OF INDIA.

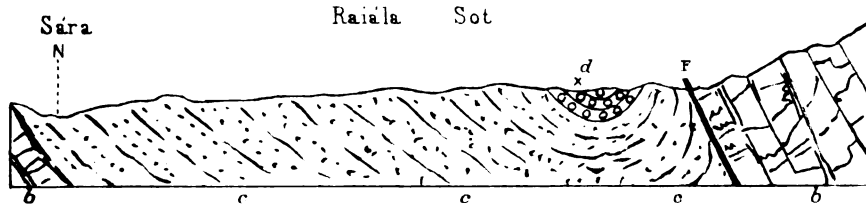
Middlemiss.

Records, Vol. XXII.



SSW

NNE



Section in which the above occurs.

- d = U. Siwalik cong^l
- c = M. do. Sand-rock
- b = L (Nahan) Sandstone.
- x = Position of distorted pebbles.

Lith^d by Lala Binduall.

matrix into something more rigid than a sand-rock capable of being dug with a spade.

But a study of the Himalaya is for ever forcing on one the inadequacy of general and sweeping theories. Contrary to what has been recently demonstrated by M. B. Lotti in the Apennines¹ where hardening and metamorphism of the Tertiaries have been connected with violent contortion of the strata, we have everywhere along the Sub-Himalaya evidence of great sigmaflexures and thrusts, occurring in the Upper and Middle Siwaliks, without in the least altering the texture of the soft clays, loams and sands of which they are composed. Everywhere material of the nature of the *molasse*, though forming gigantic folds, is as unmetamorphosed as that which M. Lotti describes in the undisturbed parts of Italy.

"The Carboniferous Glacial Period."² *Further Note*³ by DR. W. WAA-
GEN, on a letter from Mr. C. DERBY, concerning traces of a Car-
boniferous Glacial Period in S. America. Translated by E. C. COTES,
Asst. Supdt., Indian Museum.

The following extract from a letter, dated 16th April 1888, from Mr. Orville A. Derby, Director of the Geological Section Museo Nacional, Rio de Janeiro, appears to be of sufficient interest to be worth bringing to notice in Europe:—

"Your statement (Aufsatz über Carbone Eiszeit) that no traces exist in South America of ice during the carboniferous period, rests rather on want of observations, in the eastern portion of the continent, than on the actual absence of the phenomena, which have been observed in Australia, India, and South Africa.

"In South Brazil is a large palaeozoic area, which includes a large portion of the Parana basin, about which, however, practically nothing has yet been published. So far as I know, the only publication which exists, besides scanty papers on the Coal beds of Rio Grande do Sul by Weise, Plant, Carruthers and Hartt, is my own little treatise on the diamond region of the province of Parana (Proc. Am. Phil. Soc. 1879), and the very slight geological information contained in my two Geographical sketches written in Portuguese; one of these, *vis.*, 'Phisikalische Geographie u. Geologie Brazieliens,' which was intended for a school book in Abren and Cabral, has also been printed in the Mittheilungen der Geographischen Gesellschaft für Thüringen; the other, *vis.*, 'Contribuição para o Estudio da Geographia Physica do valle di Rio grande' appeared in the Bulletin da Sociedade de Geographia de Rio de Janeiro, Vol. I, No. 4. In a section through a portion of the province of Parana, which may serve as typical of the geological structure of the eastern side of this formation, we find a mountainous outer border (chiefly composed of crystalline rocks) and two broad terraces of horizontal strata. The first of these two terraces is composed of sandstone and clay slate, which belong partly to carboniferous, partly to Devonian formations. At Ponta Grossa these rocks have yielded fossils of Devonian type, *e.g.*, *Lingula*, *Discina*, *Spirifer*, *Rhynchonella*, *Vitulina*, *Streptorhynchus*, and *Homalonotus*; while at Colonia Hueza, at the foot of the second terrace, have been found such Carboniferous types as *Myalina*, *Schizodus*, *Lepidodendron* (often leaves), *Cordaites*, and *Psaronius*. The second terrace is composed of soft red sandstone and bedded trap (augiteporphyry), and is probably of Permian or Triassic age. Towards the west this formation

¹ See Extrait du bulletin de la société géologique de France, 3^e Série, t. XVI, p. 406.

² See Records, Geol. Survey of India, Vol. XXI, p. 89.

³ Neues. Jahrb f. Min. Bd. II. 1888, pp. 172-77.

stretches up to and beyond Parana, and can be traced, by its characteristic eruptive rocks, from Montevideo to the neighbourhood of the springs of Parana.

"Further to the south, in the province of Santa Catharina, the mountain chain becomes lower and the steep descent of the third division, of the profile, which is the watershed between the Uruguay and the Atlantic Ocean, approaches the sea-coast and appears to form the continuation of the Serra do Mar. In Rio Grande do Sul and in the Republic of Uruguay, it retreats further inland, at the same time losing its character of watershed. The district, traversed by the rivers flowing straight into the Atlantic Ocean, is occupied by beds denuded from the first and second divisions of the Parana profile. The Devonian formation has not as yet been traced south of the province of Parana, though it would be premature to assert its non-existence.

"Towards the north, in the province of São Paulo, the profile is similar to that of Parana: the Devonian, however, does not appear. In the southern portion of Minas Geraes, near the boundary of the province, the second (upper palaeozoic) zone disappears, and the soft sandstone and volcanics of the third zone lie directly on the metamorphics and crystallines, which belong to the first zone and compose, towards the west, the district of the springs of São Francisco. From this neighbourhood northwards, is a gap in our knowledge of the geological conditions, and it is only further towards the north-west, in the Paraguay uplands, that we again reach territory of which something is known. According to the communications of Mr. H. H. Smith, and from the fossils which he has forwarded, it would seem that Devonian, and also probably carboniferous, formations occur here, overlaid by beds containing large reptiles probably of mesozoic age. We may hope that your fellow-countryman, Dr. Vogel, who accompanied the Van den Steinen Expedition to the springs of the Xingú, and who is expected to return in a few weeks, will be able to give us further information about this neighbourhood. And it may be taken as probable that the Parana and São Paulo formations extend up to, and beyond, the Parana upland, and are connected with similar formations in Tocantin Xingú and Tapajos. However this may be, so much is certain that a broad girdle of upper palaeozoic formations (Carboniferous Permian or both) exists, and spreads itself over a great part of the length of the Parana basin.

"I have personally visited a large portion of this region, in the provinces of Parana and São Paulo, though I have been unable to examine it carefully. One of my assistants, however, found his way there through Monate; his object being to investigate parts of the province of São Paulo, and specially to observe the collections of fossils, which are somewhat scarce. The rocks are generally soft red and yellow sandstones, with reddish black clay slates. And the strata, which are occasionally thin, contain an impure coal, and one considerable limestone bed, which is full of flints. It is in this limestone bed, and its immediate neighbourhood, that all the fossils have been found.

"The most common fossil is that of a reptile described by Cope (Proc. Am. Phil. Soc. 1886) as *Stercosternum tumidum*, a new genus of Permian type; after this come various fossil woods, generally conifera of *Dadoxylon* type, though specimens with regular pittings also occur; then stems and leaves of *Lepidodendron*, with here and there fragments of *Psaronius* stems. Remains of Mollusca are rare and generally fragmentary, bivalves are the only ones that have yet been observed, and amongst these *Schisodus* and *Myalina* can be recognized, with some certainty, while the determination of other remains (e.g. *Conocardium*) is doubtful. In addition to the above a few small fishes' teeth and scales have been found, but nothing more. In this case, therefore, unaccountable as it may appear, the various common Carboniferous types are either altogether absent, or at least are very difficult to find.

"There is but one fossil-bearing bed known in the province of Parana, and that has only been cursorally examined. Unfortunately my own collections from the place have been lost; the specimens, however, only comprised a few bivalve mussels, in a better state of preservation, but probably specifically identical with, some of those of the São Paulo fossils which have been recognized. Besides these, however, fossil wood has been found in various localities, and fossil ferns also are mentioned, though I myself have not met with them.

"We thus see, in the rarity of the fossils, and in the general character of those which have been found, a certain similarity between the carboniferous of South Brazil and that of Australia, India, and South Africa. There are also other phenomena which have never yet been critically examined; I allude to those so appositely described by yourself and others as due to the action of ice.

"I usually make my geological tours here by rail, and, as I traversed the province of São Paulo in this way, I saw in the railway cuttings rounded blocks, varying from the size of a man's fist to four times that of his head: these were imbedded in, and protruded from, particularly fine clay slate. On the river Juté, near the town of Itú, is a large flagstone quarry, situated in an unusually fine sandy clay slate, which contains isolated, rounded blocks of granite, gneiss, &c., ranging up to and above, eighteen inches in diameter. Similar phenomena have also been observed near the town of Itapetininga. Last year I asked my assistant, Dr. Gonzaga de Campos, to direct his attention especially to these stones, and he has discovered some more localities in which they occur. The most interesting of these is the ravine of Capavary, near the spot where the streamlet of this name flows into the Juté, and a few miles below the town of Itú, which I have mentioned above. Here, in the bed of the streamlet, between clay slate banks lies a group of large blocks. Some years ago, when I saw these blocks myself, I thought they must be an outcrop of granite or gneiss, washed bare by the stream; Dr. Campos, however, informs me that they are of various kinds of stone, and, as far as he can make out, rest upon clay slate, but as their bases were covered with water, it is just possible that he may have been mistaken. Some of these blocks are more than a yard in diameter, and the fragments, broken from them, showed a gneiss, a fine-grained granite, and a hard coarse conglomerate. The collection of so large a quantity of different kinds of stone, combined with the fact that the clay slate of the banks, in the immediate neighbourhood, contained a great quantity of smaller blocks, points to the fact of their having been transported.

"The fact of the occurrence of large transported blocks, in the carboniferous of Brazil, is consequently sufficiently established, and the conditions of their occurrence seem to exclude the possibility of their having been brought by the action of a river or sea. It is true, indeed, that no scratched surfaces have yet been observed on the blocks, but, on the other hand, it must be remembered that no geologist, with a trained eye for such marks, has yet examined them.

"In the surveying of the province of São Paulo, which will now pass under my direction, I shall pay particular attention to these phenomena, and hope hereafter to be able to give more exact particulars of them. In the meantime you can make whatever use you think best of the above remarks."

The interesting indications, given by Mr. Derby's letter, of the occurrence in Brazil of phenomena which have already been observed in so many places in the southern hemisphere, encourage the supposition of their universality—a hypothesis already put forward, though not yet established.

The belief is spreading that it is ice which has heaped up the masses of transported blocks which are met with everywhere in the southern hemisphere; and the wide distribution of the phenomenon points clearly to a cosmic event, for which the most satisfactory explanation is that of an ice age. Mr. Derby's discovery therefore is of extraordinary importance, and he will earn the thanks of the scientific world if he devotes close attention to the matter.

The resemblance between the structures met with in the geological formations in South America, Australia, and South Africa, does not seem to be confined to the fact that glacial formations exist in their carboniferous. This is indicated in Szajnocha's notice (verhandl. K. K. Geol. Reichsanstalt), where the following Australian-African-Indian species are enumerated as also occurring in Cacheuta in the Argentine province of Mendoza:—

Estheria Mangaliensis, Jones.
Sphenopteris elongata, Carruthers.
Sphenopteris lobifolia, Morris.
Thinfeldia odontopteroides, Morr.
Thinfeldia lancifolia, Morr.
Zeugophyllites elongatees, Morr.

*Notes on DR. W. WAAGEN'S "Carboniferous Glacial Period," by
A. B. WYNNE, F. G. S., and DR. OITOKAR FEISTMANTEL.¹*

When this paper² first reached me I noticed Dr. Waagen's allusions in it to myself and decided to let them pass, as already, by anticipation, dealt with. But on reading them again, and without the slightest present intention of further recurring to the subject, I think it may be well, for the sake of establishing facts or avoiding unnecessary appearances of more controversy than these would warrant, to offer a few observations upon his references to the "Geology of the Salt Range." At page 115 the translation says, of the Report on the Salt Range compiled by myself, "that it should have been a joint one, but this was prevented by his serious illnesses, and thus Wynne was compelled to undertake the working out of it by himself."

This is quite accurate; but he should have added that the matter was very fully discussed by us (in my bungalow at Murree), and the classification of the rocks was arranged between us, even to the details of sections examined by him, and read by him from his note-book, while I transcribed them as they appear in the Report. Instead of any such statement I quote the passage immediately following that already given:—

"The employment of the material has, in consequence, often led to the different results, as if I would have disposed of them could I have influenced their being worked out. I cannot, however, for that reason entirely give up my own views, and Mr. Wynne must allow me to give them expression here and there."

And a few lines further on, "But now if, after having worked out the fossil faunas of the Salt Range in a great measure, I find myself constrained to lay yet greater stress on various points in the apprehension of which I did not agree with Mr. Wynne, it will be owing to the progress made through the more exact understanding, palæontologically, of the beds."

Dr. Waagen is quite entitled to give every expression to his views, but, having arrived at further palæontological knowledge in working out the fossils, he is not entitled, as he has hitherto done, to evade his own responsibility for the statements of the Report, and in repudiating them where it was convenient to throw the onus of what he considered erroneous views upon me.

Dr. Waagen was most fully acquainted with all of my conclusions, and if he then held opinions to the contrary, it was the time to declare and record them. Any views of his not obvious to both were given mainly from the palæontological point of view; mine rested upon structural relations: both should coincide, and both might of course be open to revision, but the insinuation conveyed in the passage quoted as to the "material"—presumably that left with me—having been distorted from his views, or in any way misused, is utterly misleading.

Some of my conclusions as to the range or horizons of the boulder beds have

¹ These notes are, I regret to find, somewhat controversial, and I think, hardly necessary on the trivial points in Dr. Waagen's paper which are questioned, or of value in the discussion of the greater feature of a carboniferous glacial period. The pity of it is that the writers are so far out of reach, and this is the only reason for these remonstrances of my two friends and former colleagues having a place in these Records, in which, as a rule, controversy should be avoided.—EDITOR.

² See Vol. XXI, p. 89.

been revised by Dr. Warth (and afterwards by Dr. King) from personal observation and discovery of a fossiliferous *Conularia* layer in ground complicated by landslips. It is perfectly possible that the conclusions to which Dr. Warth has been led are quite correct, and if I had got the clue he found I have no doubt I should have followed it in the same spirit and intention to reach the facts.

With regard to Dr. Waagen's remarks, pp. 118 and 119, upon the rolled fossiliferous pebbles which he calls "nodules" in the *Conularia* layer, I cannot consider the description of the case adduced as invalidating the conclusions of Mr. Oldham and myself.

A few explanatory notes regarding the history of the Karharbari Flora, by OTTOKAR FEISTMANTEL, M.D.

Part 3 of Vol. XXI of the Records of the Geological Survey of India contains an interesting paper by Dr. Waagen, "The Carboniferous Glacial Period," a translation of the same paper in the "Jahrb. K. K. Geolog. Reichsanstalt," Vienna, 1887. I would now ask to be allowed to make a few remarks to that part of the paper where Dr. Waagen speaks of the *Karharbari Flora* (l.c., 93-94). Dr. Waagen relates how in 1871 he visited, together with Dr. Stoliczka, the coal-field, that they observed well-preserved plant-remains, "a real joy to the eye of a palæontologist," but that the harvest was not a great one, the more as the rock was so cracked that it crumbled away under the lightest touch of chisel or hammer; they however received some specimens by Mr. Heine, then Manager of the collieries, so that they did not depart empty-handed; of these Prof. Waagen writes (l. c., p. 94), "*The specimens then procured formed the chief basis for Feistmantel's descriptions.*"

Had there been no other specimens but these the *Karharbari Flora* would, I think, have proved a very poor one, and *I can indeed say that it would hardly have been established as such on the basis of these fossils only.*

It is only doing justice to myself, and also to Mr. I. T. Whitty, C.E., late Superintendent of *Karharbari* collieries, East India Railway, when I shortly relate the history of the *Karharbari Flora*, that it may for ever be preserved in these Records.

The fact is, that the *first impulse* to our knowledge of this most interesting *Flora* was given by Mr. I. T. Whitty, C.E., who early in 1876, while I was engaged in working out the *Kach Flora*, brought to the Geological Survey, Calcutta, a magnificent slab of shale, from the *Buriadi* coal mines, containing, as it were, the nucleus of the entire *Flora*, afterwards made known. (See Preface, Vol. III, *Gondwana Flora*, page iv.) The species contained on that big slab were at first noticed and described by myself in Records, Geological Survey, India, Vol. IX, pt. 3 (August 1876), pp. 73, 75 and 77.¹ I had then no knowledge whatever of any fossils from the *Karharbari* coal-field being already in the Survey collections; I would have otherwise certainly included them in my just-mentioned paper.

The circumstance, however, that Mr. Blanford published in the same number of the Records, a paper calling in question the general value of geological

¹ The species were: *Neuropteris valida*, Fstm., figured afterwards in the *Karharbari Flora*, 1879, Pl. VI, f. 1, 2, 5 (fine, large specimens); *Gangamopteris cyclopteroides*, Fstm., l. c., Pl. XXVI, f. 1; *Voltsia heterophylla*, Bgt., l. c., Pl. XXV, f. 1-3; *Albertia* sp., l. c., Pl. XXVI, f. 2. In my above-mentioned paper the *Voltsia* was at first quoted as *Voltria acutifolia*, Bgt., but hereafter placed with *Voltsia heterophylla*.

homotaxis as drawn from the fossil remains of terrestrial life, and based upon an analysis of the evidence for the age of the Gondwana series, induced me to look more thoroughly also over the collections of the Lower Gondwana fossils, and *only then* some Karharbari (Kurhurbali) fossils turned up, which were duly noticed in my next paper, Records, Geological Survey of India, Vol. IX, Pt. 4 (November 1876).

The fossils thus discovered were from two localities of that coal-field, and were also collected at two different times. One lot contained plant-remains, rather indistinctly preserved on a light grey, weathered-looking shale: they were from Passerabha, and, as it appeared, were collected by Mr. Wilson (1859); I referred to them passingly in my Talchir-Karharbari Flora, 1879, p. 39 (under Passerabha, No. 5, D); but they were of no avail, as no horizon was marked and the fossils themselves were very indistinct; none of them could be figured.

The other lot was marked "*Domahni Ghat, Dr. Stoliczka, 1871.*" The fossils were in a dark grey, fine micaceous shale, and themselves covered with a thin coal-stratum. *These, I suppose, must be the fossils Dr. Waagen refers to;* I referred to them several times in my paper in Records, Geological Survey, India, Vol. IX, Pt. 4, everywhere mentioning that they were brought by Dr. Stoliczka, 1871; Dr. Waagen's name was not marked there, otherwise I would have mentioned it also. The most prominent of the fossils I have named and described were *Gangamopteris angustifolia*, McCoy (one leaflet); *Sagenopteris Stoliczkana*, Fstm. (one frond); *Glossosamites Stoliczkanus*, Fstm. (two leaves); and *Voltsia heterophylla*, Bgt. (three branchlets).

But all these specimens, though very interesting, could not furnish sufficient material for a monograph of the fossils of that horizon, and they were up to then treated as fossils of the Damudas.

Only after I had visited the field, in January 1877, when I made, with the assistance of Mr. I. T. Whitty and Mr. N. Miller, Inspector of Collieries, extensive collections from various localities, the character of the Karharbari Flora manifested itself, and in a short note in Records, Geological Survey, India, Vol. X, Pt. 3, 1877 (pp. 137-139), I pointed to the strong relation of the Karharbari Flora to that of the Talchirs.

Mr. Whitty and Mr. Miller continued to send further valuable information about fossils and geological relations, so that the Karharbari coal-beds were recognized as typical of a separate horizon, under the name of *Karharbari beds or Karharbari group* (see Manual, Geology of India, 1879, Vol. I, pp. 112 *et seq.*), and I myself was enabled already in 1879 to publish a monograph on the Karharbari Flora, together with that of the Talchirs. In that work I have given at end also a list of the localities (respective shafts) whence the fossils were obtained; on pp. 38-39, the locality *Domahni* is noticed, from where there were fossils since 1871 (collected by Dr. Stoliczka) amongst the collections of the Survey. The fossils were:

Neuropteris valida, Fstm.; fragment, top portion; (not figured).

Gangamopteris major, Fstm.; (not figured).

Gangamopt. Comp. angustifolia, McCoy; (not figured).

Sagenopteris (?) Stoliczkana, Fstm., Pl. XIII, f. 4: (one specimen).

Glossosamites Stoliczkanus Fstm., Pl. XX, f. 4, 5.

Noeggerathioipsis Hislopi, Fstm., Pl. XIX, f. 3-5, (three leaves).

Voltsia heterophylla, Bgt., Pl. XXIV, f. 4, (three branchlets, only one figured).

The Memoir contains, however, 27 plates (several double) with many figures, and *only* seven out of all were taken from specimens brought in 1871; *all others were collected by myself, by Mr. Whitty, and Mr. N. Miller.*

Report on the Oil-Fields of Twingoung and Beme, Burma; by FRITZ NOETLING, PH.D., Palæontologist, Geological Survey of India. (With one plate and a map.)

I.—GENERAL REMARKS.

1. *Position of the oil-fields.*—The oil-fields, generally but wrongly called oil-fields of Yenangyaung,¹ are situated at a distance of one mile and a half to east of that place near the villages of Twingoung² and Beme. Neither the names of these two villages nor the oil district is marked on the map of Burma (1 inch = 14 miles), but the position might be about where on the map the letter g of the word Yenangyaung stands, *i.e.*, lat. 29° 21' N., long. 94° 56' E.

2. *Topography.*—The map does not give the correct features of the country; a hill range, like the one marked on it, does not exist in this part of the country. The country forms a tolerably level and flat plateau, rising on the average to the height of 260 feet above the low level of the Irrawaddy at Yenangyaung; the highest point, the pagoda of Twingoung, being 313, the highest hill between Beme and Twingoung 293 feet above the same level. The whole country is intersected by numerous deep and narrow, irregular ravines, about which my map gives a very good idea. The whole country has obviously been originally one extended plateau, which has been eaten into by the action of the surface water, due to the composition of the strata forming the country and the irregularity of the rainfall during the year. The mechanical action of the water worked more in the direction of deepening and lengthening the water-courses than in widening them. By the eventual union of two opposite water-courses at their upper end into one a more or less extended piece of country was isolated, which took in time the form of a hill with flattened top and very steep slopes. On these latter of course the running water worked most energetically, notching them more or less.

Some parts of the country, especially the ferruginous, conglomeratic beds, resisted in a more energetic way the action of the surface water, which by washing away the surrounding softer strata modelled the harder ones to a kind of ridge, which was eventually eaten into a range of isolated hillocks or rocks. On the way from Yenangyaung to Beme or Kodaung we met with two of such ridges surmounting the surrounding plateau and running from S.S.E. to N.N.W. A closer examination proves that they are the remainders of a hard stratum of ferruginous conglomerate imbedded in the soft sandstones. The result of this process of the action of the water will be a country of rolling hills, with the tops generally on the same level, which are intersected by long, irregularly bent ravines, with steep, notched slopes. It is evident that a country like this is most difficult to cross, the roads being forced to accommodate themselves according to the run of the ravines. For instance, between Kodaung and Twingoung communication with carts is utterly impossible, the ravine between the two places preventing it. Therefore, a cart from Kodaung to Twingoung, a distance of 700 yards as the bird flies, had to go from either place *via* Yenangyaung, that is to say, a good day's march, in order to reach its destination.

¹ Yenangyaung = creek of oil.

² Twingoung = hill of wells.

3. *Geology of the oil-fields.*—The strata forming the country between the Irrawaddy and the Pin creek belong chiefly to the tertiary formation. For reasons which I shall give in detail elsewhere I feel inclined to believe that they represent the upper part of the tertiary formation, of no later age than Miocene. Likely enough they are of the same age as the Siwalik formation in India. As a matter of fact, the fossils I collected point to younger tertiary. Over the tertiary strata there is spread, but not continuously, a layer of ferruginous red gravel abounding in large pebbles of white quartzite and fossil wood, belonging to the diluvial formation.

The strata mostly consist of laminated and clayey sands, sometimes a little indurated, so as to form soft sandstones. Some of the beds are highly calcareous and abound in concretionary masses of sandy limestone in the most varied shapes, many looking exceedingly like organic structures and frequently being considered by people to be such. In other beds there are nodular concretions of a very hard quartzitic sandstone, sometimes of an immense size, intercalated and arranged in irregular layers. There occur a few pebbly beds, and occasionally a layer of ferruginous sand or gravel cemented into rather a hard bed of ferruginous conglomerate. These layers of peroxide of iron are not unfrequently to be met with. Of inferior importance are clays and shaly clays.

The colour of the sandstones varies from white or a light yellowish tint in all stages up to a dark red and blue colour. The clays and sand-clays have a bluish grey tint. The minerals, occasionally imbedded, are gypsum, pyrites, coal. Nitrate of lime is formed abundantly on the surface of the rocks.

I shall now proceed to describe in detail the sections which I noticed in different localities of the oil-fields followed by a record of strata noticed in native wells sunk down at the time of my stay at the oil-fields.

No. 1.—Section in Messrs. Finlay, Fleming and Co.'s bore No. 1 at Kodaung,¹ No. 1 bore being 260 feet above the level of the Irrawaddy at low water²(see Plate 1, No. 1):³

Thick-ness of strata in feet.		Total depth from the top.
	In descending order—	
5	1.—Grey stuff, soft, which grows harder and becomes yellow (evidently decomposed rock, forming the soil).	5
15	2.—Yellow stuff, which changes in red sand and clay, a little softer. (In the upper part soft, yellow sandstone, the same as met with at the end of No. 1, followed by a stratum of soft clayey red sandstone.)	20
10	3.—Red sand and clay, which changes to grey sand and clay. [The red sandstone is followed by strata of grey (better bluish-grey) colour consisting of alternate beds of soft sandstone and clay.]	30
20	4.—Grey sand and clay, very hard, oily smell. (The same strata as met with at the end of No. 3; a thin bed of harder sandstone has been noticed between 30 and 50 feet.)	50

¹ Kodaung = pigeon hill.

² I give the record of the strata as it was communicated to me by the Engineer in charge. Though correct on the whole, the record is highly unsatisfactory in detail. My own opinion about the strata is put within parentheses.

Thick-ness of strata in feet.		Total depth from the top.
50	5.—Grey sandy clay, partly hard. (The same remarks as under 4)	100
40	6.—Grey sandy clay, 2 feet of hard rock at 108 feet. (The strata are the same as before, that is to say, a frequent change of soft clayey and sandy beds, in which a band of hard sandstone is intercalated.)	140
42	7.—Grey sandy clay; 9 feet of hard rock at 150 feet. (The same as said under 6.)	142
33	8.—Grey sandy clay till 200 feet; it changes in grey clunch. (The same group of strata extends therefore to the depth of 200 feet, then by a sudden change the sandy beds disappear and are followed by a thick bed of bluish grey clunch.)	215
27	9.—Grey clunch; at the depth of 218 feet signs of oil; it changes at 220 feet in a green sand. (The clunch of No. 8 is in the upper part prevailing, but suddenly the strata change to a green sand. At 218 feet the first signs of oil are discovered. Apparently the real oil-bearing strata have now been tapped. The green colour is due to the oil with which the sand or soft sandstone is charged.)	242
38	10.—Fine sandy clay of greenish colour, changes to clay at 260 feet, 4 feet of hard white (?) rock and 1 foot more; at 270 feet oil becomes better as the well gets deeper. (These brief remarks contain a lot of information about the strata the bore is now standing in. Evidently there is the same sand or soft sandstone prevalent, but it is obvious that it frequently changes with thin beds of clay, the colour of which is not mentioned, but I have no doubt it is the same colour as that of the clunch No. 8, this is to say, rather a dark bluish grey. Besides the clay-beds occur beds of hard rock (sandstone?) of, I should prefer to say, bright greyish colour.)	280
14	11.—Green sandy shale; there still appears to be oil. (I cannot exactly understand the meaning of sandy shale. I suppose the sandstone gets more indurated, changing with laminæ of shale.)	294
6	12.—Uncertain, but very hard rock of sandy nature (evidently a bed of sandstone from the same kind as formerly has been met with (No. 10, &c.) has been found).	300
40	13.—Sandy rock of light green colour (the same soft sandstone charged with oil, but apparently this bed only contains a small quantity of oil).	340
25	4.—Light green sand, in the higher strata oil, which remains now at a depth of 130 feet from the top. (Strata the same as before, but some are more richly charged with oil than others. The oil stands apparently under pressure so as to push it up to the depth of 130 feet from the top.)	365
25	15.—Gravelly formation, mixed with gravels, just a little gas. [This notice is highly vague as it is impossible to find out the meaning of "gravelly formation mixed with gravels." There might be a conglomerate (but of what kind?), a conglomeratic sandstone, or even a bed of gravel.]	390
15	16.—The same as before, sandy, of a light greenish colour. (The same as said before.)	405

It was not easy to classify these, sometimes rather indistinct notes, but I believe the following scheme will give a fairly good section of strata :—

Thick-ness of the single beds in feet.		Total depth from the top.
	In descending order—	
3—4	Decomposed rock forming the soil	3—4
12—14	Soft, yellow sandstone	16—18
11	Soft red sandstone, probably a thin stratum of light bluish clay is imbedded .	29

Thick- ness of the sin- gle beds in feet.		Total depth from the top.
79	Soft sandstone of bluish grey colour, thinly laminated, numerous beds of clay, sandy clay and sandstone alternating; occasionally thin beds of hard sandstone. The strata are feebly soaked with oil, up to 50 feet from the top.	108
2	Hard grey sandstone	110
40	Bluish grey sandstone, of the same quality as before mentioned	150
9	Hard grey sandstone	159
41	Bluish grey sandstone, the same quality as before mentioned, but probably at its base the clayey beds grow thicker.	200
20	Blue stiff clay (clunch).	220
60	Fine soft sand of greenish colour, frequently alternating with thin beds of dark bluish clunch, a thicker bed of which has been found in an uncertain depth, the sandstone soaked with oil.	260
4	Hard grey sandstone	264
6	Soft sandstone of greenish colour soaked with oil	270
1	Hard grey sandstone	271
14	Rather hard sandstone of greenish colour alternating with beds of shale	294
6	Hard grey (?) sandstone	300
65	Soft sandstone of light greenish colour, in beds, unequally charged with oil	365
40	Conglomeratic (?) sandstone, or conglomerate of light greenish colour soaked with oil.	405

No. 2.—Section in the ravine between wells Nos. 5 and 118 :—

	Ft. In.
In descending order—	
(a) Soft sandstone of reddish colour in thick beds	10 0
(b) Soft light blue clay	2 0
(c) Soft sandstone coloured dark red	15 0
(d) Soft clayey sandstone of blue colour in beds of a few inches thickness, alternating with thin beds of dark red sandstone. The base is formed by a bed of hard red sandstone of 3 to 4 inches thickness	10 0
(e) Numerous thin beds of bluish-grey micaceous sandstone, alternating very regularly with thin beds of blue clay	8 0
(f) Hard grey sandstone	0 4
(g) Sandstone like (c), but less regularly bedded	15 0
(h) Hard grey sandstone	1 6
(i) Sandstone like (g)	15 0
TOTAL	75 10

No. 3.—Section in the eastern ravine :—

	Ft. In.
In descending order—	
(a) Soft, light yellow coloured, a little clayish, sandstone in thin beds. Occasionally thin plates of gypsum are imbedded	15 0
(b) Soft dark red coloured sandstone	2 0
(c) Soft white sandstone in thick beds	13 0
(d) Soft light blue clay	8 0
(e) Soft dark red coloured sandstone	9 0

(f) Soft light blue clay	5	0
(g) Soft light yellowish coloured sandstone in thick beds	15	0
(h) Numerous thin beds of bluish-grey sandstone, alternating with thin beds of blue clay	24	0
(i) Hard grey sandstone	0	4
(j) Soft bluish grey sandstone like (g)	9	0
	<hr/>	
TOTAL	100	4

No. 4.—Well No. 75. The well is situated on the top of the hill, and had, at the time I examined it, just passed the depth of 160 feet. I was informed that at the depth of 160 feet a bed of a very hard rock gave a good deal of trouble in breaking. Large fragments of the said rock amongst the refuse proved to be a hard quartzitic sandstone of grey colour, which formed a bed of not less than 4 feet thickness. Below this bed a soft, rather coarse sandstone of a light greenish colour and a strong oily smell was found. Remaining several days under the influence of the sun the colour faded, clearly proving that it was solely due to the oil the sandstone was charged with. The sandstone then resulting was of light bluish-grey colour, consisting of rather coarse grains of milk or light blue coloured quartzite, mixed with grains of a black mineral the nature of which I could not ascertain. Small leaves of mica were not unfrequent. Breaking a larger lump, the centre still had the greenish colour, while the peripheral parts were of the colour just described.

No. 5.—Well No. 102. At the time I examined this well it had arrived at the depth of 151 feet. It was then standing in a coarse soft sandstone of greenish colour.

No. 6.—Well No. 150. The well had the depth of 265 feet and yielded 120 viss of oil a day. For some reason the owner started further digging, and the refuse brought out proved to be a dark blue clunch, which was superficially covered with oil, but did not contain oil itself.

No. 7.—Well No. 159. In depth of 183 feet, a soft green coloured sandstone was found, which alternated with thin layers of a dark blue coloured clay without oil.

No. 8.—Well No. 173. Notwithstanding the depth, 240 feet, this well yielded daily only 30 viss of oil. The strata at that depth consisted of rather a hard, thin-bedded sandstone of dark bluish-grey colour, alternating with thin layers of a blue clay. The refuse was superficially soaked with oil, but the interior proved to be without oil. It is obvious that the oil trickles out from a higher bed.

No. 9.—Well No. 174. After a careful inquiry the workmen stated that they met at 166 feet (100 attoung) depth with the hard grey sandstone, big lumps of which were among the refuse. When I visited this well it had reached the depth of 212 feet, the rock being a fine, thin-bedded sandstone of bluish-grey colour, sparsely alternating with beds of blue clay. The well yields a small quantity of oil which certainly does not ooze out from this bed.

No. 10.—Well No. 175. The well had reached the depth of 160 feet, and there a bed of a hard sandstone gave immense trouble to native workmen. To such an extent was this the case that work was several times given up, the men being unable to remove the obstacle without blasting. Above that bed the sandstone was softer and coarse, numerous imbedded quartzite pebbles rendering it somewhat conglomeratic while it was poorly soaked with oil.

No. 11.—Well No. 195. At 200 feet depth a soft, coarse sandstone of greenish colour.

No. 12.—Well No. 212. At 239 feet depth dark blue coloured stiff clunch; containing paper-thin layers of green sand imbedded.

No. 13.—Well No. 239. At a depth of 247 feet soft fine sandstone of green colour richly soaked with oil.

No. 14.—Well No. 242. The native workmen stated that at 117 feet depth they met with a hard grey sandstone; the well had now reached the depth of 150 feet. There the sandstone was soft, of light green colour, which after having been exposed for some time to the sun quickly changed into dark brown.

No. 15.—Well No. 266. It is stated that at 117 feet depth a bed of grey hard sandstone was found; the well is now at 130 feet; the strata consist of a soft, thin, laminated sandstone of bluish-grey colour alternating with thin beds of bluish-grey clay.

No. 16.—Well No. 278. The natives state that they met with two beds of hard grey sandstone, from which big lumps are amongst the refuse, at 133 and 183 feet depth. At present the well stands at 200 feet depth in soft green sandstone, poorly soaked with oil.

No. 17.—Well No. 298. The well had reached the depth of 156 feet; the strata consist of soft, coarse sandstone of light greenish colour in which a layer of 6-inch thickness of a fossil-bearing conglomerate is imbedded. The conglomerate consists of white and black quartzite pebbles, and rolled fragments of bones cemented by a soft clayish cement of greyish colour. Crystals of pyrites are frequent.

This conglomerate is highly interesting from the numerous fossils it contains. Unfortunately the larger specimens are all broken or deformed by the rolling, but smaller specimens are well preserved. I collected—

- (1) a fragment of shinbone of a huge animal (*Elephas* ?).
- (2) a well-preserved tooth of a big carnivore.
- (3) a tooth of a herbivorous animal (*Cervus* ?)
- (4) *Crocodylus* sp., several teeth.
- (5) *Turtle* bones.
- (6) *Carcharias* sp., many teeth.
- (7) *Odontaspis* sp., many teeth.
- (8) *Myliobatis* sp., teeth.
- (9) *Teleostii* gen. et sp. div., many fragments.
- (10) *Gastropoda* gen. div.
- (11) *Pecten* sp.
- (12) *Arca* sp.
- (13) *Cardium* sp.
- (14) *Venus* sp.
- (15) *Teredo* sp.
- (16) *Corallium* gen. div.
- (17) fossil wood frequently changed into coal.

No. 18.—Well No. 321. The well, which has now the depth of 253 feet, stands in coarse soft sandstone of green colour, fairly soaked with oil. According to native

statements, the beds of hard grey sandstone were met with at 100, 117, and 166 feet depth.

No. 19.—Well No. 328. At the depth of 225 feet a bed of blue stiff clunch containing thin layers of green sandstone. The strata above this bed consist of light green coloured, soft sandstone.

No. 20.—Beme Well No. 38. The well, which is only a few feet above the bottom of the ravine, had arrived at the depth of 145 feet; the strata consisted of a blue stiff clunch in which occasionally thin beds of green sandstone were imbedded.

I must add that in this record I only put down statements on strata actually brought out from the well at the time of my presence and examined by myself. I might have guessed about the strata formerly found from the nature of the refuse around the well, but being more or less speculative, I preferred to omit this part in the record as well as in the sketch. In special cases only, when after thorough inquiry I might feel convinced that at a certain depth a certain bed had been found, I put down a note of it in both record and table.

With the view of giving a more conspicuous summary of the details here mentioned I have compiled them on the annexed plate. In designing it I had of course the difference in the level of the wells to take into consideration, but being practically very small (all the wells here mentioned are situated on the top of the hill), I considered no harm would be done in neglecting it and in drawing the section of the wells, as being all on the same level. Besides, I should hardly have been able to state the exact difference in the level of the wells as I had only a small barometer for levelling, which, well adjusted as it otherwise proved to be, hardly admitted of noting differences in levels of less than 10 feet.

Although my observations have been few, still, when viewed together, they are

Groups into which the tertiary strata may be divided. sufficient to warrant certain conclusions being drawn relative to the series of superincumbent strata and oil-bearing beds.

The record of strata so obtained might be considered in its details correct from 0 to 100 feet depth, fairly correct up to 220—225 feet, and doubtful in details, but correct as a whole in greater depths according to the better information I was able to gather.

In descending order we can distinguish four groups of strata:—

(a) *The upper group.*—Consisting chiefly of sandstones of brown and yellow colour followed by similar beds of dark red and yellowish white colour. The sandstones are soft, deposited in thin beds in the upper, in thick beds in the lower parts of the group. Gypsum in thin plates is not scarce in the upper brown sandstones; fossil wood in doubtful, highly decomposed logs in the lower sandstones. Interstratified are beds of light blue soft clay varying very much in thickness. The thickness of the whole of this group is about 20—30 feet in the centre of the field, but it rapidly increases in both directions towards west and east, for reasons which will be explained later on in section 5.

(b) *The second group.*—Consisting chiefly of bluish-grey sandstones and

clays alternating in innumerable beds very regularly in the upper less regularly in the lower parts. At the depths of 80 and 125 feet from the top (120 and 160 feet from the surface) occur beds of hard grey sandstone of sometimes more than 4 feet thickness. Concretions of hard nodules of sandstone in irregular layers are sometimes to be found as well as occasionally small fragments, and even small seams of coal, besides a small number of interesting fossils, being a mixture of terrestrial and marine animals of late tertiary age. The thickness of this group might be considered of not less than 170 feet. The lower part of this group is fairly soaked with oil which actually oozes out from the strata at numerous places in the ravines. Notwithstanding the rather considerable amount of oil with which the lower part is soaked, this group cannot be considered as the oil-bearing formation proper as is proved by the wells of less than 200 feet in depth, which never yield large quantities of oil. The strata were, apparently enough, originally not charged with oil. The oil they contain originated from deeper strata and rising by cracks gradually charged the soft sandstones. At the various outcrops of this group the oil may be seen leaking through to the surface, a circumstance which accounts for the original wells sunk by the natives.

- (c) *The third group.*—Consists of a stiff clunch of dark blue colour, having imbedded in its lower part irregular thin beds of green sandstone. Thickness 20—25 feet.

The "blue clunch," as we may call this group, forms an extremely regular bed amongst the various strata composing the tertiary strata of Twingoung. There is not a single well in the two fields deeper than 200 feet which had not to break through this bed before reaching the oil-bearing strata proper. The blue clunch forms the boundary bed between the upper strata and the oil-bearing sandstone of which it forms a hermetical covering, thus preventing the oil from escaping. The blue clunch wherever it is found may be regarded as the first sign of the presence of the oil-bearing strata, which will be met with immediately underneath. Of course the depth in which the blue clunch might be found elsewhere depends upon local conditions, but within the limits of the Twingoung and Beme oil-fields it may be said that it will be generally found at *an average depth of 200 feet when the well is on the top of the hill and of 100 feet when in the ravine.*

- (d) *The fourth group, or oil-bearing sandstone.*—The strata composing this group do not differ in any way from the constituents of the (b) group. They are more or less soft, coarse or fine micaceous sandstones, of bluish-grey colour, which is of course invariably changed into a more or less yellowish-green, according to the amount of oil the sandstone is saturated with. There are beds of hard sandstone and besides layers of greater or smaller thickness of blue clunch. In short, petrographically speaking, the (d) group is exactly the same as the (b) group, and these two, together with

the (c) group, belong to one geological system of strata; it is only from practical considerations that I have subdivided them. Unfortunately nearly all and everything is lacking on which to form a judgment regarding the constitution of this important complex of strata. The scanty data I was able to collect are by no means sufficient for the purpose. It is very likely that in the upper parts the (d) group forms a complex of beds of sandstone varying exceedingly in thickness, probably as well in vertical as in horizontal direction, which are separated by layers of blue clunch impenetrable to oil.

If I interpret in a correct way the data yielded by No. 1 bore of Messrs. Finlay, Fleming and Co., the separating clay beds thin out as the depth increases where the beds of sandstone grow thicker. The eminent importance of such a condition, if correct, will immediately be seen. Provided that the data above referred to are correct, it seems that from 300 up to the depth of 366 feet there is a bed of sandstone uninterrupted by any other beds, either clay or hard sandstone.

It further seems that from the depth of 366 feet downwards series of conglomerates or conglomeratic sandstones begin. Unfortunately I have not seen any samples of these strata, which the Managing Engineer called "gravelly formation," so I am only able to interpret his notes as a kind of conglomerate. But whether these strata are separated by beds of another constitution or whether they form an uninterrupted complex of coarse conglomerates I am not able to say.

This group is so far known to have a thickness of not less than 180—185 feet,¹ but I have no doubt that the thickness is a considerably larger one.

4. *Occurrence and origin of the oil.*—(a) *Occurrence of the oil.*—The (d) group is especially distinguished in containing a large amount of oil, and it must be considered as the oil-bearing strata proper. The oil is only to be found in soft sandy beds more or less richly soaked with oil, from which it slowly exfiltrates into the well or bore sunk in these beds. From the geological constitution of the strata I doubt the existence of natural reservoirs filled with oil and I never noticed the clayey beds or hard sandstones charged with oil. Therefore we have to consider the soft sandstones to be the valuable beds and accordingly to deduct from the total thickness the thickness of numerous beds of clay and hard sandstone in estimating the total thickness of the valuable oil-bearing sandstone.

(b) *Total thickness of the oil-bearing sandstone.*—I should think the total thickness of the useless strata is not exaggerated by estimating it at 50 feet; the present known thickness of the oil-bearing sandstone would therefore be not less than 130—135 feet. But there is more than one reason to believe that the oil is not equally diffused throughout the sandstone, that is to say, that the different beds are equally soaked with oil. On the contrary, there are several proofs that two beds of sandstone at different levels differ highly in the quantity of oil they

Difference in the production of wells of same and different depth and explanation.

¹ There is some uncertainty about the depth of bore No. 1 from which I got these data. The Engineer in charge told me at first the bore had reached the depth of 425 feet; afterwards he restricted his statements to 400—405 feet depth. According to measurements lately taken the bore has only the depth of 392 feet.

contain (see Section 3), and it is not necessary that a certain lower bed should be more richly charged with oil than an upper one. Not only do beds, different in level, differ in quantity of oil, but we also notice that wells of exactly the same depth and closely situated to each other differ highly in the production; in other words, that if at one place at a certain depth the sandstone is rich in oil, at another place close by at the same depth hardly any oil is found. The best instance are wells No. 253 and No. 244, which are only a few feet distant from each other, and yet well No. 244, which is even deeper than No. 253, yields only 50 viss per diem, while No. 253 yields 450 viss a day.

One should certainly think that the deeper well ought to have struck the beds rich in oil in sinking down, but it did not. How is this matter to be explained which puzzled everybody acquainted with the oil-fields?

There is only one solution of the problem. I stated above that in the upper parts of the (*d*) group a frequent change of beds of clay and sandstone must be supposed, and from samples I have seen it may be expected that the change is rather an irregular one; the same bed may rapidly swell at one place and likewise thin away, even perfectly die out, at another one close by. Two formerly thin beds may unite into a thick one by the disappearing of the separating medium, or a bed of clay may suddenly divide for a short distance, enclosing between the two branches a lenticular mass of sandstone which may be richly soaked with oil, while the sandstone above and below the clay is only poorly charged with oil. In Fig. 1 of plate, (*A*) well will by accident as it were strike the spot where the rich bed is enclosed, and will therefore yield a large quantity of oil, while (*B*) well, which is close by, only meets with poor sandstone. (*B*) well may be sunk to any depth, but it will never meet with the same beds supplying (*A*) well so extensively with oil.

As nearly all the native wells work the upper part of the (*d*) group, where geological conditions as described are prevalent, the large difference in production of wells of the same depth, and the fact that a well producing more oil than another one is less deep than the latter, is now easily explained.

It is obvious that under these circumstances no opinion can be formed as to the depth at which the richest beds are to be found. In fact none but the vaguest speculations could be formed. All we know at present is that the separating useless beds of clay diminish in number with the depth, so that the thickness of the valuable sandstone beds increases; but even this statement requires further confirmation. A bore of 400 feet in depth has accordingly more chance of reaching productive beds, promising a fair supply for years, than a bore of 250 feet, which might or might not instantaneously yield a great quantity of oil, but the duration of which could not be counted on because the deeper bore certainly drains the larger volume of sandstone.

In Section 3 I have stated that, according to the data of No. 1 bore, the top of the (*d*) group has been met with at a depth of 220 feet, the mouth of the shaft being 260 feet above the level of the Irrawaddy at low water. The top of the (*d*) group is therefore 40 feet above the level of the Irrawaddy and not more than 120 feet below the bottom

Difficulty in stating the depth where the richest strata may be found.

Reasons why no high pressure of gas can be expected.

of the ravine north of Kodaung. Conditions being nearly the same all over Twingoung and Beme oil-fields, as will be seen in Section 5, the highly important fact results that *the oil-bearing strata are extremely near to the surface*, and that in consequence *no high pressure of gas might be expected anywhere over the said area*. It will easily be understood that even if the oil-bearing strata were under high pressure elsewhere at a place where they are so near the surface, the pressure must rapidly decrease, owing to the intense escape of gas through cracks in the strata.

There is still a small pressure proved by the experience of No. I bore at Kodaung. The oil there is said to have been pushed up to the depth of 130 feet from the surface ; the top of the oil-bearing sandstone being 220 feet from the surface ; the pressure is therefore high enough to push up the level of the oil through a height of 90 feet, supposing the oil to ooze out from the uppermost strata. This likely enough is not the case, but the oil originates, on the contrary, from deeper strata, and hence the pressure may be considered to be stronger than one sufficient only to push up the oil 90 feet above its level. The prospects for a high pressure at places where the oil-bearing strata are not so superficially situated, are therefore not so bad. Even flowing wells might be expected in places where the oil-bearing strata are of insufficient depth to prevent too extensive an escape of gas.

I have no doubt that the oil-bearing sandstone is the oil-producing formation too, if not in its upper parts. I admit it is difficult to prove this statement at present owing to the very incomplete knowledge we have about the oil-bearing sandstone itself. But I may quote some facts. Samples of sandstone from greater depths are so richly soaked with oil that it is difficult to understand how the oil originating from lower strata was able to penetrate upper strata in such considerable amount and to soak them so intensely. Far more important, as supporting this theory, is the frequent occurrence of lumps of coal in the oil-bearing sandstone. I venture to think that by some chemical process, the nature of which is unknown, whether we call it dry distillation or decomposition, seams of coal formerly and partly still existing were changed into oil. Bores of greater depth are certain to give further and more exact information about this matter.

To examine the oil as regards both its physical and chemical qualities a well-assorted laboratory and special instruments are required, as examinations of this kind cannot be done in the field. I had to drop the matter, which is but of little importance, as a sufficient supply of samples for such an examination is easily to be got at any time and can be examined everywhere.

5. *Stratigraphical part.*—The study of the architecture of strata forming a certain tract is the foundation of every speculation based on it. From the facts we notice on the surface we may guess the features of the country underneath, for ever concealed to our eye, and, based on careful observations, conclusions so drawn may be very correct. The features of the country in the Yenangyaung district are extremely simple. In marching from the river towards the east on the road to Twingoung and from there to the Pin creek, we notice the following conditions of dip

and strike, of which the most important observations are shown in the subjoined table :—

No.	Locality.	Dipping ¹	Striking.
1	Bank of the Irrawaddy at Yenangyaung	35° S. W.	N. 40° E.
2	Road between Yenangyaung and Kodaung (foot path) .	32° S. W.	N. 40° E.
3	Near Enausu	18° S. W.	N. 40° E.
4	East of Twingoung	13° N. E.	N. 40° E.
5	Near Myausu ¹	27° N. E.	N. 40° E.
6	Pin creek, near Naka-u	34° N. E.	N. 30° E.

I only mention the principal localities; the great number of intermediate places where I observed the two constituents of geological architecture are of no interest as they yield exactly the same data.

From the above-mentioned principal data we see that, by moving in a straight line from the Irrawaddy eastwards, the dipping of the strata suddenly turns from south-west to north-east; we notice at the same time that in leaving the river the angle of dipping gradually decreases, and with the reversion of the dipping gradually increases until it has reached its former amount near the Pin creek.

I designed on Plate 1 a section illustrating this architecture of the country; the heights had of course to be exaggerated at the scale of 1 : 6·6.

The strata form therefore an anticline, on the centre or top of which the oil-fields of Beme and Twingoung are situated. The axis of the anticline agrees with the striking, *i.e.*, No. 40° E. The centre of the anticline is situated between the villages of Twingoung and Enausu, and owing to the special structure of the anticline, the strata are here horizontal, or nearly horizontal, as may be seen in the ravine north of Kodaung. Leaving the centre the strata gradually begin to dip to either side. In the beginning the angle of dipping is only small; we notice angles of 5—8° in the ravine north of Kodaung, but dipping quickly increases. We already notice angles of 27° and 32° in the ravines bordering the oil-field; the angle increases later on only at a small rate up to 34° and 35°.

It is the characteristic feature of the anticline that in its centre, strata which are elsewhere far below, are brought near to the surface. At the same time we find in its centre the oldest strata, and removing from it in either direction are constantly meeting with younger strata, being exactly the same on both sides of the anticline. For instance, we meet at the banks of the Pin creek again with the same soft sands abounding in numberless concretionary masses of sandy limestone as we noticed on the bank of the Irrawaddy.

The special architecture of the country will now easily explain why just on that very spot the oil industry has developed. The mechanical action which produced the anticline resulted in bringing those strata extremely near to the surface, which would else be far down below the surface at the spot where we notice them now. By the action of the surface-water deep ravines were eaten in, which considerably

¹ Myausu = southern village.

reduced the distance from the surface to the oil-bearing strata, allowing the oil now to ooze out from the strata at many spots in the ravines where cracks or fissures afford it an easy road.

The same architecture of the country will also explain the quaint oblong shape of the oil district. The map shows that the oil district considered in the whole, as well as in single parts, forms an oblong with two very long and two very short sides. How is this shape, which is certainly not accidental, to be explained?

Shape of the oil-fields depends on the geological structure of the strata.

The study of the architecture of the country will answer this question. I must mention beforehand that the Burmans are not able to dig wells of a greater depth than 310 feet. The section on the plate shows however that, in consequence of the dipping on each side, the oil-bearing strata at but a short distance from the centre of the anticline are far beyond the reach of Burmese art. Consequently the Burmans moved, one would almost say instinctively, on the top of the anticline, digging wells on each side as far as the dipping of the strata allowed them to do so.

The axis of the oil district Twingoung-Beme agrees therefore, or nearly agrees, with the axis of the anticline and the strike, and its longitudinal boundaries were dependent on the dipping of the strata.

I fail to understand why the Burmans never tried to sink wells on the area between the Twingoung and Beme oil-field, and why they never tried to extend the oil-fields further north or south. I suppose it is a good deal due to the tradition which taught them that if they dug a well within the boundaries of the before said oil-fields they would get oil, while elsewhere no oil was to be got. Probably the failures of wells sunk at many places, as, for instance, the old wells east of the Twingoung oil-field, confirmed their belief. So I was told that the Burmans foresaw an absolute failure of the bores at Kodaung and subsequently were highly astonished when they learnt that the bore yielded oil. On the other hand, there is certainly a good deal of superstition which prevents them from digging wells at certain places. When I pointed out a place south of the oil-fields of Beme to a Burman, and asked him why people did not sink wells on that spot, he had any amount of subterfuges explaining why it was impossible to dig a well, at this place, which he admitted to be a good one. Several men had already tried there to dig wells, but nobody had succeeded in doing so. But evidently he concealed the true reason of the dislike of digging a well at this place, and so I am inclined to believe that some superstition was the true reason preventing people from digging.

The theory I have thus arrived at regarding the geological structure of the country gives the means of answering the highly important question as to where we shall meet with the oil-bearing strata—

Depth of the oil-bearing strata some distance from the oil-fields.

- (a) in $\frac{1}{2}$ mile, or 1 mile, distance or any other distance in an eastern or western direction ;
- (b) in $\frac{1}{2}$ mile, or 1 mile, or any other distance in a northern or southern direction ;

from the line I fixed as axis of the anticline.

In answering question (a) we have to keep in mind that in moving in a line perpendicular to the axis of the anticline, *i.e.*, in the direction of the dipping, the vertical

depth from the surface of a certain stratum or bed in a given horizontal distance from a starting point is only dependent on the angle of dipping. In Section 5 I stated that the angle of dipping gradually increases with the distance from the centre up to 34° and 35° at the banks of the Pin creek or Irrawaddy. Taking 35° as basis of the calculation, the top of the (*b*) group would be found—

	Ft.
At $\frac{1}{2}$ mile distance from the centre in	1,890
At 1 mile distance from the centre in	3,750

The top of the (*d*) group would be found—

At $\frac{1}{2}$ mile distance from the centre in	2,080
At 1 mile distance from the centre in	3,940

The centre of the anticline being not a mathematical line, a certain allowance must of course be admitted as to the real and the supposed centre; a range of four chains might be considered a fair one. The probable mistake in the vertical distance might therefore be estimated 3.5 per cent. of the horizontal distance at 1 mile, 7 per cent. of the horizontal distance at $\frac{1}{2}$ mile.

As bores of 3,000 feet afford under normal conditions no especial difficulties, a bore sunk at a distance of $\frac{1}{2}$ mile from the centre could still drain 800—900 feet of the oil-bearing strata in a vertical direction. At a distance of 1 mile the difficulties would be considerably greater as regards the oil-bearing strata, which would not be reached under 4,000 feet deep.

Question (*c*) is easy to answer if one considers that the N.-S. direction nearly corresponds to the strike of the strata; therefore, in moving from the oil-fields in that direction, the depth in which the oil-bearing strata are to be found will be everywhere the same as it is at Twingoung and Beme as far as the tertiary strata extend in either direction.

II.—THE OIL-FIELD OF TWINGOUNG.

6. *Area of the Twingoung oil-field.*—The area on which between the villages of Twingoung and Enasu¹ the oil-wells are situated forms an oblong the length of which is nearly three times its breadth, being 50 chains and 15—20 chains respectively. Narrow deep nullas with steep slopes form the boundary lines. The S.E. side forms part of a ravine, which continuing westwards reaches the Irrawaddy north of the police station of Yenangyang; the opposite N. W. side is formed by a ravine, the continuation of which I did not examine. The S. W. side is formed by two ravines, which beginning near Enasu on the top of the plateau run in opposite directions towards S. S. E. and N. N. W., eventually joining the north and south ravine respectively. We notice the same conditions on the eastern side formed by two ravines, which, commencing close together at a point east of the village of Twingoung, carry the water away thence in opposite directions. As I have already mentioned in Section 1, this main ravine is notched and scored by smaller ones.

The superficial area of the Twingoung oil-field within the limits just described is some 90 acres. In this area are situated the whole of the productive oil-wells of

¹ Enasu = western village.

the Twingoung district. There are on the eastern and western sides a small number of wells, outside these limits, but not a single one is productive.

The western group consists of not more than four wells, Nos. 92 to 95, of which three have fallen into disuse; only No. 95 shows any signs of being worked, but I am sure that it does not happen very often.

The eastern group, situated on both the slopes of a ravine east from Twingoung, contains only ruined wells. I could not get any information whether these wells ever yielded oil, or whether they were given up as fruitless experiments in early stages of the digging. However, some of them are of a considerable depth. Being therefore quite unimportant, these two groups of wells may remain out of consideration. They only are of use as demonstrating the architecture of the country, as pointed out in Section 5. The oil-bearing strata at these two places are at such a depth that they are beyond the reach of Burmese digging.

The oil-fields of Twingoung afford a highly interesting and characteristic view.

Characteristics of the oil-fields.

On every side a feverish unceasing industry is apparent, unaffected either by the scorching rays of the mid-day sun or the blackness of night. Devoid, however, of all system or method, the bountiful soil is robbed of its riches in an aimless fitful manner, without thought for the future, or with any object beyond the rapid achievement of a momentary success.

Here we notice a well just stopped in the very commencement of digging years ago; there an old well, probably disused for years, undergoing resuscitation. Why? I am sure even the man who works it does not know it himself. Very likely the well yielded in former times a large quantity of oil and he hopes now to tap again the rich vein which grants him a high rent without much trouble. Here we see a black soil so richly soaked with oil that it stands in small pools, while the worn-out cylinder of the cross-beam proves that the well is worked at high pressure and yields probably a fair quantity of oil, while close to it the rotten cross-beam, partly eaten by the ants, and the broken walls, show us the inevitable end; the walls of the well quietly slide down until a funnel-shaped hole results, partly hidden by quickly-growing plants, and constituting a serious peril to the stranger. Here a well which slacked in the production is cleaned and deepened, and there a new well is busily starting; everywhere work, but unreasonable, either overhasty or neglected work! The oil-wells are a striking instance of the Burman's love for gambling. He knows he will find oil at that place; his friend probably owns a well which yields 300 viss a day. Why should he not harvest the same crop? And so he starts digging as close as possible to his friend's well; but his work proves to be a failure, or his money runs short: at any rate the well is given up and quickly breaks down; if not, another one takes up the work with probably a better success.

7. *Number of the wells. Productive and unproductive wells.*—In making an exact record of the wells I had at first to design a map of the oil district and to put down on it the wells. Having no other instruments for this purpose but a prismatic compass, and having to depend on pacing for the distances, my map cannot be expected to be absolutely correct. But it is more than sufficient to illustrate this report, and having put down the features of the country as correctly as possible, it will not be difficult to identify any well.

With regard to the record I had to number the wells, and I considered a separate numbering of each oil-field preferable to a continuous numbering of the two fields.

In the Twingoung field I began with the wells of the southern ravine, and continuing westwards along the slope to the northern end of the western boundary I turned then back in a southern direction across the plateau, and on arrival at the southern ravine I again turned eastwards and followed the slope of the eastern ravine across the plateau near Twingoung, keeping as much as possible to the course of the ravine, finishing up near the village of Enausu.

In the Beme field numbering commenced at its northern corner and running thence along the slopes of the hill finished on the southern slope of the hill facing the Minling creek.

There exists an older numbering and which, if it could have been accepted, would have simplified matters, but such evident confusion existed in these numbers in addition to some being wanting that to do so was impossible. However, I always put down in the record the older numbers where I could ascertain them, and I am at least able to trace the course of the older numbers. Numbering commenced at the north-western corner of the Twingoung field on the slope and ran straight to the Beme field, including in one continual rotation the wells of the two fields. The general course of it will be seen from the table appended to the record, with the help of which it is easy enough to identify the older numbers corresponding to mine. There are unfortunately enough many gaps in the wheels, with which the wells were worked, of the labels bearing their former numbers and confusion often occurs, two wheels bearing the same number.

I was not able to ascertain the time when the wells were thus numbered. Some of the natives told me that it was done under the Burmese Government, others stated that it was done immediately after the annexation. However, the wooden labels on which the numbers are marked are so rotten in many cases that I should incline to the opinion that the numbering must have been done previously to 1886.

The total number of wells in the oil-fields of Twingoung amounts to 375. According to the older numbering there were 396 wells; at least No. 396 was the highest amongst the old numbers. The older and the more recent counting of the wells therefore agree very well, as the small difference of 21 wells is of no importance. I venture to think that my counting is the exacter of the two, as three repeated countings gave always the same result, and so I shall consider 375 as the real total number of wells in April 1888. And even if I should have actually overlooked some wells, they were certainly not productive wells, but old, disused ones, hidden by the vegetation. In any case the number accepted, whether it be 375 or 396, does not mean only "productive wells." It contains wells of all kinds, new and old ones, wells where digging is still going on, and wells where it has been stopped years ago.

Amongst the 375 wells there are 166 (44·3 per cent.) which are utterly unproductive (U. P. W.); the greater portion have fallen in and will never be repaired; those in which digging had ceased at early stages of their existence are but few in number. Work might be again taken up later on, but at present they must rank amongst the unproductive.

The remainder, 209 (55·7 per cent.), we may call productive wells, but we have again to distinguish between wells from which oil is regularly drawn up and those from which it is only occasionally drawn. In those belonging to the latter category two causes may be at work, namely, either they are old and nearly exhausted, or they are new wells in which the work of digging is not yet completed, from which oil is only drawn when a small quantity has collected during a few days' cessation of work. Of the first class, *productive wells* (P. W.), there are 120 (32·0 per cent. of the total number); of the second class *scarcely productive wells* (S. P. W.), there are 89 (23·7 per cent. of the total number). Of the total of productive wells the P. W. would be 57·4 per cent., the S. P. W. 42·5 per cent. There could not be better illustrations of the meagre proportion of the Burmese oil industry than these few data. Of a total number of 375 existing, only 32 per cent., that is to say, hardly a third, supply the oil trade.

8. *Depth of the wells.*—I considered it as one of the most important parts of my work to ascertain the depth of the wells, because several essential questions, as, for instance, whether the quantity of oil increases with the depth, might so be answered. I therefore carefully measured the depth of all wells as far as they were accessible. Wells the depth of which was not measured, as will be seen from column 4 of the record, were only old, disused wells, to measure the depth of which was of no sort of use. Besides my own measurements I inquired the depth of each well according to native statements (column 5 of the record). Comparing the two data I was able to judge of the trustworthiness of native statements. The difference between the two data I put down in column 6 of the record, and marked it with + if the native statement was larger than my own measuring, with — if smaller. Mostly both measurements agreed fairly, but in single cases I had to notice a large difference. In such cases I ascertained the depth by repeated measurements; my results may therefore be taken as reliable. The incorrectness of the native statements was certainly due in most cases to the ignorance of the labourers, who always considered an incorrect statement preferable to none at all.

The greatest depth reached by a Burmese well is 310 feet (No. 129), the next is No. 135 with 305 feet, but none of the others reach depths of more than 300 feet.

I measured the depth of 236 wells, that is to say, of all the productive wells, besides a small number of unproductive ones, and these I have divided into five classes according to their depth:—

Table No. 2.

Well.	Class.	Total number.	B. W.	S. P. W.	U. P. W.
Wells up to 150 feet depth . . .	V	26	3	11	12
Wells up to 200 feet depth . . .	IV	66	28	27	11
Wells up to 250 feet depth . . .	III	111	66	41	4
Wells up to 300 feet depth . . .	II	30	20	10	...
Wells of more than 300 feet depth .	I	3	...	...	...

In the above table the first and second columns show the class of depth; the 3rd the total number of wells in each class; the 4th, the number of productive; the

D

5th, that of scarcely productive; and the 6th, that of unproductive wells in each class.

The table is highly instructive in several respects. It shows that the total number of wells increases from the V to the III class, where the maximum is reached, and then in the II and I classes rapidly decreases. The bulk of the wells of the V class digging is not yet completed; they have not yet reached the oil-bearing strata, so they can hardly be expected to be productive, a supposition which is proved by the next three columns; but in a short time, as soon as the work of digging is finished, a good number of these wells will rank amongst the productive ones. The wells of the IV class have, with the exception of a few wells which were sunk in the ravines, not reached the oil-bearing sandstone; they only drain the lower parts of the (c) group. The greatest number of wells belongs to the III class; the wells stand in the upper part of the (d) group, but they hardly drain more than 30 feet of it. We notice in the II class not more than 30 wells, a rapid decrease after the 111 wells in the III class and still more rapid decrease in the I class.

There could hardly be a better illustration to prove the unreasonable style of Burmese working. Beyond 250 feet the difficulties of digging increased so greatly that they could hardly be vanquished. Only 33 wells out of a total of 209 wells could be sunk beyond that limit.

I pointed out in Section 3 that the (d) group, the oil-bearing sandstone, is known to have a thickness of at least 200 feet; therefore those wells which we have to consider as being the main oil-producers do not drain more than 30 feet of the upper and worst part of the oil-bearing sandstone, and only 33 wells drain the oil-bearing sandstone up to about 80 feet. To work to a greater depth is impossible for the Burmese style of working. Therefore all over the place where the Burmese wells are situated nearly 100 feet of oil-bearing sandstone remain untouched and its wealth of oil measuring millions of viss unraised.

9. *Production of oil.*—As the data given by former examiners relative to the production of oil differ considerably from one another, I paid special attention to this part of my work by collecting as many authentic data about it as possible. I tried to find out the total daily production of oil by inquiring of the owners or labourers working the wells, the daily yield of each well and summing up the data thus obtained.

Difficulty in getting exact data. But matters proved more difficult than I expected for the following reasons:—

- (1) The production, not being a regular one at present, depends on the demand. Hence it happens that for days the production of oil is nearly stopped. At another time, if there is demand for oil, the hardest working goes on. Keeping in mind what I pointed out in Section 4, it is therefore quite intelligible that after three days' rest, the production of the fourth day is higher than the daily average if worked for four consecutive days. Therefore the data regarding the daily production must be expected to differ, especially as there does not exist a written record about the production of a single well.
- (2) It is highly difficult, if not impossible, to control data given by the natives, provided even that they do their best to tell the truth.

But for reasons easily intelligible a native will state the daily production of his well rather too low than too high.

Accordingly, my statements about the daily production of oil must be read in the light of the above-mentioned facts, and by summing up the single data, the total production at least may be expected to be lower than it is in fact.

I succeeded in getting data about the production of 144 wells, but the total number of productive wells being 209, those regarding 65 wells are wanting. This last fact will not however, in my opinion, affect in any sensible degree the general results obtained, as the bulk of these wells belong to that class from which oil is only drawn at greater or less intervals.

I divided in Section 7 the productive wells into two classes, namely,—

- (a) wells yielding less than 20 viss per diem = S. P. W. = scarcely productive wells ;
- (b) wells yielding from 20 viss upwards der diem = P. W. = productive wells.

Wells belonging to class (a) I do not consider as exercising any essential influence on the total daily production. Most of them prove by their rotten condition that they are not regularly worked, but that oil is occasionally drawn up only on account of the existence of the well. They are hardly worked oftener than once a month, some of them even only every two months, and, calculated per diem, the production would hardly reach the amount of 10 viss. I need not mention that any data collected regarding these wells cannot but be more or less unreliable.

There are 89 wells of this class, but I only succeeded in getting data regarding 26 of them ; of the remainder 63 wells, I was unable to obtain any information. Of course the S. P. wells are to be found at all depths (Table No. 2, Section 8). The bulk of them might be considered as exhausted wells, *i.e.*, wells that have exhausted the possible draining area at a certain depth. Only very few belong to that class which in the process of digging have not reached the oil-bearing sandstone, but which daily yield a small quantity of oil.

The 26 wells have a daily total production of 206 viss, the daily average therefore being hardly 8 viss. Admitted the daily average per well being 10 viss, that is, about one of the small pots in use, the total production of the S. P. wells [class (a)] would therefore be 890 viss, say 1,000 viss.

Of class (b), there are 120 wells which yield according to my enquiries 10,384 viss per diem, that is, a daily average of 86.5 viss per well.

The daily total, therefore, would amount to 11,274 viss, say 12,000 viss, which we might consider as the present minimum daily production, as according to information otherwise obtained, the average daily total production amounts to 15,000 viss, recently even to 17,000 viss.

Taking the other two data as bases of the calculation, the daily average of the P. wells [class (b)] after deducting 1,000 viss for the S. P. wells [class (a)] would be—

	Viss.
(1) At the rate of 15,000 viss =	117
(2) At the rate of 17,000 viss =	133

We therefore might estimate the average daily yielding of a well [class(b)] at not less than 87 viss, but more probably as between 117 and 133 viss, estimations which will be fairly correct.

Taking the wells as a whole, *i.e.*, 209, the average yield per well per diem would be—

	Viss.
(1) At the rate of 12,000 viss =	57'4
(2) At the rate of 15,000 viss =	71'7
(3) At the rate of 17,000 viss =	81'3

The lowering influence of the S. P. wells is evident when compared with the data before mentioned, and it would be a great mistake to take these wells, which are hardly of any importance as regards the production of oil, into consideration. It further results that Oldham, in estimating the number of wells as correctly as possible, so far overestimated their average yield as to place it two or three times higher than it is in fact.

In Section 8 I classified the wells in five classes according to depth. It is a matter of the highest importance to know whether there is any relation between quantity of production and depth. It will, therefore, be necessary to arrange the wells according to their depth, and to take the average production of each class as it is shown in the appended table :—

Table No. 3.

Depth.	Class.	Number of wells of each class.	Total daily production in viss.	Daily average per well in viss.
0—150 feet	V	3	80	26
150—200 feet	IV	28	1,857	66
200—250 feet	III	66	5,802	88
250—300 feet	II	20	2,290	115
300 feet and more	I	3	365	121

It is obvious that the lower strata of the oil-bearing formation produce more oil than the upper ones, a fact which the geological consideration that I adduced in Section 4 might have led us to expect. Of course it must be borne in mind that this rule does not mean that well (a), for instance, which is deeper than well (b), but less than well (c), must consequently yield more oil than well (b) and less than well (c). Such a conclusion would be quite wrong, as very likely exactly the contrary might occur as will be seen from the record in many instances. These average rates only prove the fact that at a greater depth the strata as a whole are richer in oil; therefore the same number of wells of say 250 feet depth will produce more oil than the same number of wells of only 200 feet depth. The truth of this rule, that the production is in direct proportion to the depth, is a fact of considerable importance in its bearing on the further development of the oil industry of the Twingoung oil-fields. Unfortunately the total absence of the necessary data precludes its being tested for depths greater than 300 feet.

The table above shows that the increase in the yield of oil between depths of 150 and 200 feet is rapid, amounting to 154 per cent. The next 50 feet show an increase of 33·3 per cent., the next 50 feet 30·6 per cent., and greater depths only 6 per cent.

The conclusion therefore might not be utterly wrong, that further increase of oil with that of depth might be expected, but assuredly at a lower rate than in the upper parts of the strata.

The highest daily production of a single well was 500 viss (well No. 253).

Rich and poor wells. There being no greater production at present, we can again divide them into three classes according to the daily yield of the wells:—

Table No. 4.

(I) Poor wells, yielding less than 20 viss per day	. . . . .	89
(II) Fairly rich wells—		
(a) from 20 to 100 viss = 74	}	105
(b) from 100 to 200 viss = 31		
(III) Rich wells—		
(a) from 200 to 300 viss = 10	}	15
(c) more than 300 viss = 5		
	TOTAL	<u>209</u>

It is obvious from this table how poor the native wells are. Wells yielding less than 100 viss a day are 163, or 77.9 per cent. of the whole number; of wells yielding more than 100, but less than 200, there are only 31, or 14.8 per cent.; and of wells yielding more than 200 viss, not more than 15 or 7.1 per cent.

Therefore in sinking a new well, the odds of obtaining a daily yield of more than 100 viss would be 1 to 5, of more than 200 viss 1 to 11.

There is another question to be answered which is of the highest importance as regards the future development of the oil-fields. It is this, *Is there any regularity in the decrease in the production of oil from a single well within a given space of time?*

It is obvious that there must be a decrease in the production after a certain time; any mine will be exhausted in time, and likewise the wealth of the oil-bearing sandstone must similarly become exhausted, and the production necessarily diminish. But it is important to know whether the decrease is a *rapid irregular one* or a *regular gradual one*. It would hardly be worth while to start an extensive working of the oil-bearing strata with the prospects that a bore might for instance yield this year 500 viss, and the next year only 50 viss or *nil*.

I am sorry to say that I could get but very scanty data, by no means sufficient to answer the question in a satisfactory way, as it is difficult to say how far they are reliable.

These data are summarized in the appended table:—

Table No. 5.

Consecutive number of the well.	Depth in feet.	Present daily production in viss.	Former daily production in viss.	Time of former production in years.	Annual rate of decrease in viss.	Annual rate of decrease per cent.
21	201	9	200	5	38	19
25	235	80	200	4	30	15
41	215	140	190	1	50	26
51	203	200	800	15	40	5

Consecutive number of the well.	Depth in feet.	Present daily production in viss.	Former daily production in viss.	Time of former production in years.	Annual rate of decrease in viss.	Annual rate of decrease per cent.
81	245	140	180	2	40	22
84	263	90	300	2	105	35
103	183	150	260	6	18·3	7
126	263	100	200	10	10	5
129	310	160	180	1	20	11
138	260	60	80	1	20	25
195	200	50	200	8	18	9
253	233	450	1,000	4	137	13·7
295	251	270	1,000	4	182	18·2
314	196	120	160	1	40	25
			<i>Beme.</i>			
108	?	<i>Nil</i>	2,000	60	33·3	1·6
151	?	<i>Nil</i>	1,000	30	33·3	1·6

All the wells in the above table occur at the level of the (*d*) group, as according to the place where they have been started, a certain allowance in the height must be admitted. Provided the data are correct, it would appear that in the first year the decrease is a rapid one, amounting to 25 per cent. of the original quantity. If the figures in the case of No. 84 are correct, the decrease would be even higher still, namely, 35 per cent. Later on the decrease goes on more slowly. Within a space of four, five, and six years we notice an average yearly decrease of 19 per cent., 7 per cent.; within 10 to 15 years the average is 5 per cent. per year.

Therefore all I am at present able to say is that in the first two years a rapid decrease of the daily production will be noticed amounting to not less than 25 per cent.; later on the decrease goes on very slowly, so that after 10 or even 15 years' existence the yearly rate is not more than 5 per cent. of the original production. It may even become so small as hardly to be noticed for some time; at least so I understand the statements of natives, who absolutely deny any decrease in the production of numerous wells within recent years.

The statements about the two Beme wells I only mention as curiosities as I do not believe them to be correct, but the headman of Beme, whose statements I have reason to believe are fairly reliable, assured me that they are correct. I asked him no particulars regarding these two wells because they are at present only funnel-shaped holes, but when we passed them, the headman volunteered the information as to their exceedingly rich production. No. 108 is said to be 80 years old, and has now been disused some 20 years; the life of the well therefore would appear to have been 60 years with an average yearly decrease of 1·6 per cent.

10. *Age of the wells.*—One should anticipate that the age of a single well would yield useful hints as regards the intricate matter I discussed in Section 9. This would certainly be the case, provided that the well remained all the time at the same depth at which digging ceased, and thus drained the same bed or beds of oil-bearing strata; but this is by no means the case, as the native at once commences to deepen the well if he sees any chance of success. The age of the well therefore means in plain English only the age of the shaft. Of course there are wells which have evidently remained for a good many years at the same depth, but sooner

or later their time will arrive for deepening. The highest age of any of the Twingoung wells is said to be 70 years, but the bulk of them are much younger. As a matter of fact the Twingoung wells are younger than the Beme wells; the first mentioned oil-field has as a whole been certainly later started than the Beme field.

11. *Digging of wells.*—As soon as a native has made up his mind where he is going to have a new well, the workmen, usually four in number, begin to dig a square shaft, the sides of which measure between 4 and $4\frac{1}{2}$ feet.

Over the well a cross-beam supported on stanchions at either side is placed, and in the centre of this is a small wooden drum¹ or cylinder; the drum and its axis are made of a single piece of wood; the axis runs on coarse, naturally grown, fork-shaped supports.

Tools used for digging the wells and hauling up oil, &c.

The leather rope used in hauling up the oil passes over the drum, and on it is fastened the workman who is going to be lowered down as well as the common earthenware pot called *yenanoie*² in which the oil is drawn up. If possible, the well is so placed that the men or women who are drawing up either the pot filled with oil or the workmen walk down an inclined plane along the slope of the hill.

The instruments used for digging are extremely simple and chiefly consist of a tool called *jayuwen*. The instrument, the shape of which is shown in the Fig. 2, Plate 1, is about $4\frac{1}{2}$ feet in length; it consists of a wooden handle and an iron shoe; the handle is club-shaped, flattened on the top and deeply notched 6 inches below the top; a conical iron tube, which ends in a two-pointed edge, is fixed to it. In working, the man grasps with his two hands the wooden handle at a little above the iron shoe, and, leaning the notch against his shoulder, forces the tool into the ground with all his strength; he loosens small pieces of the rock, which are brought out in a basket from the bottom of the shaft. It is obvious that a tool such as this can only be used with success in soft strata, while hard ones are a nearly invincible obstacle.

To support the walls timber is freely used, and the shaft is throughout lined with timber. The timber consists of clumsy beams, corresponding in length to the breadth of the well, of 3 to 4 inches breadth and 1 inch in thickness. The beams are notched at both ends with the object of admitting of no movement after once being fixed. This wooden wall has considerable strength, but it has to be frequently repaired, and permanently to be kept under supervision lest it should give way. It may be mentioned here that every well wants permanently to be looked after; cleaning and repairing take a good deal of time if the well is to remain in good condition.

The lowering of the workmen is rather ingenious. The man sits on two slings formed of strong rope running between his legs and knotted over his left shoulder. To prevent sliding, a thin rope runs down from the knot across the breast underneath the right shoulder to the back, where it is fastened to the rope forming the slings; a second rope for the same purpose is fastened round the hips. On account of the explosive gas filling the shaft, no light can be taken down; the workman is therefore obliged to tie up his eyes previously to descending to enable him to see during the short time he is down in the well. Without this simple device, it would take more time to accustom his eyes

¹ Gyin.

² *Yenanoie* = oil-pot.

to the dark than he is able to stay down. The gas, which renders breathing a difficult matter, prevents his staying below for any time. I made several notes regarding the time occupied in the descent, staying below, and the subsequent ascent, and give these observations in Table No. 6 (time in seconds).

Table No. 6.

	Well No. 228, depth 227 feet.	Well No. 262, depth 210 feet.		Well No. 278, depth 195 feet.	Well No. 321, depth 253 feet.	
		First observation.	Second observation.		First observation.	Second observation.
Descent . . .	45	44	44	43	47	47
Ascent . . .	80	91	89	62	121	120
Period below .	280	257	180	118	60	89

Further observations are needless, these few data clearly demonstrating how disproportional to the profit gained is the amount of labour and money expended in the Burmese method of working. The time usefully spent is hardly 25 per cent. of the total working time. Of course the time of staying down depends to a considerable degree on the quantity of gas which is developed, and the physical strength of the labourer. A young man will stay longer than a weak, old one, and in cases where the development of gas is great, the stay must be shorter compared with one where gas is not so rapidly developed. However, I never saw even a young and strong man able to stay down longer than 290 seconds, which I consider to be the longest time a man may remain in a well without becoming unconscious.

It hardly needs mention that in the upper parts of the well, where the development of gas is *nil* or nearly *nil*, the workmen are not troubled by it, consequently remain down in the well for a longer time.

From the facts I stated above, it is obvious that the digging of wells after the Burmese fashion is costly and takes a good deal of time owing to the primitive tools and the natural difficulties. It further results that with increasing depth, the difficulties increase tremendously until they become invincible, forming thus a natural limit of depth for Burmese wells. This limit is about 310 feet, but I noticed that the Burmans dislike to going deeper than 250 feet as is clear from Table 2, Section 8.

The drawing up of the oil is as primitive as everything else; the rope is fastened round the neck of the ball-shaped pot, and being lowered is allowed to fill by sinking in the oil below. The oil thus raised is poured into another pot of the same shape containing from 10 to 16 viss of oil, 12 of which are packed on each country cart.

12. *Wages paid for digging.*—The wages for digging a well are paid according to the depth on a scale which will be seen from Table 7:—

Table No. 7.

Depth in attaug.	Rupees per attaug.
From 0 to 80 attaug . . .	From ₹1-5-0 to ₹1-8-0.
From 80 to 90 attaug . . .	From ₹3-8-0 to ₹4-8-0.
From 90 to 100 attaug . . .	From ₹5-8-0 to ₹7.
From 101 per each additional attaug .	From ₹10 to ₹20.

As a rule the digging is paid in the following way. According to previous agreement, for the first 80 attauangs R105 to R120 are paid; for the next 10 attauangs are paid R35—45; from 90 attauangs (150 feet) the price increases largely as for the next 10 attauangs between R55 and R70 are paid; generally from 100 attauangs (166 feet) digging is paid per attauang and varies according to the difficulty of the work, and the greater or less development of gas, from R10 to R20.

13. *Value and interest of oil-wells.*—Referring to the rates paid for digging in Section 12, it is not difficult to estimate the total expenses of a well.

Taking for instance a well of 250 feet depth, without any special difficulties, the expenses for digging would amount to R970. For timber and wages for the men serving as draught-horses, R500 would not be too high an estimate. The total expenses of this well would therefore amount to R1,470, say R1,500. I do not think that this estimate is too high. In special instances, the total expenses are considerably higher. Calculating the expenses of the deepest well, No. 129—

	R
The wages for digging would amount to	2,170
The expenses for timber and other items	750
	2,920
TOTAL	2,920

or R3,000.

I never succeeded in getting exact data as to the total expenses of a well from natives; either they did not want to tell me the truth or they did not know it themselves. Such data as I received were vague and often enough highly exaggerated, as a Burman once smilingly admitted when I told him that his statements were exceedingly exaggerated.

The estimates that I have given here have, however, been calculated on the basis of certain well-established facts, and so should preferentially be adopted in further investigations of this nature.

Admitting a rate of interest of 10 per cent. and the same for amortization, the total annual interest of a well of medium size (R1,500) would amount to R300. The expenses being between R2,000 and R3,000, an annual interest of R400—600 would be required, or a monthly revenue of at least R25—50 would be required to cover interest and amortization of the invested capital after ten years.

At present for 10 viss crude oil 4 annas are paid; therefore to cover interest and amortization a monthly production of 1,000—2,000 viss, or a minimum daily production of 33·3—66·6 viss is required.

From the data given in Section 9 it clearly results that even the lowest daily average of 57·4 viss would cover the interest on wells of R1,500 and R2,000 value, and would still yield a small surplus. A well, however, of the value of R3,000 would not be covered by such a production. We may, however, take it as pretty well certain that the number of wells at the rate of R3,000 is a very small one; and, on the other hand, we know the daily average of 57·4 viss is at the least a low estimate.

I stated that the probable daily average is between 87 and 133 viss, but 117 to 133 viss would probably be nearer the mark.

From these data it is obvious that an oil-well is a source of gold for its proprietor yielding him yearly a considerable revenue; and, considered as an investment of

capital, it pays as high an interest as almost any other mining industry. An instance will render this statement more conspicuous.

I estimated in Section 12 the capital invested in well No. 129 to be ₹3,000. It would be required to pay—

	Viss.
(1) Interest and amortization per month	2,000
(2) Loss, breakage, holidays, 15 per cent. of the monthly production	720
(3) Wages and other necessary expenses, 15 per cent. of the monthly production	720
TOTAL	3,440

The well has a daily production of 160 viss, or 4,800 viss per mensem. Deducting 3,440 viss as calculated above, there remain 1,360 viss as a net monthly revenue; they would sell for ₹34, which would mean a net interest of 13·6 per cent., and in the case that the owner of the well is the owner of the capital, a total interest of 23·6 per cent., with amortization of the invested capital after ten years. Certainly not a bad investment of capital, and one which would be still better supposing the invested capital lower and the production better.

14. *Proprietors of the wells.*—The bulk of the wells is owned by natives, but there are a few which were confiscated from the former private owners by the Burmese Kings and now belong to the British Government.

Examining these Government wells, the remarkable fact is to be noticed, that only a small number are productive; the rest are unproductive disused wells. This apparently strange fact is susceptible of easy explanation. Whenever one asks who the owner of a mined well is, the invariable answer is “the Government,” as in the eyes of a Burman it seems only right as doing no one any harm to put down the ownership of an utterly useless hole to Government. Such few of the “productive wells” as are recognized as Government wells yield but very little oil.

III.—THE OIL-FIELD OF BEME.

15. *Topography.*—The outlines of the Beme oil-field are much less marked than those of the Twingoung field. The bulk of the wells is situated on the north and south slope of a hill east of the Beme village, the top of which rises to 250 feet above the level of the Irrawaddy. In general its slopes are less steep than those of the Twingoung oil-field, but deeply notched on the southern side, producing thus a number of sharp spurs. The two water-courses on either side of the hill run east and west, joining a somewhat larger one running north-east and south-west, which after a sharp turn north of Beme joins the creek coming down from the Minling hill which reaches the Irrawaddy south of the police station of Yenangyaung. There are two smaller groups of wells north and south of the main group.

As a whole the Beme oil-field covers an area of about 35 acres, and its length in a N. S. direction is something like 27 chains, its breadth 20 chains.

16. *Geology*.—I have nothing to add to the geological remarks in Section 3 as being peculiar to the Beme field. There are the same strata and there is the same geological architecture. I will only describe the position of the oil-field with regard to the anticline. In the western part of the field, the strata show a dipping towards the south-west gradually increasing from 11° to 23° . The same bed of blue clay, which is noticed on the top of the main hill, is found on the opposite slope of the water-course only a few feet above the bottom of the ravine. The angle of dip gradually decreases towards east, and at a small distance beyond the upper end of the southern ravine the change in the direction of the dip towards the north-east is again noticed. The position of the oil-field is therefore exactly the same as that of the Twingoung oil-field, only that the wells of Beme are situated on the top and western side of the anticline.

17. *Number of wells*.—The number of wells is considerably smaller than that of Twingoung as there are on the whole not more than 151. Amongst these there are not more than 72 (47.6 per cent.) productive wells, and the rest 79 (52.3 per cent.) are unproductive old wells which are mostly mere holes.

Amongst the 72 productive wells, there are 50 or 33 per cent. of the total number of wells which yield more than 20 viss a day, and 22 or 14.6 per cent., the production of which is less than 20 viss per diem.

18. *Depth of the wells*.—The Beme wells are more favourably situated than the Twingoung wells; their depth in general is therefore smaller than that of the Twingoung wells, the deepest well being not more than 270 feet (wells Nos. 41 and 89). I measured the depth of 78 wells, half of them ranging amongst the V and IV classes,—a fact which is easy to understand if we keep in mind that on account of their situation on the slope the oil-bearing strata were earlier reached.

The appended table shows the wells classed according to depth and the number of productive, scarcely productive, and unproductive wells. We notice exactly the same facts as I stated in Section 8, namely, the greatest number of wells in the III class, and the increase of productive and decrease of unproductive wells in proportion to the depth.

Table No. 8.

Depth.	Class.	Total number.	P. W.	S. P. W.	U. P. W.
Up to 150 feet	V	23	8	9	6
Up to 200 feet	IV	12	5	7	...
Up to 250 feet	III	36	31	5	...
Up to 300 feet	II	7	6	1	...
More than 300 feet	I	...	...	...	...

19. *Production of oil*.—The oil-production of the Beme field is much smaller than that of the Twingoung field, being not more than 3,658 viss,—that is, exactly one-third of the total production of the oil-fields. Those wells yielding more than 20 viss a day are not above 50 in number with a total production of 3,437, which

means a daily average of 68·7 viss per well ; the remaining 22, "scarcely productive" wells, yield not more than 221 viss per diem ; the average is therefore not more than 10 viss. The total average of the 72 wells is therefore 50·8 viss per diem.

If the wells be arranged according to depth and the average calculated for every range, we find exactly the same fact proved as stated in Section 9, *i.e.*, the *increase of the quantity of oil in lower strata* notwithstanding the seeming exception that the wells of the III class give a smaller average than those of the IV class.

Table No. 9.

Depth.	Class.	Number of productive wells in each class.	Total daily production in viss.	Average daily production per well in viss.
Up to 150 feet	V	8	505	63
Up to 200 feet	IV	5	365	72
Up to 250 feet	III	31	2,080	70
Up to 300 feet	II	6	487	81
More than 300 feet	I	...	...	...

The Beme wells have a considerably smaller yield than the Twingoung wells ; there is not a single well producing more than 165 viss per diem ; and even wells producing more than 100 viss are scarce, there not being more than nine.

It is difficult to say whether the wells on the whole are really poorer, or whether this smaller production is only due to the age of the wells. I incline to the latter opinion being the more probable because all the wells are of considerable age, and because no decrease has been noticed for a long time in the bulk of the wells. The Beme wells have now arrived at a stage where the decrease in the production is a very small one and hardly perceptible in a few years.

The data regarding the decrease of the Beme wells are even more vague than those of the Twingoung wells. However there is no reason to doubt the truth of the conclusions arrived at in Section 9.

20. *Age of the wells.*—Passing through the records we notice that there are a good many wells which are said to have an age of 100 years and not a few too between 70 and 80 years of age. I do not know whether these data are reliable or not ; they prove, however, that the Beme field is of great age and is certainly older than the Twingoung field.

21. *Proprietors of the wells.*—There are also some wells which are owned by the Government, the number of which amounts to 28 ; but of these only nine are productive wells, yielding 261 viss per diem. All the other wells are owned by natives.

22. *Digging, wages, value of the wells.*—Conditions here are exactly the same as at the Twingoung fields, and are described under Sections 11, 12, and 13.

IV.—COMPARISON OF THE TWINGOUNG AND BEME OIL-FIELDS.

A comparison of the two oil-fields, not uninteresting in some ways, proves that as a whole the character of the two fields is exactly the same without any especially remarkable difference in either.

There are 526 wells in the whole oil-district, but only 281 (53·4 per cent.) of them produce oil, and of these some 170 (32·3 per cent.) account for nearly the total production of oil, their production being 92·5 per cent. of the whole.

These few data speak volumes. The entire oil industry is supplied by not more than one-third of the existing wells. Two-thirds are either utterly unproductive or their production is so exceedingly small that it is not more than 7·5 per cent. of the whole. What a waste of labour!

According to my notes, the total daily production amounts to 14,932 viss, of which the Twingoung oil-field supplies two-thirds, the Beme oil-field one-third. For reasons I mentioned in Section 9 my calculations are probably below the mark; still they may be taken as fairly correct, or at least as showing the minimum daily production of the oil-fields.

If the other data regarding the production are correct, the production of the two fields would amount from 18,658 to 20,658 viss per diem. It is not uninteresting to notice the very equal conditions of the two oil-fields, which might of course be anticipated from the geological conditions. The productive wells of both the oil-fields amount to nearly the half of the existing wells, and the wells which may be considered as the really productive ones amount to almost exactly one-third of the whole number. In the Beme field the unproductive wells surpass a little the productive ones, which points obviously to the higher age of the Beme field.

In both the fields the share of the production of the P. W. is nearly the same, being 92·1 and 93·9 per cent. of the total production; but remarkably enough the average per well is considerably lower in the Beme field (68·7 viss per diem) than in the Twingoung field, where it is 86·5 viss per diem, which again points to the higher age of the Beme field. The S. P. W. have in both the fields the same daily average of 10 viss.

Regarding the depth, the distribution of the wells is exactly the same in both the fields as will be seen from Table 12.

The relation between quantity of oil and depth is explained in Table 13. There is no doubt that, notwithstanding the exception of the III class wells of the Beme field, which have a lower average than the IV class wells, in both fields an increase of the quantity of oil with the depth is proved.

It seems strange that the average of the V class wells of the the Beme field exceeds considerably the average of the same class of the Twingoung field. But this is easily explained if we keep in mind that most of the Beme V class wells, situated on the slope, are in fact equal to IV class wells of Twingoung,—that is to say, if both the wells had been commenced at the same level on the top of the hill, the V class Beme wells would range amongst wells of the IV class.

If we sum up the most striking features of the two oil-fields, we may thus characterize them in a few words:—

The Beme field is at the end of its production, which has been in the past.

The Twingoung field is at the height of its production with a prospect of a small increase in the future.

Table No. 10.

Showing the number of Productive and Unproductive Wells in the Oil-fields of Twingoung and Beme.

	Total number of wells.	UNPRODUCTIVE WELLS.		PRODUCTIVE WELLS.		WELLS PRODUCING MORE THAN 20 VISS PER DIEM.			WELLS PRODUCING LESS THAN 20 VISS PER DIEM.		
		Number.	In per cent. of the total number.	Number.	In per cent. of the total number.	Number.	In per cent. of the total number.	In per cent. of the productive wells.	Number.	In per cent. of the total number.	In per cent. of the productive wells.
Twingoung .	375	166	44·3	209	55·7	120	32	57·4	89	2·7	42·6
Beme .	151	79	52·3	72	47·6	50	33	69·5	22	14·6	30·5
Total of the two oil-fields	526	245	46·5	281	53·4	170	32·3	60·5	111	21·1	39·5

Table No. 11.

Showing the daily production of Oil of the Oil-fields of Twingoung and Beme.

	DAILY PRODUCTION OF OIL IN VISS AT 3·65 lbs.								AVERAGE DAILY PRODUCTION PER WELL IN VISS AT 3·65 lbs.		
	TOTAL.		OF PRODUCTIVE WELLS.			OF SCARCELY PRODUCTIVE WELLS.			Total average of all the productive wells.	Average of the productive wells.	Average of scarcely productive wells.
	VISS.	In per cent. of the total number.	VISS.	In per cent. of the total number.	In per cent. of the special number.	VISS.	In per cent. of the total number.	In per cent. of the special number.			
Twingoung .	11,274	75·5	10,384	69·5	92·1	890	6·	7·9	53·4	86·5	10
Beme .	3,658	24·5	3,437	23·0	93·9	221	1·5	6·1	50·8	68·7	10
Total of the two oil-fields.	14,932	100·0	13,821	92·5	...	1,111	7·5	...	53·1	81·3	10

Table No. 12.

Showing the Wells of Twingoung and Beme arranged according to their Depth.

Depth.	Class.	TOTAL.		PRODUCTIVE WELLS.		SCARCELY PRODUCTIVE WELLS.		UNPRODUCTIVE WELLS.	
		Twin-goung.	Beme.	Twin-goung.	Beme.	Twin-goung.	Beme.	Twin-goung.	Beme.
Up to {	150 feet . . . V	26	23	3	8	11	9	12	6
	200 feet . . . IV	66	12	28	5	27	7	11	...
	250 feet . . . III	111	36	66	31	41	5	4	...
	300 feet . . . II	30	7	20	6	10	1	...	...
More than 300 feet . . . I	3	...	3	...	...	...	...	...

Table No. 13.

Showing the increase of Oil with the Depth at the Twingoung and Beme Oil-fields.

Depth.	Class.	NUMBER OF PRODUCTIVE WELLS.		TOTAL DAILY PRODUCTION OF THESE WELLS.		DAILY AVERAGE PER WELL.	
		Twin-goung.	Beme.	Twin-goung.	Beme.	Twin-goung.	Beme.
Up to {	150 feet . . . V	3	8	80	505	26	63
	200 feet . . . IV	28	5	1,857	365	66	72
	250 feet . . . III	66	31	5,802	2,080	88	70
	300 feet . . . II	20	6	2,290	487	115	81
More than 300 feet . . . I	3	...	365	...	121	...	

V.—FUTURE PROSPECTS OF THE OIL COUNTRY.

Before speculating on the future of the oil country in the Yenangyoung district it will be useful to discuss the future of the Burmese oil-fields.

This can be done in a few words as most of what will be said will be found in former paragraphs.

The future of the oil-fields depends on the style of working and on geological conditions. As I pointed out in Section 11, a depth of 310 feet means the limit beyond which Burmese workmanship cannot go.

As the geological conditions only admit of a small area being worked by Burmese labour, and as this limited space is now pretty well filled up with wells, leaving but little more for new ones, the future can easily be foreseen.

As soon as all the wells now in progress or that can be dug reach the depth of 310 feet the Burmese oil-industry must inevitably come to an end. But it is difficult

even to guess the number of years when the Burmese oil-industry will belong to the past. This depends mainly on the greater or less intensity with which the oil-field is worked. If there is a large demand for oil, which forces the Burmans to increase the depth of the wells to supply the demand, the end will rapidly arrive; if the deepening of the wells proceeds slower, the existence of the Burmese oil-industry will be prolonged. According to the way the working of the oil-fields is going on at present there will be a small increase of the production for the next years; it will then remain steady for a time, after which it will commence to fall.

While abstaining from any attempt to indicate precisely the exact number of years during which the Burmese oil-industry will continue to exist, still the various facts and data which I have collected warrant the conclusion that it can be only very short-lived.

The future, as I have depicted it, of the oil industry of Burma presents a somewhat dismal picture, and it would be still more so were European energy and enterprise not at hand to rescue it.

Before I discuss the prospects of a European management of the Burmese oil-fields it is necessary to consider the relations between area and production, *i.e.*, to know (1) how many viss per acre and day the oil district can possibly yield, and (2) how many square feet of ground, or how many cubic feet of oil-bearing strata, are necessary to yield a certain amount of oil per diem. I base my calculations on the present daily average production of 12,000—17,000 viss (12,000 viss as the minimum production of the Twingoung field and 17,000 as the maximum present average of the district).

The Twingoung oil-field covers, according to a careful calculation, an area of 90 acres; the daily production per acre would therefore amount to 133—188 viss.

This area is drained by 209 wells, of which only 120 are considered to be real oil-producers. Taking this number, a single well would drain an area of 0.75 acre; we might also say on nearly every three-fourths of an acre there are two wells, but only one of which produces oil.

Calculating from the data at hand regarding 141 wells, each well drains in the average 42 feet thickness of the oil-bearing sandstone; therefore a well which yields 133 viss per diem drains a volume of 1,372,140 (1½ millions) cubic feet of oil-bearing sandstone, provided that the sandstone is uniformly charged with oil.

On the basis of this calculation a well which yields 100 viss a day drains 1,031,684 cubic feet. As from the Burmese method of working only a relatively small portion of this volume can be referred to height, it is evident that the Burmese well needs for its supply a large horizontal area. Supposing the owner of the well is able to work 100 feet thickness of the oil-bearing strata, I estimate the smallest area necessary for a well yielding 100 viss a day to be one-fourth of an acre. According to this supposition the area of the Twingoung oil-field could supply 360 wells at the daily rate of 100 viss. But as it is not very likely that each well will drain 100 feet oil-bearing sandstone (only three wells do so in fact), we assume this area would supply only half the estimated number of wells, namely, 180, yielding 100 viss per diem. The daily production would therefore amount to 18,000 viss, which comes so near to the stated production of 17,000 viss that in future only a small increase in production from native wells is to be expected.

It would not be difficult to calculate the probable further duration of the wells in years if the quantity of oil contained in one cubic foot of oil-bearing sandstone were known. Unfortunately, however, I can only state that the sandstone is charged with oil, but what the relative proportions of the oil and sandstone are in a cubic foot I am unable to say. To ascertain this would require years of the most careful observation. In this respect one is much worse situated than in the case of, say, a coal seam or a galena vein, where the volume of the existing mineral can be calculated fairly correctly, and once the yearly production is known, the number of years the mine will last is simply a matter of division.

The evil effects attendant on the unmethodical and irrational mode of working the oil-bearing strata adopted by the Burmese are thus evident. Their inability to drain any great thickness causes much valuable surface to be lost, and the oil-field yields less than it should do. The millions and millions of viss contained in the second hundred feet are thus irretrievably lost within the area of the present oil-fields.

In the case of European enterprise these hindrances to Burmese labour would not exist. Nowadays machinery is so perfect that the deepest bores can be sunk without any difficulty. A European bore would therefore drain probably the whole thickness of the oil-bearing strata with the following advantages:—

- (1) the oil-bearing strata could be tapped by a greater number of bores;
- (2) the production of each bore would probably be higher than 100 viss because we know that the quantity of oil increases with the depth;
- (3) the supply would likely be a very steady one, less liable to change.

Working the oil-fields after European style would therefore considerably increase the production of oil without damage to the field. I have no doubt that the production of the Twingoung field might easily be raised up to 50,000 viss or more per diem if regular boring were substituted for the present wells. European bores would infuse new life into the present exhausted Beme fields.

An estimate of the probable minimum production of that small area between the two oil-fields on the map between squares Nos. 10 and 19, where Finlay, Fleming and Co. have started boring, will not be uninteresting. Taking only that area into consideration, which would fall within the limits of the Twingoung field if traced across this country, the area might be estimated at about 65 acres. Two bores per acre would certainly yield 500 viss per diem if sunk to 400 feet depth; the total daily production would therefore amount to 32,500 viss.

If we consider the rate of 500 viss per acre as the minimum production of a bore, one square mile would thus produce 320,000 viss per diem. The lease of Messrs. Finlay, Fleming and Co. reaches to within 4 miles of the boundaries of the two oil-fields. For reasons pointed out in Section 5, only 1 mile east or west can be considered as valuable ground. There would therefore be 16 square miles of highly valuable ground which would produce at least half a million of viss per diem, and I have not the slightest doubt that this quantity would be surpassed.

There is only one difficulty in working the oil-bearing strata to any extent, and this is that, in consequence of the very small amount of pressure that exists, pumping will have to be resorted to in order to raise the oil. This fact will considerably limit the powers of production of each individual bore as pumping cannot be continuous,

Technical difficulties
in working the oil-fields.

E

intervals being necessary to allow of the oil exfiltrating again. The production is therefore completely dependent on the number of bores, and to work an oil district extensively would require a large number of wells. However, this is a technical matter, and once the necessary apparatus for boring is purchased the sinking of even a great number of bores would not be expensive. Should flowing wells by chance be tapped, the conditions would be totally altered and that too in a highly favourable direction.

My own opinion is that such wells will be found, if borings are carried out far enough away from the centre of the anticline to reach the oil-bearing strata at a sufficient depth to stop the gas escaping. It is only repeated experiments, however, that can prove their existence. The risk of boring at a fair distance from the centre of the anticline must be run. The result may of course prove either success or failure, but my own opinion is that success is the more probable of the two. Our knowledge regarding the composition of the oil-bearing group is at present still too limited to admit of a decisive judgment being given in this very important matter.

On the whole there is every reason to believe that the oil industry will develop in the future and will rank amongst the important mineral industries of Burma. Wild ideas about beating or competing with American or Russian oil cannot be too strongly deprecated as being only too likely to prove utterly illusory. The oil-fields, if worked rationally and methodically, will pay well enough, and if in future there should be found flowing wells, equal in production to American ones, so much the better for the Burmese oil-industry.

Summary.

1. The oil-bearing strata in the Yenangaung division belong to the upper tertiary formation.
2. The oil-bearing strata chiefly consist of a fine soft sandstone of bluish-grey colour which is more or less soaked with oil, changing the colour of the sandstone into a yellowish green, but no data can be given as to the quantity of oil contained in 1 cubic foot of sandstone.
3. So far the oil-bearing strata are known to have a thickness of 200 feet, but there is no doubt that they are considerably thicker.
4. The oil-bearing strata are deposited in beds varying with the quantity of oil contained, separated, especially in the upper parts, by layers containing no oil.
5. The quantity of oil contained in the oil-bearing strata increases with the depth.
6. A bed of blue stiff clay of 20—25 feet thickness is invariably superimposed on the oil-bearing sandstone.
7. The oil-bearing sandstone is found very near the surface, its depth being not more than about 220 feet from the top of the plateau and 120 feet from the bottom of the ravines.
8. Owing to their superficial position no high pressure can be expected within the limits of the oil-fields.
9. The strata form an anticline, the strike of which is N. 40 E., with a maximum dip of 35° towards S. W. and N. E.

10. The oil-fields of Twingoung and Beme are situated on the top of the anticline.

11. The Twingoung oil-field covers an area of about 90 acres, its length being about 50 chains, its breadth between 15 and 20 chains.

12. There are 375 wells in the Twingoung field, of which 166 are totally unproductive.

13. Of the 209 wells which yield oil only 120 produce more than 20 viss a day.

14. The maximum produced by a single well is 500 viss a day; the bulk of the wells produce between 20—100 viss.

15. The total daily production amounts, according to my inquiries, to 12,000 viss, according to other statements from 15,000—17,000 viss per diem.

16. The daily average of a productive well ranges from 86.5 to 133 viss.

17. At present no exact data can be given about the yearly rate of decrease in the production of a well.

18. The wells are rather shallow; the deepest does not exceed 310 feet.

19. The Burmese wells yield a high interest, ranging from 23.6 per cent. upwards, with amortization of the invested capital after ten years.

20. The Beme field only covers 35 acres, its length being 27 chains, its breadth 20 chains.

21. There are 151 wells in the Beme field, of which 79 are totally unproductive.

22. Of the 72 productive wells only 50 produce more than 20 viss per diem.

23. The maximum production of a single well is not more than 165 viss.

24. The total daily production amounts, according to my enquiries, to 3,658 viss.

25. The daily average of a productive well amounts to 68.7 viss.

26. The wells are equally shallow, the deepest being not more than 270 feet.

27. The total number of wells in the two oil-fields is 526, of which 281 yield oil, but only 170 yield more than 20 viss per diem.

28. The total daily production of the two fields ranges from 14,932 to 20,658 viss.

29. The daily average production of one of the 170 productive wells amounts from 81.3 to 133 viss.

30. The Twingoung oil-field is at present at the zenith of its production, but still a small increase may be expected for the next few years.

31. The Beme wells have nearly extracted the oil existing in the oil-bearing sandstone and a decrease of production is to be expected.

32. The oil-fields, as worked by natives, have only a limited life; the oil industry could not be developed to a greater extent than it is at present.

33. As worked by natives only a small part of the oil-bearing sandstone is touched, for the greater part remaining untouched.

34. If worked according to European style, by bores, they are capable of a considerable development in the future.

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RECORD OF THE WELLS OF THE OIL-FIELDS OF
TWINGOUNG AND BEME.

- I.—Record of the wells of the Twingoung oil-field.
II.—Record of the wells of the Beme oil-field.

Explanation.

Column 3 refers to the map.

In columns 4 and 5, *n. m.* means not measured.

Column 6.—The difference is marked with + if the native statement of the depth (column 5) has been found to exceed my measuring; — if the opposite case.

Column 9.—T. W. means twinza wells. G. W. means Government wells.

TWINGOUNG.

Key to find from a given old Burmese number the consecutive number given by me to the wells of Twingoung.

Remarks.—Burmese numbers in Roman: 1, &c.

Consecutive numbers in *Italics*: 1, &c.

Burmese No.	Consecutive No.	Burmese No.	Consecutive No.	Burmese No.	Consecutive No.
1	...	55	...	109	300
2	...	56	190	110	...
3	...	57	191	111	293
4	...	58	192	112	275
5	217	59	196	113	276
6	...	60	203	114	...
7	213	61	205	115	...
8	...	62	...	116	281
9	...	63	264	117	...
10	227	64	...	118	...
11	...	65	261	119	...
12	224	66	...	120	286
13	...	67	...	121	287
14	214	68	...	122	...
15	...	69	361	123	290
16	212	70	241	124	...
17	213 (P)	71	237	125	292
18	...	72	...	126	294
19	...	73	...	127	...
20	181	74	249	128	...
21	...	75	247	129	295
22	...	76	246	130	...
23	194	77	251	131	...
24	...	78	259	132	...
25	...	79	269	133	302
26	...	80	...	134	...
27	...	81	266	135	...
28	...	82	...	136	308
29	253	83	199	137	...
30	244	84	...	138	...
31	...	85	201	139	...
32	...	86	...	140	...
33	...	87	...	141	...
34	230	88	...	142	309
35	231	89	...	143	311
36	234	90	174	144	...
37	235	91	188	145	354
38	...	92	...	146	314
39	232	93	...	147	315
40	238	94	280	148	...
41	240	95	278	149	...
42	245	96	...	150	323
43	242	97	...	151	318
44	...	98	273	152	322
45	262	99	...	153	324
46	...	100	270	154	...
47	...	101	271	155	320
48	...	102	...	156	...
49	...	103	256	157	325
50	195	104	248	158	...
51	193	105	305	159	317
52	...	106	...	160	328
53	179	107	...	161	...
54	...	108	257	162	...

Key to find from a given old Burmese number the consecutive number given by me to the wells of Twingoung—continued.

Remarks.—Burmese numbers in Roman: 1, &c.
Consecutive numbers in *Italics*: 1, &c.

Burmese No.	Consecutive No.	Burmese No.	Consecutive No.	Burmese No.	Consecutive No.
163	...	217	...	271	...
164	<i>289</i>	218	...	272	...
165	...	219	...	273	<i>103</i>
166	<i>331</i>	220	...	274	<i>104</i>
167	<i>330</i>	221	...	275	<i>144</i>
168	<i>332</i>	222	...	276	<i>145</i>
169	...	223	...	277	<i>143</i>
170	<i>336</i>	224	...	278	<i>136</i>
171	<i>338</i>	225	...	279	<i>135</i>
172	...	226	<i>156</i>	280	<i>134</i>
173	...	227	<i>153</i>	281	<i>133</i>
174	...	228	<i>159</i>	282	<i>131</i>
175	<i>345</i>	229	...	283	...
176	...	230	<i>158</i>	284	...
177	<i>350</i>	231	...	285	<i>129</i>
178	...	232	<i>149</i>	286	<i>128</i>
179	<i>351</i>	233	<i>148</i>	287	...
180	...	234	<i>147</i>	288	...
181	...	235	<i>141</i>	289	...
182	...	236	...	290	<i>106</i>
183	<i>346</i>	237	...	291	...
184	<i>344</i>	238	<i>139</i>	292	<i>76</i>
185	<i>347</i>	239	<i>137</i>	293	<i>77</i>
186	...	240	<i>142</i>	294	...
187	<i>334</i>	241	...	295	<i>73</i>
188	<i>333</i>	242	<i>150</i>	296	...
189	...	243	...	297	...
190	...	244	<i>101</i>	298	...
191	<i>161</i>	245	...	299	<i>75</i>
192	...	246	...	300	<i>69</i>
193	...	247	<i>99</i>	301	<i>70</i>
194	...	248	...	302	...
195	<i>162</i>	249	...	303	...
196	...	250	...	304	...
197	...	251	...	305	<i>94</i>
198	<i>170</i>	252	...	306	...
199	<i>171</i>	253	...	307	<i>123</i>
200	<i>168</i>	254	...	308	...
201	...	255	<i>85</i>	309	<i>126</i>
202	...	256	...	310	<i>125</i>
203	...	257	<i>88</i>	311	<i>122</i>
204	...	258	<i>87</i>	312	<i>113</i>
205	...	259	...	313	<i>120</i>
206	...	260	<i>89</i>	314	<i>121</i>
207	...	261	...	315	<i>110</i>
208	...	262	...	316	<i>109</i>
209	...	263	<i>92</i>	317	<i>22</i>
210	...	264	<i>95</i>	318	<i>111</i>
211	...	265	...	319	<i>65</i>
212	...	266	...	320	<i>29</i>
213	...	267	...	321	<i>30</i>
214	...	268	...	322	<i>64</i>
215	...	269	<i>81</i>	323	<i>63</i>
216	...	270	<i>80</i>	324	...

Key to find from a given old Burmese number the consecutive number given by me to the wells of Twingoung—concluded.

Remarks.—Burmese numbers in Roman: 1, &c.
Consecutive numbers in *Italics*: 1, &c.

Burmese No.	Consecutive No.	Burmese No.	Consecutive No.	Burmese No.	Consecutive No.
325	...	349	<i>55</i>	373	<i>11</i>
326	<i>60</i>	350	...	374	<i>12</i>
327	...	351	<i>39</i>	375	...
328	...	352	<i>54</i>	376	<i>40</i>
329	...	353	...	377	...
330	...	354	...	378	...
331	...	355	...	379	<i>15</i>
332	<i>61</i>	356	...	380	...
333	...	357	<i>57</i>	381	...
334	...	358	...	382	<i>20</i>
335	<i>31</i>	359	...	383	<i>42</i>
336	<i>32</i>	360	<i>118</i>	384	...
337	...	361	...	385	...
338	...	362	...	386	...
339	...	363	...	387	...
340	<i>18</i>	364	...	388	<i>45</i>
341	<i>19</i>	365	...	389	<i>46</i>
342	...	366	<i>5</i>	390	<i>47</i>
343	...	367	...	391	...
344	...	368	...	392	<i>52</i>
345	<i>26</i>	369	...	393	...
346	...	370	<i>9</i>	394	<i>50</i>
347	<i>33</i>	371	<i>10</i>	395	<i>53</i>
348	...	372	...	396	<i>51</i>

I.—Record of the Wells of the Oil-field of Twingoung.

Consecutive No.	Old No.	Locality.	Depth in feet.	Stated depth in strata, at 20 inches.	Difference between 4 and 5 in feet.	Stated daily yield in vis.	How often oil is drawn up.	Proprietor of the well.	Stated age of the well.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11
1	?	9 D.	155	90	..	15	Once a month	T. W.	More than 10 years.	Decrease in yield of oil has not been noticed within the last 10 years.
2	?	9 D.	185	120	-15	140	Daily	T. W.	?	Old well, broken down, yields no oil.
3	?	9 D.	186	120	-20	60	Every 10 days	T. W.	?	
4	?	10 D.	n. m.	n. m.	..	..	..	T. W.	?	} Old well, broken down, yields no oil.
5	366	10 D.	208	132	-12	32	Daily	T. W.	?	
6	?	10 D.	243	140	+10	40	Daily	T. W.	?	Decrease in yield of oil has not been noticed within the last nine years. This well yields at present no oil; the owner tries to get oil in a greater depth, so digging is going on, but has been stopped since six weeks.
7	369	10 D.	167	..	..	..	..	T. W.	?	
8	?	10 D.	..	..	..	..	..	T. W.	?	No further information could be got about this well, which evidently yields only a small amount of oil.
9	370	10 D.	248	150	-2	200	Daily	T. W.	More than 9 years.	
10	371	10 D.	220	..	..	..	..	T. W.	?	No further information could be got about this well, which evidently yields no large quantity of oil. The well contains much water; it is said to have yielded, five years ago, about 200 viss a day.
11	373	10 D.	206	130	-10	120	Daily	T. W.	?	
12	374	10 B.	190	151	-1	60	Daily	T. W.	15 years.	New well; digging started since six weeks. Old well, broken down, yields no oil.
13	?	10 D.	213	140	-20	200	Daily	T. W.	?	
14	?	10 E.	215	125	+7	80	Daily	T. W.	?	No further information could be got about this well, which evidently yields only a small amount of oil.
15	379	9 D.	205	130	-11	70	Daily	T. W.	?	
16	?	9 D.	225	..	..	?	?	T. W.	?	
17	?	9 D.	231	130	+15	30	Daily	T. W.	?	No further information could be got about this well, which evidently yields no large quantity of oil. The well contains much water; it is said to have yielded, five years ago, about 200 viss a day.
18	340	8 D.	241	140	+8	40	Every 5 days	T. W.	25 years.	
19	?	9 D.	233	134	+10	50	Daily	T. W.	30 years.	New well; digging started since six weeks. Old well, broken down, yields no oil.
20	?	8 D.	232	?	..	?	?	T. W.	?	
21	?	9 D.	201	150	-40	9	Every 13 days	G. W.	?	
22	317	9 E.	230	120	+30	50	Daily	T. W.	30 years.	New well; digging started since six weeks. Old well, broken down, yields no oil.
23	?	9 E.	111	66	+1	..	..	T. W.	?	
24	?	9 E.	n. m.	..	..	..	..	T. W.	?	

I.—Record of the Wells of the Oil-field of Twingoung—continued.

Consecutive No.	Old No.	Locality.	Depth in feet.	Stated depth in inches.	Difference between 4 and 5 in feet.	Stated daily yield in viss.	How often oil is drawn up.	P. w. l. Proprietor of the well.	Stated age of the well.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11
25	?	9 E.	235	140	+ 2	80	Daily	T. W.	20 years .	It is said that this well yielded 200 viss a day about three or four years ago. When the present owner started work, the well yielded 10 viss a day only; by increasing the depth about 5 attangs the present daily amount was got. The daily quantity of oil was increased, by further digging; before digging was started, the well only yielded 40 viss a day. The well contains much water. Old well, broken down, yields no oil. The well yields at present nearly no oil, but much water. Old well, which had broken down and is now worked up again; yields at present no oil. Old well, broken down, yields no oil. This well yields nearly no oil, and it is hardly worked. The well contains much water. Old well, which yields at present no oil, but is going to be worked up again. Old well, broken down, yields no oil. The well contains much water; no decrease of oil has been noticed within the last three years. Last year the well yielded 190 viss a day. This well contains some water. The well yielded, at the depth at 110 attangs, only nine viss a day. The owner started further digging, which is still going on.
26	345	9 E.	243	137	+15	100	Daily	T. W.	?	
27	?	8 E.	245	140	+12	110	Daily	T. W.	50 years .	
28	?	8 E.	230	140	- 3	40	Daily	T. W.	30 years .	
29	320	9 E.	60	...	...	...	.....	G. W.	?
30	321	9 E.	220	120	+20	...	.....	T. W.	?
31	335	9 E.	196	...	...	...	.....	T. W.	?
32	336	9 E.	220	130	+ 4	20	Every 8 days	T. W.	3 years.	
33	347	9 E.	n. m.	...	...	...	.....	G. W.	?
34	?	9 E.	200	...	...	...	.....	G. W.	?
35	?	9 E.	235	160	-31	80	Daily	T. W.	?	
36	?	9 E.	227	130	+11	10	Daily	T. W.	?	
37	?	9 E.	n. m.	...	...	...	.....	?	?
38	?	9 E.	n. m.	...	...	...	.....	T. W.	?
39	351	9 E.	195	150	-54	110	Daily	T. W.	?	
40	376	10 E.	170	95	+12	40	Every 3 days	T. W.	?	
41	215	10 E.	125	140	+ 7	140	Daily	T. W.	10 years .	
42	383	10 E.	187	130	-49	20	Every 6 days	G. W.	30 years .	
43	382	10 E.	205	120	+ 5	350	Daily	T. W.	10 years .	
44	?	10 E.	207	120	+ 7	80	Daily	T. W.	60 years .	

45	368	10 E.	272	130	6	30	Once a month	T. W.	30 years	A short time ago the well yielded 60 viss a day. Three years ago the well is said to have yielded 170 viss a day.
46	369	10 E.	229	130	7	150	Daily	T. W.	?	No further information could be got about this well, which evidently yields only a small amount of oil.
47	390	10 E.	129	?	...	...	?	T. W.	?	} Old well, broken down, yields no oil.
48	?	10 E.	n. m.	...	...	...	.....	T. W.	?	
49	?	10 F.	n. m.	...	...	...	.....	T. W.	?	} Fifteen years ago this well is said to have yielded 800 viss a day.
50	304	10 E.	n. m.	...	...	...	.....	G. W.	?	
51	396	10 E.	203	120	3	200	Daily	T. W.	More than 15 years.	No further information could be got about this well, which evidently yields only a small quantity of oil.
52	392	10 E.	212	?	...	?	?	T. W.	?	} This well is said to have yielded formerly 700 viss a day.
53	395	10 E.	197	130	19	100	Daily	T. W.	?	
54	332	9 E.	228	140	5	200	Daily	T. W.	?	} This is a new well where digging has just been started; yields no oil.
55	349	9 E.	235	130	19	300	Daily	T. W.	15 years.	
56	...	9 E.	65	30	...	...	.....	T. W.	.....	} This well is hardly worked and yields evidently nearly no oil.
57	359	8 F.	171	?	...	...	.....	T. W.	.....
58	?	9 F.	241	?	...	?	?	G. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil.
59	?	9 F.	252	145	11	200	Daily	T. W.	8 years.	} This well yields no oil; it is used as a cistern.
60	326	9 F.	166	80	33	...	.....	T. W.	?	
61	332	9 F.	262	152	9	40	Daily	T. W.	?	This well contains water at the rate of 10 viss water in 40 viss oil.
62	...	8 F.	249	150	1	140	Daily	T. W.	?	No decrease of oil has been noticed within the last four years.
63	323	9 F.	235	115	44	90	Daily	T. W.	30 years.	The daily quantity of 40 viss was increased to the present rate by digging 10 attangs more; the well contains much water.
64	322	9 E.	250	150	0	120	Daily	T. W.	?	} The well contains much water.
65	319	9 E.	209	160	3	45	Every 10 days	T. W.	?	
66	?	8 E.	...	...	...	...	.....	G. W.	?	} Old well, broken down, yields no oil.
67	?	8 E.	287	157	26	80	Daily	T. W.	20 years.	
68	?	8 E.	n. m.	...	...	...	.....	T. W.	?	} This well yields nearly no oil; no further information could be got.
69	300	8 E.	n. m.	...	...	...	.....	G. W.	?	
70	301	8 F.	210	?	?	?	?	G. W.	?	} Old well, broken down, yields no oil.
71	?	8 F.	n. m.	?	?	?	?	G. W.	?	
72	?	8 F.	n. m.	...	...	...	.....	G. W.	?	} The well contains water at the rate of 25 viss water in 30 viss oil.
73	295	7 F.	245	140	12	30	Daily	T. W.	60 years.	

I.—Record of the Wells of the Oil-field of Twingoung,—continued.

Consecutive No.	Old No.	Locality.	Depth in feet.	Stated depth in ataungs, at 20 inches.	Difference be- tween 4 and 5 in feet.	Stated daily yield in viss.	How often oil is drawn up.	Proprietor of the well.	Stated age of the well.	REMARKS.
			4	5	6	7	8	9	10	11
74	?	8 E.	161	?	...	?	?	T. W.	?	No further information was to be got about this well.
75	299	8 E.	190	90	+ 10	...	.....	T. W.	1 year	This well has been recently started and has not reached the oil-bearing strata; it yields at present no oil.
76	292	8 E.	224	133	+ 3	...	.....	T. W.	3 years	This well yields at present no oil.
77	293	7 E.	100	127	...	...	.....	T. W.	15 years	The well yields at present no oil; it is an old well which had broken down and is not worked up again, the depth of 127 ataungs means the former depth.
78	?	7 E.	258	?	...	?	?	G. W.	;	This well yields evidently only a small amount of oil, as it is very rarely worked; no further data were to be got.
79	?	7 F.	n. m.	?	...	?	.....	T. W.	?	Old well, broken down, yields no oil.
80	270	7 F.	219	?	...	?	.....	T. W.	?	This well yields evidently only a small amount of oil, as it is rarely worked; no further data were to be got.
81	269	7 G.	245	150	- 5	140	Daily	T. W.	?	The well contains much water; two years ago it yielded 180 viss a day.
82	?	7 G.	224	130	+ 8	110	Daily	T. W.	?	The well yielded three years ago 150 viss a day; the well contains no water.
83	?	6 G.	195	130	- 20	...	.....	T. W.	?	Old well; broken down and is worked up again; yields no oil at present.
84	226	6 G.	263	150	+ 13	90	Daily	T. W.	?	Two years ago this well is said to have yielded 300 viss a day; the owner tries now to increase the daily quantity of oil by further digging.
85	255	6 G.	193	130	- 23	...	.....	T. W.	19 years	The well yields at present no oil, as it is broken down and is going to be worked up again; formerly it yielded 40 viss a day.
86	?	6 G.	n. m.	...	...	...	.....	T. W.	?	} Old well, broken down, yields no oil.
87	258	6 G.	n. m.	...	...	...	.....	G. W.	?	
88	257	6 G.	247	145	+ 6	150	Every 3 days	T. W.	?	

86	260	7 G.	170	?	...	?	?	?	T. W.	?	?	This well, which is scarcely worked, yields evidently only a small quantity of oil; no further information was to be got.
90	257	7 G.	235	?	...	?	?	?	T. W.	?	?	} Old well, broken down, yields no oil.
91	263	7 G.	n. m.	?	...	?	?	G. W.	?	?		
93	?	7 H.	n. m.	?	...	...	...	...	G. W.	?	?	} No further data could be got about this well, which evidently yields nearly no oil.
94	?	7 H.	n. m.	?	...	...	...	...	G. W.	?	?	
95	264	7 H.	136	?	...	...	...	...	T. W.	?	?	} Old well, broken down, yields no oil.
96	?	6 G.	n. m.	?	...	...	...	...	T. W.	?	?	
97	?	7 F.	n. m.	?	...	...	...	...	G. W.	?	?	} The well yielded formerly 30 viss a day. This well yields nearly no oil.
98	?	7 F.	233	143	10	35	60 years.	T. W.	?	60 years.		
99	247	7 F.	236	140	3	10	13 years.	G. W.	?	13 years.		} No further data were to be got about this well, which evidently yields only a small quantity of oil.
100	?	7 F.	?	130	?	2	6 months	G. W.	?	6 months		
101	244	6 E.	281	?	...	...	...	T. W.	?	15 years	16 years.	} A recently started well, which yields no oil at present. Six years ago this well is said to have yielded 260 viss a day.
102	?	6 E.	151	90	1	...	6 months	T. W.	?	15 years		
103	273	7 E.	183	150	77	150	15 years.	T. W.	?	15 years	16 years.	} This well is said to have yielded formerly when unknown 100 viss a day.
104	274	7 E.	276	160	10	12	16 years.	T. W.	?	16 years		
105	?	7 E.	n. m.	...	...	...	?	G. W.	?	?	?	} Old well, broken down, yields no oil.
106	?	7 E.	n. m.	...	...	...	?	T. W.	?	?	?	
107	?	7 E.	n. m.	...	...	...	?	T. W.	?	?	?	} Old well, broken down, yields no oil.
108	305	8 E.	215	?	...	5	6 months	T. W.	?	?	?	
109	316	8 E.	n. m.	...	...	...	?	G. W.	?	?	?	} Old well, broken down, yields no oil.
110	315	8 E.	n. m.	165	2	20	15 years.	T. W.	?	?	?	
111	318	8 E.	n. m.	...	...	...	?	T. W.	?	?	?	} Old well, broken down, yields no oil.
112	?	8 E.	n. m.	...	...	...	?	G. W.	?	?	?	
113	312	8 D.	250	140	17	20	30 years.	T. W.	?	30 years.		} Old well, broken down, yields no oil.
114	317	8 D.	240	140	7	50	30 years.	T. W.	?	30 years.		
115	222	9 C.	187	130	30	50	?	T. W.	?	?	?	} Old well, broken down, yields no oil.
116	?	9 C.	n. m.	...	...	...	?	G. W.	?	?	?	
117	?	9 C.	n. m.	...	...	...	?	G. W.	?	?	?	} Old well, broken down, yields no oil.
118	360	9 C.	205	125	3	80	15 years.	T. W.	?	15 years.		
119	?	9 C.	208	120	8	35	70 years.	T. W.	?	70 years.		} Old well, broken down, yields no oil.
120	313	8 D.	n. m.	...	...	...	?	T. W.	?	?	?	
121	314	8 D.	255	170	28	3	10 years.	T. W.	?	10 years.		} Six years ago the well yielded 100 viss a day, ten years ago 150 viss.
122	311	8 C.	n. m.	140	...	...	40 years.	T. W.	?	40 years.		
123	307	8 C.	n. m.	...	...	...	?	G. W.	?	?	?	} Old well, broken down, and is now going to be worked up again.
124	?	7 D.	298	170	15	50	70 years.	T. W.	?	70 years.		
125	310	8 C.	283	150	33	200	20 years.	T. W.	?	20 years.		

I.—Record of the Wells of the Oil-field of Twingoung—continued.

Consecutive No.	Old No.	Locality.	Depth in feet.	Stated depth in strauges, at 20 inches.	Difference between 4 and 5 in feet.	Stated daily yield in viss.	How often oil is drawn up.	Proprietor of the well.	Stated age of the well.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11
126	309	8 G.	263	160	—	100	Daily	T. W.	?	Ten years ago this well is said to have yielded 200 viss a day.
127	?	8 D.	281	167	+ 3	40	Daily	T. W.	?	Old well, broken down, yields no oil.
128	286	8 D.	n. m.	...	+ 3	...	...	T. W.	?	One year ago the well yielded 180 viss a day.
129	285	7 D.	310	170	+ 27	160	Daily	T. W.	?	Old well, broken down, yields no oil.
130	?	7 D.	n. m.	...	...	...	...	G. W.	?	} Old well, broken down, yields no oil.
131	282	7 D.	280	160	+ 14	500	Daily	T. W.	?	
132	?	7 D.	n. m.	...	...	...	...	G. W.	?	} Old well, broken down, yields no oil.
133	281	7 D.	n. m.	...	...	...	...	T. W.	?	
134	280	7 E.	276	160	+ 10	140	Daily	T. W.	?	} Yields nearly no oil.
135	279	6 E.	305	160	+ 49	120	Daily	T. W.	19 years.	
136	278	6 D.	282	170	— 1	25	Daily	G. W.	10 years.	} Last year the well yielded 80 viss a day.
137	239	6 D.	189	?	...	?	?	G. W.	6 years.	
138	?	6 D.	200	160	— 6	60	Daily	T. W.	18 years.	} This well yields at present no oil, as digging has been started three months ago.
139	238	6 D.	223	130	+ 7	9	Every 6 days	T. W.	3 months.	
140	No number.	6 D.	102	50	+ 19	...	.....	T. W.	?	} No further information could be got about this well, which evidently yields only a small amount of oil.
141	235	6 D.	186	?	...	...	.....	G. W.	?	
142	240	6 D.	n. m.	...	...	...	.....	G. W.	?	} No decrease of oil has been noticed within the last three years.
143	277	6 E.	295	?	...	...	.....	T. W.	?	
144	275	6 E.	286	160	+ 20	140	Daily	T. W.	25 years.	} This well yields no oil at present; it is an old well which had tumbled down and is to be repaired.
145	276	6 E.	101	60	1	...	.....	T. W.	?	
146	?	6 E.	286	?	...	?	?	G. W.	?	} No further information could be got about this well, which is hardly worked and yields only a small quantity of oil at all.
147	334	6 D.	208	120	+ 8	1	Once every 2 months.	G. W.	?	
148	333	6 D.	273	?	...	?	?	G. W.	?	Yields nearly no oil; no further information could be got.

49	232	6 E.	190	105	+ 15	10	Once a month	T. W.	?	} Old well, broken down, yields no oil. New well, but digging has been stopped.
150	242	6 E.	265	157	+ 4	120	Daily	T. W.	?	
151	?	n. m.	...	...	...	...	.....	G. W.	?
152	?	n. m.	...	...	...	...	.....	T. W.	?
153	227	6 E.	201	125	- 7	10	.....	G. W.	?
154	?	5 E.	n. m.	...	...	...	Once a month	T. W.	?
155	?	5 E.	195	130	...	...	.....	G. W.	?
156	226	5 E.	272	150	+ 22	28	Every 6 days	T. W.	?	
157	?	5 E.	n. m.	...	...	...	Daily	T. W.	20 years
158	230	5 E.	n. m.	?	...	...	.....	T. W.	?
159	228	5 E.	197	?	...	?	?	T. W.	?	
160	?	5 E.	n. m.	?	...	...	.....	T. W.	?
161	191	5 E.	261	130	+ 45	70	Daily	T. W.	?	
162	195	5 E.	195	130	- 21	25	Every 6 days	G. W.	30 years.	
163	?	5 E.	n. m.	...	...	...	.....	T. W.	30 years.
164	?	5 E.	n. m.	...	...	...	.....	T. W.	?
165	?	5 E.	n. m.	...	...	...	.....	T. W.	?
166	?	4 D.	n. m.	...	...	...	.....	G. W.	?
167	?	5 D.	n. m.	...	...	...	.....	T. W.	?
168	200	4 D.	183	130	- 33	80	Daily	T. W.	?	
169	?	4 D.	n. m.	...	...	...	.....	G. W.	?
170	198	4 E.	248	?	...	?	?	T. W.	?	
171	199	4 E.	250	160	- 16	150	Daily	T. W.	?	
172	?	3 E.	n. m.	...	...	...	.....	T. W.	?
173	?	2 E.	240	138	+ 10	...	.....	T. W.	?
174	90	2 E.	212	125	+ 4	10	Daily	T. W.	?	
175	?	2 E.	160	100	- 6	8	Daily	T. W.	?	
176	?	1 E.	205	?	...	?	?	G. W.	?	
177	No number.	1 E.	n. m.	...	...	...	.....	T. W.	?
178	No number.	1 E.	120	75	- 5	...	.....	T. W.	1½ months
179	53	1 E.	244	142	+ 8	166	Daily	T. W.	16 years	
180	?	1 F.	203	?	...	?	?	T. W.	?	

Old well, broken down, yields no oil.
New well, but digging has been stopped.

Old well, broken down, yields no oil.
This well, which yields no oil at present, had broken down and is now going to be worked up again from 10 attangs depth.
A newly started well, which yields no oil and where digging is still going on.
New well, but further digging has been stopped.

Old well, broken down, yields no oil.
This well is said to have yielded 100 viss a day about four years ago.
Old well, broken down, yields no oil.
This well is hardly worked and yields either a small quantity or no oil at all.

New well, but further digging has been stopped.
This well, where digging is still going on, yields at present no oil.

Digging is still going on.
No further data could be got about this well, which is hardly worked and yields evidently only a small quantity of oil.
New well, about 6 feet deep, further digging stopped.

Recently started well; yields no oil at present.

This well yielded formerly only 30 viss a day; after digging 5 attangs the amount increased to the present daily quantity.
No further information was to be got about this well, but evidently it yields only a small quantity of oil, which is not often drawn up.

I.—Record of the Wells of the Oil-field of Twingoung,—continued.

Consecutive No.	Old No.	Locality.	Depth in feet.	Stated depth in attauggs, at 20 inches.	Difference between 4 and 5 in feet.	Stated daily yield in viss.	How often oil is drawn up.	Proprietor of the well.	Stated age of the well.	REMARKS.
181	20	1 F.	231	?	...	?	?	T. W.	10	11
182	?	1 F.	120	?	...	?	?	T. W.	?	No further information could be got about this well, but evidently it only yields a small quantity of oil.
183	?	1 F.	191	110	+ 8	80	Daily	T. W.	4 years	No further information was to be got about this well; the yielding of oil is very small. Once drawn, it yielded about 100 viss, and then the stock was exhausted and working was stopped.
184	?	2 E.	n. m.	...	...	160	.....	T. W.	?	This well yielded formerly only 15 viss a day, but by further digging the daily amount was increased.
185	?	2 E.	210	120	+ 10	...	Daily	T. W.	40 years	Old well, broken down, not worked. Six years ago this well yielded 100 viss a day, at the depth of 100 attauggs, as it is stated; after digging further 4 attauggs the daily amount increased to its present rate.
186	?	2 E.	...	...	...	...	.....	T. W.	?	A new well of about 15 feet depth, where further digging has been stopped.
187	?	2 E.	157	...	...	...	.....	T. W.	?	Old well, which does not yield any oil.
188	91	2 E.	185	110	+ 2	230	Daily	T. W.	25 years	At the depth of about 105 attauggs the well yielded 100 viss a day; by digging 4 to 5 attauggs more the daily amount increased to its present rate.
189	?	2 E.	n. m.	...	...	...	.....	G. W.	?	} Old well, broken down, yields no oil.
190	56	2 E.	n. m.	...	...	...	.....	T. W.	?	
191	57	2 E.	221	130	+ 5	70	Daily	T. W.	15 years	The well yielded formerly 150 viss a day; to increase the present daily amount the owner started fresh digging.
192	58	2 E.	n. m.	?	...	...	.....	G. W.	?	Old well, broken down, yields no oil.
193	51	2 E.	n. m.	?	...	...	.....	T. W.	?	This well evidently yields no oil.
194	23	2 E.	n. m.	...	...	...	.....	G. W.	?	Old well, broken down, yields no oil.
195	50	2 E.	200	110	+ 17	50	Daily	T. W.	?	The well contains much water; eight years ago it is stated that it yielded 300 viss a day; further digging is still going on.
196	59	2 E.	185	110	+ 2	5	Once a month	T. W.	20 years	

197	?	2 E.	n. m.	...	...	...	...	...	G. W.	?	Old well, broken down, yields no oil.
198	?	2 E.	n. m.	151	+ 12	...	20	..... Daily	G. W.	?	The well had broken down and was worked up again from the depth of 130 attangs.
199	83	2 E.	204	?	...	?	?	?	T. W.	15 years	A rarely worked well, which evidently yields only a small quantity of oil; no further information was to be got.
200	?	2 E.	212	?	...	?	?	?	T. W.	?	Old well, broken down, yields no oil.
201	85	2 E.	n. m.	??	...	?	?	.....	G. W.	?	No further information was to be got; the well is evidently scarcely worked.
202	?	2 F.	227	?	...	?	?	.....	T. W.	?	As this well hardly yields any oil it is used as a kind of reservoir to keep oil from other wells.
203	60	2 F.	190	120	- 10	?	?	.....	T. W.	?	The data about this well are uncertain, but evidently the production of oil is not large.
204	?	2 F.	180	104	+ 7	?	40	Every 3 days.	T. W.	25 years.	No further information could be got, but the well yields evidently only a small quantity of oil.
205	61	2 F.	231	134	- 9	?	20	Daily	T. W.	20 years.	Old well, broken down, yields no oil.
206	?	2 F.	210	?	...	?	15	Every 4 days two following days.	T. W.	?	
207	?	2 F.	188	?	...	?	?	?	G. W.	?	
208	?	1 E.	138	?	...	?	?	?	G. W.	?	
209	?	1 F.	n. m.	...	...	?	...	?	G. W.	?	
210	?	2 F.	210	120	+ 10	?	90	Every 3 days	T. W.	10 years.	
211	...	2 F.	190	120	- 10	?	50	Every 2 days	T. W.	25 years.	
212	16	1 F.	239	140	+ 6	?	20	Daily	T. W.	?	
213	17	1 F.	160	90	+ 10	?	15	Every 10 days, 2 following days.	T. W.	?	The well contains much water; it yielded formerly 100 viss a day; to increase the present amount further digging is still going on.
214	14	1 F.	182	108	+ 2	?	40	Every 3 days.	T. W.	33 years	
215	?	1 F.	n. m.	...	...	?	...	.....	T. W.	?	The well contains much water; formerly it yielded 70 viss a day, but within the last five years no decrease of oil has been noticed.
216	?	1 F.	170	110	- 7	?	40	Every 3 days	T. W.	?	Old well, broken down, yields no oil.
217	5	1 F.	244	140	+ 11	?	30	Every 2 days	T. W.	?	The well contains much water.
218	?	1 G.	n. m.	...	...	?	...	.....	G. W.	?	The well yielded one year ago, at the depth of 130 attangs, 40 viss a day, but instead of increasing, the daily quantity decreased after further digging.
219	?	1 G.	n. m.	...	...	?	...	.....	G. W.	?	Old well, broken down, yields no oil.
220	?	1 F.	n. m.	...	...	?	...	.....	G. W.	?	No further information was to be got about this well, but evidently it yields only a small quantity of oil.
221	?	1 F.	n. m.	...	...	?	...	.....	G. W.	?	One year ago this well yielded 100 viss a day.
222	?	1 F.	n. m.	...	...	?	...	.....	T. W.	?	Old well, broken down, yields no oil.
223	7	1 G.	173	?	...	?	?	.....	T. W.	?	No further information was to be got about this well, but it evidently yields only a small quantity of oil.
224	12	1 H.	165	95	+ 7	?	20	Every 5 days	T. W.	?	
225	?	1 H.	n. m.	...	...	?	...	.....	T. W.	?	
226	?	1 I.	145	?	...	?	?	.....	G. W.	?	
227	10	1 I.	n. m.	?	...	?	?	.....	G. W.	?	

I.—Record of the Wells of the Oil-field of Twingoung—continued.

Consecutive No.	Old No.	Locality.	Depth in feet.	Stated depth in inches, at 20 fathoms.	Difference between 4 and 5 in feet.	Stated daily yield in vis.	How often oil is drawn up.	Proprietor of the well.	Stated age of the well.	REMARKS.
228	?	1 I.	227	130	+ 11	20	Daily	T. W.	10	Digging is still going on. Old well, broken down, yields no oil. No further information was to be got about these wells, but they evidently yield only a small quantity of oil.
229	?	2 I.	n. m.	...	...	?	.....	T. W.	?
230	34	2 I.	162	?	...	?	?	T. W.	?	
231	35	1 I.	150	?	...	?	?	T. W.	?	
232	39	2 I.	100	?	...	?	?	T. W.	?	
233	?	2 I.	140	?	...	20	Every 5 days	T. W.	?	This well, which is rarely worked, yields evidently only a small quantity of oil. Digging still going on.
234	36	2 I.	n. m.	?	...	?	.....	T. W.	?
235	37	2 I.	133	T. W.	?	Old well, broken down, yields no oil.
236	?	2 I.	n. m.	...	...	...	.....	T. W.	?
237	71	2 I.	147	75	+ 22	40	Every 3 days	T. W.	20 years.	This well yielded formerly (when unknown) 30 vis a day. No further information could be got about this well, but it evidently yields only a small quantity of oil. Digging is still going on.
238	40	2 I.	166	100	— 0	35	Once a month	T. W.	8 years.	
239	?	2 H.	247	145	+ 5	30	Every 4 days	T. W.	25 years.	
240	41	2 H.	161	90	+ 11	8	Once a month	G. W.	6 years.	
241	70	2 H.	149	?	...	?	?	T. W.	?	No further information could be got about this well, but it evidently yields only a small quantity of oil. Digging is still going on.
242	43	2 H.	146	90	— 4	1	Daily	T. W.	?	
243	17	2 H.	145	?	...	?	?	T. W.	?	No further information could be got about this well, which is evidently hardly worked and yields only a small quantity of oil. At the depth of 137 attains this well yielded 2.20 vis; after digging 3 attains the present daily amount was got. Further digging is still going on.
244	30	2 H.	242	140	+ 9	300	Daily	T. W.	4 years.	
245	42	2 H.	246	145	+ 4	30	Daily	T. W.	3 years.	
246	76	2 H.	145	?	...	?	?	T. W.	?	No further information could be got about this well, but it evidently yields only a small quantity of oil. This well contains much water.
247	75	2 H.	165	80	+ 32	30	Every 3 days	T. W.	?	
248	104	2 H.	145	120	— 55	20	Once a month	T. W.	?	
249	74	2 I.	100	80	— 33	2	Once a month	T. W.	50 years.	

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350	?	2 H.	n. m.	?	G. W.	?	Old well, broken down, yields no oil.
351	77	2 H.	n. m.	?	T. W.	?	New well, of about 5 feet depth, but further digging stopped.
352	?	2 H.	n. m.	...	...	...	...	?	T. W.	?	Old well, broken down, yields no oil.
353	29	2 H.	n. m.	140	...	...	450	3 years.	T. W.	?	Four years ago this well is said to have yielded 1,000 viss a day.
354	?	2 H.	172	?	...	...	?	?	T. W.	?	No further information could be got about this well, but it evidently yields only a small quantity of oil.
355	?	2 H.	n. m.	...	...	...	...	?	T. W.	?	New well, further digging stopped.
356	103	2 H.	145	?	...	...	?	?	T. W.	?	Old well, which evidently yields not much oil.
357	108	2 H.	197	?	...	...	?	?	T. W.	?	No further information could be got about this well, but it evidently yields only a small quantity of oil.
358	?	2 H.	n. m.	?	...	...	?	?	T. W.	?	New well, but further digging stopped.
359	78	2 H.	151	?	...	...	?	?	T. W.	?	No further information could be got about this well, but it evidently yields only a small quantity of oil.
360	...	2 H.	230	?	...	...	?	?	T. W.	?	(No further information could be got about this well, which evidently yields only a small quantity of oil.)
361	65	2 H.	n. m.	?	...	...	?	?	T. W.	?	Further digging is still going on.
362	45	2 H.	210	119	...	...	1	5 years	T. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil.
363	?	2 G.	206	?	...	...	?	?	T. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil.
364	63	2 G.	201	120	...	...	20	8 years	T. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil.
365	?	2 G.	228	?	...	...	?	?	T. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil.
366	51	2 G.	130	70	...	...	13	?	T. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil.
367	?	2 G.	n. m.	...	...	...	...	?	T. W.	?	Old well, broken down, and is being worked up again, yields at present no oil.
368	?	2 G.	162	?	...	...	?	?	T. W.	?	Old well, broken down, yields no oil.
369	79	2 G.	n. m.	...	...	...	?	?	T. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil.
370	100	2 G.	n. m.	?	...	...	?	?	T. W.	?	New well, but further digging stopped; no oil.
371	101	2 G.	188	?	...	...	?	?	T. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil.
372	?	2 G.	n. m.	...	...	...	...	?	G. W.	?	Old well, broken down, yields no oil.
373	98	2 G.	n. m.	...	...	...	...	?	G. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil.
374	?	2 G.	n. m.	?	...	...	?	?	G. W.	?	Old well, broken down, yields no oil.
375	112	2 G.	159	?	...	...	?	?	T. W.	?	Digging is still going on.
376	113	2 G.	200	110	...	...	17	?	T. W.	?	A new well, of about 10 feet depth; further digging stopped.
377	?	2 G.	n. m.	...	...	...	...	?	T. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil.
378	95	2 F.	195	120	...	...	5	?	T. W.	?	This well, which yields no oil, is used as a kind of reservoir for oil got from other wells.
379	?	3 F.	n. m.	...	...	...	...	?	T. W.	?	Digging is still going on.

I.—Record of the Wells of the Oil-field of Twingoung—continued.

Consecutive No.	Old No.	Locality.	Depth in feet.	Stated depth in fathoms, at 2 inches.	Difference between 4 and 5	Stated daily yield in vials.	How often oil is drawn up.	Proprietor of the well.	Stated age of the well.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11
280	94	2 F.	n. m.	?	..	?	?	T. W.	?	No further information could be got about this well, which yields either no oil or only a small quantity. Old well, broken down, yields no oil.
281	?	2 F.	n. m.	150	.. 15	.. 150	..... Daily	G. W.	?	} Old well, broken down, yields no oil.
282	116	2 E.	235	?	..	..	..... Daily	T. W.	?	
283	?	2 F.	n. m.	?	..	..	.....	G. W.	3 years.	} Old well, broken down, yields no oil.
284	?	2 F.	n. m.	?	..	..	.....	T. W.	?	
285	?	3 F.	n. m.	?	..	..	.....	T. W.	?	} No further information could be got about this well, which yields either no oil or only a small quantity. This well yielded at the depth of 125 fathoms only 90 vials a day; after digging 5 fathoms more the present quantity was got.
286	120	3 F.	172	?	..	..	.....	T. W.	More than 15 years.	
287	121	3 G.	229	130	+ 13	140	Daily	T. W.	?	} Old well, broken down, yields no oil.
288	?	3 F.	n. m.	?	..	..	.....	G. W.	?	
289	164	3 F.	221	133	+ 0	.. 12	Twice a month	T. W.	?	} Old well, broken down, yields no oil.
290	123	3 G.	n. m.	?	..	..	.....	T. W.	?	
291	?	3 G.	n. m.	?	..	.. 20	Every 7 days	G. W.	?	} No further information could be got about this well, which yields either no oil or only a small quantity.
292	125	3 G.	193	?	..	?	.....	T. W.	?	
293	111	3 G.	180	?	..	?	.....	T. W.	?	
294	126	3 G.	172	100	+ 6	10	Every 10 days	G. W.	15 years.	} Four years ago this well is said to have yielded 1,000 vials a day.
295	?	3 G.	251	143	+ 13	270	Daily	T. W.	5 years.	
296	?	3 H.	n. m.	?	..	..	.....	T. W.	?	} Old well, broken down, yields no oil.
297	?	3 H.	n. m.	?	..	..	.....	T. W.	?	
298	129	3 G.	136	82	+ 0	..	.....	T. W.	?	} New well where digging has been started only a few months ago; the well yields at present no oil.
299	?	3 H.	n. m.	?	..	..	.....	G. W.	?	
300	109	3 H.	200	135	- 25	50	Every 3 days	G. W.	18 years.	} Old well, broken down, yields no oil.
301	?	3 H.	n. m.	?	..	..	.....	T. W.	?	
302	133	3 H.	213	?	..	..	.....	T. W.	?	} No further information could be got about these wells, which evidently yield nearly no oil.
303	?	3 H.	n. m.	?	..	..	.....	G. W.	?	
304	?	3 H.	203	?	..	..	.....	T. W.	?	

305	105	3 H.	100	120	- 10	100	Daily	T. W.	20 years?	Old well, broken down, yields no oil. Within the last five years no decrease of oil has been noticed.
306	?	3 H.	150	150	- 20	50	Every 3 days	G. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil. Old well, broken down, yields no oil. Formerly this well yielded 600 viss a day.
307	?	3 H.	230	150	- 20	50	?	T. W.	?	
308	136	3 I.	240	130	+ 24	100	Daily	T. W.	6 years.	} Old well, broken down, yields no oil. The well contains much water; the last year it yielded 160 viss a day.
309	142	3 H.	232	?	...	?	?	T. W.	?	
310	?	3 I.	n. m.	...	...	...	...	G. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil. No further information could be got about this well, which evidently yields only a small quantity of oil.
311	143	3 H.	220	140	- 13	160	Daily	T. W.	?	
312	?	3 I.	n. m.	...	...	...	...	T. W.	?	} New well of small depth; further digging stopped. This well is said to have yielded formerly when unknown 400 viss a day.
313	?	3 H.	n. m.	...	...	...	...	G. W.	?	
314	145	3 H.	196	130	- 20	120	Daily	T. W.	?	This is an old well, which had broken down and was worked up again since three years; digging is still going on. This well yielded one year ago only 50 viss; after digging 1 attaug the present daily amount was got. No further information could be got about this well, which evidently yields only a small quantity of oil.
315	147	4 H.	190	120	- 10	20	Every 3 days	T. W.	?	
316	?	4 G.	198	?	...	?	?	T. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil; digging is still going on. No further information could be got about this well, which evidently yields only a small quantity of oil.
317	159	4 G.	224	?	...	?	?	T. W.	?	
318	151	4 G.	251	140	+ 18	3	Once a month	T. W.	80 years.	New well of small depth; further digging stopped. This well is said to have yielded formerly when unknown 400 viss a day.
319	?	4 G.	n. m.	...	...	...	...	T. W.	?	
320	155	3 G.	250	150	+ 0	20	Every 10 days following 5 days.	T. W.	?	This is an old well, which had broken down and was worked up again since three years; digging is still going on. This well yielded one year ago only 50 viss; after digging 1 attaug the present daily amount was got. No further information could be got about this well, which evidently yields only a small quantity of oil.
321	...	4 G.	253	151	+ 1	6	Daily	T. W.	?	
322	152	4 G.	245	140	+ 12	100	Daily	T. W.	50 years	No further information could be got about this well, which evidently yields only a small quantity of oil. No further information could be got about this well, which evidently yields only a small quantity of oil.
323	150	4 G.	221	?	...	?	?	T. W.	?	
324	153	4 G.	215	?	...	?	?	T. W.	?	No further information could be got about this well, which evidently yields only a small quantity of oil; digging still going on at present. New well; further digging is stopped.
325	157	4 G.	50	...	...	...	...	T. W.	;	
326	?	4 F.	n. m.	...	...	...	...	T. W.	;	} Old well, broken down, yields no oil. Old well, which had broken down and is worked up again since three years; further digging is still going on. New well of small depth; further digging is stopped.
327	?	3 F.	n. m.	...	...	...	...	T. W.	?	
328	160	4 F.	225	130	+ 9	16	Daily	T. W.	40 years	New well of small depth; further digging is stopped.
329	?	4 F.	n. m.	...	...	...	...	T. W.	?	
330	167	4 F.	242	150	- 8	100	Daily	T. W.	...	New well of small depth; further digging is stopped.
331	166	4 F.	250	150	+ 0	8	Once a month	G. W.	...	

I.—Record of the Wells of the Oil-field of Twingoung—continued.

Consecutive No.	Old No.	Locality.	Depth in feet.	Stated depth in attauangs, at 20 inches.	Difference be- tween 4 and 5 in feet.	Stated daily yield in viss.	How often oil is drawn up.	Proprietor of the well.	Stated age of the well.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11
332	168	4 F.	243	150	- 7	220	Daily	T. W.	7 years.	} No further information could be got about this well, which evidently yields nearly no oil.
333	188	4 F.	302	170	+ 19	85	Daily	T. W.	40 years.	
334	187	4 G.	262	?	...	?	?	T. W.	?	
335	?	4 G.	247	?	...	?	?	T. W.	?	
336	170	4 G.	243	150	- 7	30	Every 3 days	T. W.	?	} Old well, broken down, yields no oil.
337	?	4 G.	n. m.	...	...	...	...	G. W.	?	
338	171	4 G.	230	150	- 20	200	Daily	T. W.	?	} No further information could be got about this well, which evidently yields only a small quantity of oil; digging still going on.
339	172	4 G.	215	?	...	?	?	T. W.	?	
340	?	4 H.	n. m.	...	...	...	...	T. W.	?	} Old well, broken down, yields no oil.
341	?	4 H.	n. m.	...	...	...	...	G. W.	?	
342	?	4 H.	n. m.	...	...	...	...	G. W.	?	} New well of small depth, about 10 feet; further digging stopped.
343	?	4 G.	n. m.	...	...	...	...	T. W.	?	
344	184	4 H.	250	?	...	?	?	T. W.	?	} No further information could be got about this well, which evidently yields only a small quantity of oil.
345	175	4 G.	258	?	...	?	?	T. W.	?	
346	183	4 H.	225	140	- 8	50	Daily	T. W.	?	} Within the last five years no decrease of oil has been noticed.
347	185	4 G.	245	?	...	?	?	T. W.	?	
348	?	5 G.	n. m.	...	...	...	...	T. W.	?	} No further information could be got about this well, which evidently yields only a small quantity of oil.
349	?	5 H.	233	140	- 0	30	Every 3 days	T. W.	More than 27 years.	
350	170	4 H.	223	140	- 10	90	Daily	T. W.	25 years.	} This well yields at present no oil; had broken down and is to be repaired.
351	179	5 H.	129	?	...	...	...	T. W.	?	
352	?	5 H.	n. m.	...	...	...	...	T. W.	?	} Old well, broken down, yields no oil.
353	?	4 H.	n. m.	...	...	...	...	G. W.	?	

354	145	4 H.	n. m.	?	..	?	?	T. W.	?	No further information could be got; the well evidently yields only a small quantity of oil.
355	?	4 H.	n. m.	?	..	?	?	G. W.	?	
356	?	3 I.	n. m.	?	..	?	?	G. W.	?	
357	?	3 J.	n. m.	?	..	?	?	G. W.	?	
358	?	5 H.	n. m.	?	..	?	?	G. W.	?	
359	?	10 E.	n. m.	?	..	?	?	T. W.	?	
360	?	7 E.	n. m.	?	..	?	?	T. W.	?	
361	69	2 H.	n. m.	?	..	?	?	T. W.	?	
362	?	6 B.	n. m.	?	..	?	?	G. W.	?	
363	?	6 B.	n. m.	?	..	?	?	G. W.	?	
364	?	5 B.	n. m.	?	..	?	?	G. W.	?	
365	?	5 A.	n. m.	?	..	?	?	G. W.	?	
366	?	5 A.	n. m.	?	..	?	?	G. W.	?	
367	?	4 A.	n. m.	?	..	?	?	G. W.	?	
368	?	4 A.	n. m.	?	..	?	?	G. W.	?	
369	?	5 B.	n. m.	?	..	?	?	T. W.	?	
370	?	5 B.	n. m.	?	..	?	?	G. W.	?	
371	?	5 B.	n. m.	?	..	?	?	G. W.	?	
372	?	5 B.	n. m.	?	..	?	?	G. W.	?	
373	?	5 B.	n. m.	?	..	?	?	G. W.	?	
374	?	5 B.	n. m.	?	..	?	?	G. W.	?	
375	?	6 C.	n. m.	?	..	?	?	T.	?	Old well, broken down, yields no oil.

BEME.

Key to find from a given old Burmese number the consecutive number given by me to the wells of Beme.

Remarks.—Burmese numbers in Roman: 390.

Consecutive numbers in Italics: 7.

Burmese No.	Consecutive No.	Burmese No.	Consecutive No.	Burmese No.	Consecutive No.
390	7	440	...	490	49
391	...	441	76	491	50
392	...	442	...	492	51
393	...	443	39	493	53
394	...	444	40	494	54
395	...	445	...	495	55
396	...	446	88	496	52
397	68	447	86	497	56
398	...	448	87	498	57
399	4	449	100	499	...
400	3	450	102	500	58
401	...	451	103	501	59
402	2	452	106	502	67
403	6	453	...	503	66
404	...	454	...	504	65
405	17	455	167	505	63
406	16	456	113	506	64
407	18	457	112	507	60
408	10	458	111	508	61
409	21	459	...	509	62
410	20	460	...	510	126
411	...	461	114	511	127
412	27	462	...	512	125
413	...	463	...	513	128
414	28	464	...	514	122
415	23	465	...	515	123
416	...	466	132	516	129
417	...	467	...	517	124
418	24	468	...	518	121
419	...	469	...	519	120
420	26	470	...	520	130
421	0	471	89	521	117
422	13	472	75	522	116
423	10	473	...	523	118
424	11	474	93	524	115
425	12	475	94	525	119
426	14	476	92	526	131
427	...	477	95	527	140
428	30	478	96	528	...
429	90	479	44	529	...
430	31	480	...	530	141
431	32	481	...	531	...
432	33	482	...	532	...
433	34	483	77	533	...
434	35	484	78	534	144
435	41	485	70	535	145
436	35	486	80	536	146
437	37	487	46	537	147
438	38	488	47	538	148
439	...	489	48	539	149

11.—Record of the Wells of the Oil-field of Beme.

Consecutive No.	Oil No.	Locality.	Depth in feet.	Stated depth in attains, at 20 inches.	Difference between 4 and 5 in feet.	Stated daily yield in viss.	How often oil is drawn up.	Proprietor of the well.	Stated age of the well.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11
1	?	19 C.	n. m.	n. m.	G. W.	Unknown	} Old well, broken down. Seven years ago, this well is said to have yielded about 170 viss a day. The native statements regarding the depth are obviously utterly wrong.
2	402	19 C.	n. m. 110	n. m. 156	+ 150	70	Daily	G. W. T. W.	Unknown 30 years	
3	400	19 D.	n. m.	n. m.	...	...	.....	T. W.	Unknown
4	399	19 D.	n. m. 128	n. m. 150	+ 122	70	Daily	T. W. T. W. G. W.	Unknown 30 years	} Old well, broken down, not worked. Two years ago this well is said to have yielded 150 viss a day. The native statements regarding the depth are obviously wrong.
5	403	19 C.	n. m.	n. m.	...	...	.....	T. W.	Unknown
6	?	19 C.	n. m.	n. m.	T. W.	Unknown	} The oil is mixed with much water. The native statements regarding the depth are obviously wrong. Old well, broken down, not worked.
7	390	19 C.	n. m. 155	n. m. 150	+ 74	105	Daily	T. W.	Unknown	
8	?	19 C.	n. m.	n. m.	G. W.	Unknown	} Twenty years ago this well is said to have yielded 100 viss a day (?). The native statements regarding the depth are obviously wrong. This well yields nearly no oil; oil is drawn up once a month. The amount then got is about 30 viss, as the oil is mixed with much water.
9	421	20 D.	n. m.	n. m.	+ 95	75	Daily	T. W.	Unknown	
10	423	21 D.	60	40	+ 6	...	Once a month	T. W.	Unknown	
11	424	21 E.	n. m.	n. m.	T. W.	Unknown	} Old well, broken down, not worked. This well yields nearly no oil; oil is drawn up once a month; the amount then got is about 10 viss. The well contains much water. The native statements regarding the depth are obviously wrong.
12	425	21 E.	n. m. 60	n. m. 40	+ 6	1	Once a month	T. W. T. W. G. W.	Unknown Unknown	
13	422	21 D.	n. m.	n. m.	...	...	.....	G. W.	Unknown
14	426	21 D.	110	100	+ 83	10	Daily	T. W.	Unknown	} Old well, broken down, not worked. This well yields at present nearly no oil. The amount got once a month is about 10 viss, as the well contains much water. Formerly, 9 years ago, this well is said to have yielded 100 viss a day.
15	?	21 E.	n. m.	n. m.	...	...	.....	T. W.	Unknown
16	406	19 C.	n. m.	n. m.	...	...	.....	G. W.	Unknown
17	405	19 C.	105	80	+ 28	...	Once a month	G. W.	40 years	

11.—Record of the Wells of the Oil-field of Beme—continued.

Consecutive No.	Old No.	Locality.	Depth in feet.	Stated depth in inches, attained, at 20	Difference between 4 and 5 in feet.	Stated daily yield in vis.	How often oil is drawn up.	Proprietor of the well.	Stated age of the well.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11
18	407	19 C.	215	130	+ 1	60	Daily	G. W.	40 years	Twenty years ago this well is said to have yielded 200 vis a day.
19	408	19 C.	n. m.	n. m.	"	"	"	T. W.	?	This is a well, about 5 feet deep, where further digging has been stopped.
20	410	19 C.	245	150	+ 5	100	Daily	T. W.	60 years.	This well is said to have yielded formerly (when unknown) 300 vis a day.
21	409	19 C.	245	144	- 4	110	Daily	T. W.	100 years	Old well, broken down, not worked.
22	?	20 D.	n. m.	n. m.	"	"	"	G. W.	Unknown	This well is said to have yielded formerly (when unknown) 400 vis a day, vide—No. 3.
23	415	20 D.	205	156	+ 55	90	Daily	T. W.	60 years	This well is said to have yielded formerly, 30 years ago, 300 vis a day, vide—No. 3.
24	418	20 D.	210	150	+ 40	70	Daily	T. W.	60 years	The well, which contains much water, yields nearly no oil, as the amount got at present is not more than 30 vis a month; nine years ago it is said to have yielded 80 vis a day.
25	?	20 D.	120	80	+ 13	1	Once a month	T. W.	Unknown	The well contains much water.
26	420	20 D.	132	80	+ 1	40	Daily	T. W.	Unknown	The well contains little water.
27	412	20 D.	225	130	- 0	60	Daily	T. W.	50 years	This well is said to have yielded formerly, about 40 years ago, 300 vis a day.
28	414	20 D.	235	150	+ 15	80	Daily	G. W.	60 years	Old well, broken down, no oil.
29	425?	21 E.	n. m.	n. m.	"	"	"	T. W.	Unknown	The well contains much water.
30	428	21 D.	95	60	+ 5	40	Daily	T. W.	100 years	The well contains much water; it is said to have yielded formerly, nine years ago, 110 vis a day.
31	430	21 D.	120	80	+ 13	90	Daily	T. W.	Unknown	Old well, broken down, yields no oil.
32	431	21 D.	n. m.	n. m.	"	"	"	T. W.	Unknown	The well contains much water.
33	432	21 D.	70	50	+ 13	10	Three times a month.	T. W.	100 years	Old well, broken down, yields no oil.
34	433	21 D.	n. m.	n. m.	"	"	"	T. W.	Unknown	} Old well, broken down, yields no oil.
35	?	21 D.	n. m.	n. m.	"	"	"	G. W.	Unknown	
36	?	21 C.	n. m.	n. m.	"	"	"	T. W.	Unknown	
37	437	21 C.	230	153	+ 25	165	Daily	T. W.	100 years	

38	438	21 C.	145	90	+	5	T. W.	This is a new well where digging has been started a short time ago.
39	434	21 C.	262	150	-	12	110	Daily	T. W.	100 years.	The well yields at present nearly no oil; the owner tries to get more by further digging. The well is said to have yielded formerly, when unknown, 100 viss a day.
40	444	21 C.	350	150	-	0	50	Daily	T. W.	80 years.	
41	435	21 C.	270	150	-	20	3	Once a month	T. W.	80 years.	
42	?	21 D.	n. m.	n. m.	T. W.	?	} Old well, broken down, yields no oil.
43	?	21 D.	n. m.	n. m.	...	...	...	.....	T. W.	?
44	479	21 C.	208	120	-	8	40	Daily	T. W.	80 years.	The well contains much water; ten years ago it is said to have yielded 200 viss a day.— <i>vide</i> No. 3.
45	?	21 C.	190	150	+	60	60	Daily	T. W.	100 years.	
46	487	21 C.	227	157	+	35	90	Daily	T. W.	100 years.	The native statements regarding the depth are evidently exaggerated.
47	488	21 B.	230	140	+	3	60	Daily	T. W.	100 years.	} Old well, which was broken down and is now to be repaired again; no oil at present.
48	489	21 B.	207	130	+	9	70	Daily	T. W.	100 years.	
49	490	21 B.	236	145	+	5	90	Daily	T. W.	100 years.	
50	491	21 B.	117	65	-	9	T. W.	?	} The owner tries to get more oil by further digging and increasing the depth of the well.
51	492	21 B.	235	150	+	15	105	Daily	T. W.	100 years.	
52	495	21 B.	203	120	-	3	80	Daily	T. W.	100 years.	} The native statements regarding the depth are evidently highly exaggerated.
53	493	21 B.	210	130	+	6	40	Daily	T. W.	100 years.	
54	494	21 B.	195	157	+	66	10	Once a month	T. W.	100 years.	This well has just begun to be dug; yields no oil.
55	495	21 B.	n. m.	80	T. W.	} Old well, broken down, yields no oil.
56	497	21 B.	205	110	-	22	20	Daily	T. W.	100 years.	
57	498	21 B.	205	100	-	40	10	Once a month	T. W.	30 years.	New well, about 5 feet deep; further digging stopped.
58	500	21 B.	172	100	+	6	10	Once a month	T. W.	30 years.	
59	501	21 A.	250	130	-	34	30	Daily	T. W.	80 years.	The owner tries to increase the amount of oil by further digging.
60	507	21 A.	n. m.	n. m.	...	...	...	.....	T. W.	?
61	508	21 A.	n. m.	n. m.	T. W.	?	} The native statements regarding the depth are evidently highly exaggerated.
62	509	21 A.	240	130	-	24	80	Daily	T. W.	100 years.	
63	505	21 A.	105	120	+	95	40	Daily	T. W.	100 years.	New well, about 5 to 6 feet deep; further digging has been stopped.
64	506	21 A.	n. m.	n. m.	...	...	...	.....	T. W.	?
65	504	21 A.	252	145	-	11	105	Daily	T. W.	100 years.	} Old wells, broken down, yield no oil.
66	?	21 A.	207	110	-	24	70	Daily	T. W.	100 years.	
67	502	21 B.	630	130	-	14	70	Daily	T. W.	100 years.	} Old wells, broken down, yield no oil.
68	397	20 E.	n. m.	n. m.	...	...	...	.....	G. W.	?
69	?	19 C.	n. m.	n. m.	...	...	...	.....	G. W.	?
70	?	20 D.	n. m.	n. m.	...	...	...	.....	G. W.	?
71	?	20 D.	n. m.	n. m.	...	...	...	.....	G. W.	?

II.—Record of the Wells of the Oil-field of Beme—continued.

Consecutive No.	Old No.	Locality.	Depth in feet.	Stated depth in fathoms, at 20 inches.	Difference between 4 and 5 in feet.	Stated daily yield in vis.	How often oil is drawn up.	Proprietor of the well.	Stated age of the well.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11
72	?	20 C.	n. m.	n. m.	...	...	.....	G. W.	?	} Old wells, broken down, yield no oil. The native statements regarding the depth are obviously wrong.
73	?	20 C.	n. m.	n. m.	...	...	Daily	G. W.	?	
74	495	20 C.	190	156	+ 70	160	.....	T. W.	100 years.	} Old well, broken down, yields no oil. This well yields nearly no oil,—vide No. 74.
75	472	20 C.	100	100	+ 66	10	Once a month	G. W.	?	
76	441	20 B.	n. m.	n. m.	...	...	.....	T. W.	?	} Old wells, broken down, yield no oil.
77	483	21 B.	n. m.	n. m.	...	...	.....	T. W.	?	
78	484	20 B.	85	70	+ 31	10	Once a month	T. W.	100 years.	} This well yields nearly no oil,—vide No. 74.
79	485	20 B.	60	80	+ 73	1	Once a month	T. W.	100 years.	
80	486	21 B.	n. m.	n. m.	...	...	.....	T. W.	?	} Old wells, broken down, yield no oil.
81	?	20 A.	n. m.	n. m.	...	...	.....	T. W.	?	
82	?	20 A.	n. m.	n. m.	...	...	.....	T. W.	?	} The well contains much water.
83	?	20 A.	n. m.	n. m.	...	...	.....	T. W.	?	
84	?	20 D.	n. m.	n. m.	...	...	.....	T. W.	?	} New well, is about 3 feet deep; further digging stopped; yields no oil.
85	?	21 D.	n. m.	n. m.	...	...	.....	T. W.	?	
86	447	21 D.	243	130	- 27	30	Daily	T. W.	100 years.	} Old well, broken down, yields no oil. This well is going to be dug, but digging has not started at present.
87	448	21 D.	155	120	- 45	30	Daily	T. W.	100 years.	
88	446	21 D.	195	110	- 12	10	Once a month	G. W.	30 years.	} Old well, broken down, yields no oil.
89	471	21 D.	270	150	- 20	115	Daily	T. W.	100 years.	
90	?	22 D.	n. m.	n. m.	...	...	.....	T. W.	.....	} Old well, broken down, yields no oil.
91	472	21 D.	185	110	+ 2	10	Once a month	G. W.	30 years.	
92	476	22 C.	n. m.	n. m.	...	...	.....	G. W.	?	} Old well, broken down, yields no oil.
93	474	22 C.	195	110	- 12	10	Once a month	G. W.	30 years.	
94	475	22 D.	n. m.	n. m.	...	...	.....	G. W.	?	} Old well, broken down, yields no oil. This well is going to be dug, but digging has not started at present.
95	477	22 C.	n. m.	n. m.	...	...	.....	G. W.	?	
96	478	22 C.	n. m.	n. m.	...	...	.....	T. W.	?	} Old well, broken down, yields no oil.
97	No number.	22 C.	...	...	...	...	.....	T. W.	?	
98	?	22 C.	n. m.	n. m.	...	...	.....	G. W.	?	} Old well, broken down, yields no oil.
99	439	21 D.	n. m.	n. m.	...	...	.....	T. W.	?	

100	449	21 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	Old well, broken down, yields no oil.
101	?	21 A.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	Old well, broken down, is going to be worked up again at present.
102	450	22 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	Old well, broken down, yields no oil.
103	451	22 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	Old well, yields no oil.
104	?	22 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	Old well; digging stopped.
105	?	22 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	The well contains much water; it is said to have yielded formerly, 20 years ago, 80 viss a day. The native statements regarding the depth are obviously wrong.
106	452	22 D.	n. m.	n. m.	n. m.	+ 78	50	Daily	T. W.	100 years.	
107	455	22 D.	n. m.	n. m.	n. m.	+ 1	40	Daily	T. W.	70 years.	This well, which is broken down and not worked since 20 years, is said to have yielded, at 147 attainings depth, 80 years ago, 2,000 viss a day.
108	?	22 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	
109	?	23 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	
110	458	23 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	
111	457	22 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	
112	457	22 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	
113	456	22 C.	n. m.	n. m.	n. m.	-113	40	Daily	T. W.	100 years.	Old wells, broken down, yielding no oil.
114	461	23 C.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	This well is said to have yielded, 20 years ago, 170 viss a day.
115	524	22 C.	n. m.	n. m.	n. m.	+ 1	70	Daily	T. W.	?	Old well, broken down, yields no oil.
116	522	22 C.	n. m.	n. m.	n. m.	+ 2	10	Once a month	T. W.	100 years.	The well contains much water.
117	521	22 B.	n. m.	n. m.	n. m.	+ 3	40	Daily	T. W.	100 years.	
118	523	23 B.	n. m.	n. m.	n. m.	+ 0	40	Daily	T. W.	100 years.	
119	525	23 C.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	Old well, broken down, yields no oil.
120	519	22 B.	n. m.	n. m.	n. m.	+ 10	50	Daily	T. W.	100 years.	
121	518	22 B.	n. m.	n. m.	n. m.	- 17	30	Daily	T. W.	100 years.	
122	514	22 B.	n. m.	n. m.	n. m.	- 2	60	Daily	T. W.	100 years.	
123	515	22 B.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	Old well, broken down, yields no oil.
124	517	22 B.	n. m.	n. m.	n. m.	+ 6	15	Once a month	T. W.	100 years.	
125	512	22 A.	n. m.	n. m.	n. m.	- 17	70	Daily	T. W.	30 years.	
126	510	22 A.	n. m.	n. m.	n. m.	+ 15	15	Once a month	T. W.	70 years.	
127	?	23 B.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	
128	513	23 B.	n. m.	n. m.	n. m.	- 2	40	Daily	T. W.	100 years.	
129	516	23 B.	n. m.	n. m.	n. m.	+ 2	60	Daily	T. W.	100 years.	
130	520	23 B.	n. m.	n. m.	n. m.	+ 11	70	Daily	T. W.	100 years.	
131	520	23 C.	n. m.	n. m.	n. m.	+ 19	15	Once a month	T. W.	70 years.	
132	466	23 C.	n. m.	n. m.	n. m.	+ 46	15	Once a month	T. W.	100 years.	
133	?	23 D.	n. m.	n. m.	n. m.	+ 31	15	Once a month	T. W.	100 years.	Old well, which yields no oil.
134	?	23 D.	n. m.	n. m.	n. m.	...	...	...	G. W.	?	Old well, broken down, yields no oil.
135	?	23 D.	n. m.	n. m.	n. m.	+ 64	15	Once a month	T. W.	100 years.	This well contains much water.
136	?	23 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	
137	?	23 D.	n. m.	n. m.	n. m.	...	...	...	T. W.	?	
138	?	23 D.	n. m.	n. m.	n. m.	...	...	...	G. W.	?	Old wells, broken down, yielding no oil.

II.—Record of the Wells of the Oil-field of Beme—concluded.

Consecutive No.	Old No.	Locality.	Depth in feet.	Stated depth in inches, at 20	Difference between 4 and 5 in feet.	Stated daily yield in viss.	How often oil is drawn up.	Proprietor of the well.	Stated age of the well.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11
139	?	22 D.	n. m.	n. m.	T. W.	?	} Old wells, broken down, yielding no oil. This well yields at present no oil, but it is said to have yielded 20 years ago 100 viss. The owner tries to get oil by increasing the depth of the well.
140	527	24 A.	n. m.	n. m.	..	..	.....	T. W.	70 years
141	530	24 B.	105	100	+ 61	..	.....	T. W.	70 years
142	531	24 B.	..	n. m.	G. W.	?	} Old wells, broken down, yielding no oil.
143	532	24 B.	n. m.	n. m.	..	..	.....	T. W.	?
144	534	23 B.	n. m.	n. m.	..	..	.....	T. W.	?
145	535	24 B.	n. m.	n. m.	..	..	.....	T. W.	?
146	536	24 B.	n. m.	n. m.	..	..	.....	T. W.	?
147	537	24 B.	n. m.	n. m.	T. W.	?	
148	538	24 B.	n. m.	n. m.	G. W.	?	
149	539	23 B.	n. m.	n. m.	T. W.	?	
150	?	24 C.	n. m.	n. m.	T. W.	?	
151	?	22 C.	n. m.	n. m.	T. W.	?	

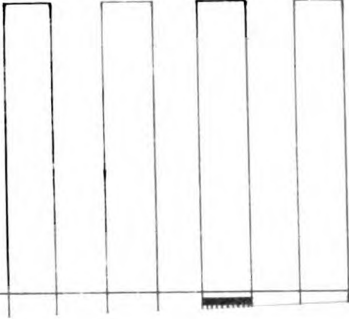
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*The gypsum of the Nehal Naddi, Kumaun : by C. S. MIDDLEMISS, B.A.,
Assistant Superintendent, Geological Survey of India. (With a
plate.)*

The gypsum of this locality is briefly referred to in the "Manual of the Geology of India" in the following words :¹ "The most promising source is near the Nihal Bridge on the [old] road between Kaladhungi and Naini Tal ; plaster of Paris of good quality has been made from it." Before my survey operations had taken me there my attention was directed to the gypsum by Col. Thomason, R.E., and I shortly afterwards visited the place in the company of Mr. W. F. Wells, C.S., Offg. Director of Land Records and Agriculture, N.-W.-P. and Oudh, who was anxious to find a source of gypsum, as there was a demand for it for fertilizing purposes. Still later I showed the beds to Lieutenant-Colonel Campbell, B.S.C., of the Forest Department. A rough cart-track has since been made between the quarries and the Kaladhungi-Haldwani road, and about 4,000 maunds collected for despatch to Tirhoot. So far very little quarrying has been done, scarcely anything but loose blocks having been picked up and gathered together in heaps. Although, therefore, no steps have been taken to ascertain the actual depth to which the beds of gypsum go, or their full thickness, the following notes and rough estimate of the probable amount available may be less of use.

Although very small quantities of gypsum are found in more than one locality in the neighbourhood of Naini Tal, the deposit we are considering at the present moment is situated south of the main boundary fault which divides the Sub-Himalayan from the Himalayan groups of formations. There are two positions on the right bank of the Nehal N., between Nehalpur and a point a mile north of Dhapla village, where the mineral is aggregated into considerable beds. Further details as to localities for quarrying will be given later. Unlike the gypsum of the Salt Range, and like that of Spiti, described by Mr. F. R. Mallet,² the deposit is not a stratified but a superficial one. It clothes the hill-side in amorphous masses associated with the re-made rock from underneath and with scree material which has descended from the array of bare precipices, forming what are known as the "landslips" south of Ayarpatha peak. The bed-rock on which it rests belongs to the Nahan stage of the sub-Himalayan group, being composed of sandstone, with partings of shale or hardened clay. The beds are nearly horizontal, having a slight dip of from 3° to 10° N.N.E. At the points where the gypsum has been formed, the side of the valley cut out in the sandstone is fairly steep, the slope being about 40°. Conforming to this slope comes a more or less irregularly bedded surface accumulation of material in which the gypsum is aggregated. This surface material is partly older than, and partly contemporaneous with, the gravel banks and terraces which line the river banks. Its composition is as follows :—In some places it is as much as 80 or 90 feet in thickness and is made up largely (especially in the parts higher up the hillside) of fragments of purple and grey shale of angular form, derived from the Nahan rocks, set in earthy material. But there are also intermixed many pieces of limestone and

¹ Manual of the Geology of India, Part III, Economic Geology, p. 454.

² Mem. Geol. Surv. of India, Vol. V, Part II, p. 153.

slate from the Himalayan series at the head of the Nehal N. This surface accumulation possesses two distinct colours, *vis.* purple and a greenish grey or black. The lower 45 feet, resting on the Nahan sandstone, are of the dark neutral tints. In this, there are no beds of gypsum, but an efflorescence gives it superficially a white appearance which at first suggests a large amount within. A similar efflorescence is visible here and there among the recent gravels of the river-terraces, both in this river and in the Ballia ravine. The upper 45 feet take on a distinctly purple colour from the larger intermixture of purple shales in a fragmentary and much disintegrated state. It is in these purplish beds that the gypsum occurs.

As shown in the accompanying diagram, the gypsum is present in lenticular bands or layers, which are not continuous, but which thin out in one place and begin again in another. At the highest point on the hill-side at which the purple surface material is found, the included layers of gypsum are very thin and closely aggregated: they are like a set of veins which pursue roughly parallel courses in a wavy irregular manner; and they give blocks of about a foot square or less. These lenticular layers of the mineral slope down the hillside at an angle of about 40° , following in a rough and uncertain way the general slope of the *débris* in which they are imbedded. As they are traced downwards the thin bands give place to thicker and more massive beds: the isolated 'fingers' unite as it were, so that near the base of the slope of *débris* the gypsum is seen at its best.

There is no selenite, or coarsely crystalline form of gypsum, as far as I have seen.

Form of gypsum.

That present is uniformly of a white, or whitey grey colour, though very occasionally it is flesh-red. A broken surface sparkles like a mass of snow, owing to the innumerable micro-crystals of which it is composed. Where the lenticular layers thicken they become denser, purer, and massive. Even then, however, they are interrupted, here and there, by shaly impurities of shining greenish colour. On the other hand, near the upper and lower surfaces of the bed and in those upper parts of the hill-side where the beds are at their thinnest, the gypsum is not so pure, but is largely mixed with shale and sometimes brecciated with it into a rock that is half gypsum and half shale. There are, therefore, roughly speaking, a better and a worse variety of the gypsum, looked at it from a commercial point of view.

As deducible from its irregular collection on the surface of the hill-sides the gypsum does not seem to have been formed over any large area, nor can it have been chemically precipitated from a

Origin of the gypsum.

surcharged lake or from any body of water which has been ponded back. The history of the Sub-Himalaya, through Recent and Tertiary times, is unanimous in testifying that the margin of the Himalaya has always been under the same conditions of rapid sub-aerial decay by streams and torrents, as are witnessed to-day; no sea nor expanse of water having washed its foot since nummulitic times. The explanation of the gypseous deposits is the same here as Mr. Mallet propounded for the Spiti gypsum. They are manifestly the result of springs of water which, even at the present day, are seen to be laying down the mineral on a small scale. Whether the ultimate source of the sulphur which enters into the composition of the gypsum be due to percolation of water through pyritous slates or whether a defunct volcanic origin is indicated, it is certain that the immediate explanation of the gypsum is in the

W.N.W

E.S.E



- RECENT r = Gravel or river-terrace
- SUB- ω = Purple surface material containing g.
- RECENT g = Lenticular beds of gypsum.
- b = Black & gray surface material.

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springs charged with sulphuretted hydrogen which issue at at least two points near Naini Tal and in the large amount of massive limestone in the vicinity.

An estimate of the amount of the mineral, based on what can be seen at the surface, is liable to a certain error from the fact that the beds are not regular strata of the nature of coal seams, but are prone to thicken and thin out, to be developed in one place and to be suddenly absent in another. The first of the gypsum localities is about $1\frac{1}{2}$ miles N. of Dhapla village. For a distance of about 70 yards from the south end of the exposure the mineral is partially laid bare up the slope of the hill by weathering and by such working as has already taken place. A side-stream to the north of this gives a section somewhat imperfect, but which, taken with other observations on the face of the quarry, indicates a set of lenticular beds swelling out below and which may be represented in the aggregate as a wedge-shaped mass of gypsum; the thicker end being the bottom of the slope and the thinner end being the top of it. Taking the thickness of the wedge at the base as 10 feet and the thickness at the top at 2 feet, we have, with a length of 70 yards and a breadth of 40 yards, about 151,000 maunds represented. As already stated, the still more recent gravels forming the terrace at the foot of the slope cover up the continuation of the gypsum beds downwards; but, as it is impossible to say whether the wedge goes on thickening downwards or becomes thinner again, I have taken an intermediate value of 6 feet as the probable thickness for a further distance of 20 yards below the gravel terrace. Another 75,500 maunds may therefore be added, giving a total of 226,500 maunds. North of the little side-stream just mentioned the gypsum is not laid bare on the slope of the hillside, but is covered up by more surface screen material for a distance of 200 yards up the river as far as the next side-stream which descends from the 4,658 feet hill. The surface material is continuous all the way with its two characteristic colours, and the outcrop of various bands of gypsum among purple débris indicate in a sense their persistence for these 200 yards. Thus, with an average breadth of 40 yards and thickness of 6 feet, we get 432,000 maunds represented. The next exposure is a little over $\frac{1}{4}$ mile beyond the last locality, between which two places bed-rock, consisting of Nahal sandstone, is free from the gypsum-bearing surface débris. This exposure is about 200 yards long, but it does not reach so far up the hillside and is not quite so thick as in the last place. In breadth it is about 20 yards, which, with an average thickness of 5 feet, gives about 180,000 maunds. There are some very small veins of gypsum still higher up the Nehal N., but none worth quarrying. The total amount of gypsum available, therefore, calculated on measurements which may be slightly below the mark but are not above it, is 838,500 maunds, or 37,430 tons.

On some of the Materials for Pottery obtainable in the neighbourhood of Jabalpur, and of Umaria; by F. R. MALLETT, Superintendent, Geological Survey of India.

For many years past ornamental bricks, and other articles, have been made, at Jabalpur, from certain white clays which occur in the immediate neighbourhood of the station. Struck with their apparently excellent quality, and impressed with the idea that they could be used for the production of a superior class of pottery, Mr. J. H. Glass, C.E., then Executive Engineer of the division, sent specimens of these clays, in 1881, to Mr. Dejoux for analysis. The results obtained confirming the opinion already formed, Mr. Glass submitted a scheme to the Government of the Central Provinces for the establishment of pottery works, on an experimental scale, in the Central Prison. This project has remained in abeyance, although not forgotten, and comparatively recently the Geological Survey has been applied to for any information available respecting the clays in question, and subsidiary materials such as felspar and flint. In consequence of this requisition, I was directed, in January last, to examine the neighbourhood of Jabalpur with reference to the points alluded to above.

At the time Mr. Glass's Memorandum was penned the existence of the white clays elsewhere than near Jabalpur does not appear to have been known, and, as a source of fuel, he looked to the coal at Lameta Ghát, about 9 miles distant, which might be supplemented by that of Mopáni. But, since then, the Umaria coal-field has been opened out, and clay, identical with that of Jabalpur, has been found within a reasonable distance from the colliery. These facts were sufficient to suggest that Umaria, with its cheap and abundant coal, might be a more advantageous site for pottery works than Jabalpur, and I accordingly made some examination of that neighbourhood also.¹ Had circumstances allowed I would have been glad to spend a longer time there, as well as in the Jabalpur district, but, although I was not able to do all I wished, I still saw enough to form a decided opinion on the most important points.

CLAYS.

The white clays of Jabalpur are already well known through the efforts of Mr. Glass to bring their excellent qualities into notice. They are interstratified with the soft white sandstones of the Upper Gondwánas (Jabalpur group), into which they frequently pass vertically by insensible gradations, so that in many sections it is difficult to say where the line should be drawn between sandy clay and argillaceous sandstone. In other sections, again, the line of demarcation between the two rocks is comparatively sharply marked, and two or more beds of clay may be noticed with some feet or yards of sandstone between. In some of the pits which have been opened, 4 or 5 feet of good clay is exposed without any intermixture with that of a lower quality. The varying

¹ With the exception of that south and south-west of Jabalpur, the entire area referred to in the following notes is included in the map attached to my paper on the Iron Ores, &c., of the north-eastern part of the district (Records, G. S. I., Vol. XVI, part 2).

character of the clay is well indicated by the analyses quoted by Mr. Glass, one sample yielding (after treatment with acid and elutriation) 87.2 per cent. of clay, with 5.1 of sand, while in another the proportions were 39.6 and 52.2.

The clays attain their greatest development, both vertically and superficially, in the vicinity of Chota Simla. At one place, on the southern flank of the hill, nearly fifty feet of clay and earthy sandstone is exposed, the lower beds extending for some hundred yards into the plain to the south-east and west of the outlying hill west of Chota Simla. The clays are also exposed in the railway cutting, and all round the hill north of the line; they may likewise be traced eastwards, along both sides of the Marjadlia Valley, as far as the edge of the trappean area. Here, however, they are much thinner, a fact which is connected with the unconformity of the overlying Lameta limestone. The preservation of the clays, near Jabalpur, is largely due to the protection from denudation they have received from the more resistant limestone above.

The clay is whitish, or sometimes pale gray. The latter variety, however, turns white on ignition, the colour being doubtless due to a trace of carbonaceous matter. A slight reddish tinge is also sometimes noticeable, due to iron. The purer clay is highly plastic and very infusible. Small bricks measuring $1\frac{3}{4}'' \times \frac{1}{2}'' \times \frac{1}{4}''$, after exposure for an hour to a dazzling white heat in an injector gas furnace, were found to have contracted $\frac{1}{4}$ th in length, to have retained their sharp edges, and to have become sufficiently hard to scratch glass, the structure being finely vesicular. Those made of grayish clay were pure white, or very nearly so, while those of clay with a slight reddish tinge were also white, although less pure in tint.

A sample of clay, taken from a pit at the base of the hill west of the railway, has been analysed by Mr. Blyth with the following result:—

	Air-dried clay.	Clay dried at 100C.
Moisture (loss at 100C.)	1'73	...
Loss on ignition	7'80	7'92
Alumina	24'05	24'41
Ferric oxide	2'88	2'92
Lime	'75	'76
Magnesia	'59	'60
Silica (combined)	27'14	27'54
Siliceous sand	35'33	35'85
	<hr/>	<hr/>
TOTAL	100'27	100'00
	<hr/>	<hr/>

The ferric oxide exists in the free state, being dissolved out completely, or nearly so, by cold strong hydrochloric acid, which does not attack the silicate of alumina. The same reagent also extracts the lime and magnesia, which, however, would appear to be combined with silica, as there is no carbonic acid present. Deducting the above, and the sand, we have, as the composition of the true clay—

Loss on ignition	13'23
Alumina	40'77
Silica ¹	46'00

¹ Some deduction should be made from the silica on account of that combined with the lime and magnesia.

which is very close to the theoretical composition $(\text{H}_2\text{O}\cdot\text{Al}_2\text{O}_3\cdot 2\text{SiO}_2 + \text{H}_2\text{O}$ or $\text{H}_2\text{O}\cdot\text{Al}_2\text{Si}_2\text{O}_8 + \text{H}_2\text{O})$ as given below :—

Water	13'92
Alumina	39'68
Silica	46'40
TOTAL	100'00

Clays of a character similar to those of Jabalpur, except that as a whole they are more ferruginous, overlie the coal of Lameta Ghát.¹

Lameta.

Some parts are as white as the clays of Chota Simla, but others are yellowish or reddish, and even contain nodules of ochreous ferric oxide. Some distance to the eastward of the quarry described on page 146, associated with the clays just mentioned, there is some highly ferruginous red clay, which might be used in combination with other clays for producing various tints in terra cotta ware.

The existence of white clays in the Upper Gondwana beds of the Umaria region was first brought to notice by Lála Hira Lál, of the Geological Survey. In 1883 he reported their occurrence in large

Near Umaria.

quantities on a hill one mile west of Amdári, a village 15 miles to the westward of Umaria, and pointed out their perfect similarity in appearance to the clay of Jabalpur.² Near the base of the hill, three quarters of a mile west-south-west from Baroudi (11 miles west of Umaria), about 40 feet of white clay and earthy sandstone is exposed. Here, as at Amdári, the clay is protected from denudation by a covering of Lameta limestone. Again, in the Mahanaddi, west of Chandia, beds of white and grayish-white clay or shale are intercalated with the Jabalpur sandstones. They are exposed on both banks of the stream for a distance of more than a mile at least, the principal seams being 4 or 5 feet thick. Such clays, indeed, are amongst the most characteristic beds of the Jabalpur group, and there can be no reasonable doubt that, if looked for, they would be found abundantly in many other places besides those mentioned. The most likely position to find them in is at the edge of (beneath) the Lameta limestone, and, for use at Umaria, search might be made where that group is exposed to the south of the station. It is to be recollected, however, that owing to the unconformity of the two groups, the limestone in many places has no clay beneath it, and that where the latter does exist it is often concealed by superficial soil washed down the slopes of the hills.

Small bricks made of the Amdári and Mahanaddi clays gave results similar to those made from the clay of Jabalpur in respect to contraction and colour. They were found to vary somewhat in their capacity for withstanding heat; some samples were quite infusible, while others softened slightly at a white heat. Although none of the Jabalpur clays that were tried yielded in this way, I apprehend that more extended experiments would show that such less refractory clays exist.

All the clays described above are of Upper Gondwana age. In 1886, however, Mr. Reynolds, then Deputy Manager of the Colliery, sent us specimens of a grayish-

¹ *Vide* page 146. The clay is often more or less laminated, so that it is difficult to draw the line between it and shale. The latter term is used in the section alluded to.

² Volume XVI, page 114.

white Barákar fire-clay,¹ which outcrops in the railway cutting, about 200 yards from the station towards the Colliery. The same stratum was passed through in sinking all the wells in the vicinity, the thickness being 3 feet, more or less. A sample of this clay, treated in the same way as the preceding, was found to be quite infusible, and to produce a whitish brick.

The 6-foot seam of coal includes a 'parting' of dark-gray shale, averaging 10 inches in thickness. This is separated from the coal by picking, and many thousand tons have accumulated on the spoilbank near the pit's mouth. It contains a good deal of pyrites, and does not look very promising as a fire-clay, but still, as it is to be had in such abundance for nothing, the point was worth examination. A sample, recently received from Mr. Maughan, Manager of the Central Provinces State Collieries, has been tried, both in its natural state and after burning off the carbonaceous matter. The results in both cases were unsatisfactory, and did not give much hope that the material could be turned to practical account.

FELSPAR.

In the area with which we are concerned, the metamorphic rocks, consisting as they do almost entirely of gneiss, are those in which all the available felspar is contained. As a constituent of the gneiss itself, as well as of the Jabalpur granite, felspar is ubiquitous, but in this form it is crystallized on too small a scale, and too intimately mixed with the other components of the rock to be of any use. The largely crystallized felspar, which is of value for pottery purposes, is found in veins of pegmatite by which the gneiss is traversed. These veins are of a highly irregular, stragulated character, running usually parallel, or nearly so, to the foliation of the gneiss, but sometimes obliquely to it. Many of them are several yards wide, but the thickness varies greatly and rapidly, and few of them can be traced for any great distance longitudinally. This, however, is of little consequence practically, as any want of continuity in the individual veins is amply compensated by their number.

The pegmatite is composed of flesh-coloured (or occasionally white) orthoclase or microcline felspar, and quartz, with very commonly a small proportion of schorl or mica, or both. In the best veins these latter minerals are nearly or quite absent, and the amount of quartz is so small that the rock is almost pure felspar, which would be easy to split up and quarry owing to the cleavage planes being several inches long. In other veins of an inferior character the proportion of quartz, &c., is greater, and the felspar crystallized on a smaller scale, while some veins, again, are worthless from excess of non-felspathic minerals.

The granite which occurs in the neighbourhood of Jabalpur, extending for some 12 miles from south-west to north-east, and which is noticeable from the manner in which it weathers into piles of huge rounded masses, does not appear to contain any veins of pegmatite.

The metamorphic area nearest to the station is that which runs in a north-easterly direction from Sundarpur towards Dhumdhuma. In two traverses of this area I

¹ In speaking of the Barakár material as fire-clay, I would not be understood as implying that the Gondwána clays are not capable of being applied to the same use. The experiments detailed above show that most of them are highly refractory.

observed no pegmatite, but in the light of what I subsequently saw further east, I regretted not having made a more detailed examination, and circumstances prevented my returning for the purpose. In the event of pottery works being established at Jabalpur, it would be well to re-examine these rocks, which could be most advantageously done from Bhaunraha, by searching the beds of the different branches of the Barnu and Didula rivers, where they flow over the metamorphic formation.

Some good pegmatite was noticed in the crystalline area south-west of Silondi, but not in any quantity. The rocks, however, are greatly obscured by alluvium, and it is very probable that there are thicker veins than any I met with.

Pegmatite is plentiful in a small stream (or rather water-course, quite dry on 21st February), which joins the Sua naddi on the right (north) side, about half a mile south-east of the deserted village of Singrampur, and 2 miles east of Silondi. From the mouth of the stream for, say, half a mile up, numerous veins are met with, varying from 1 or 2 up to 5 feet in thickness, and the bed of the water-course is strewn abundantly with loose lumps of every size up to 2 or even 3 feet in diameter. In a small tributary of this stream veins are equally common. The pegmatite is composed almost entirely of flesh-red felspar with large cleavage faces, and quartz. The latter mineral is always very subordinate, and in many of the veins the rock is practically pure felspar. The mineral is fresh and undecomposed, although the gneiss in which it occurs is soft and rotten, so that the veins could be easily worked. A large supply could be obtained from them, and from the loose fragments. I have little doubt that pegmatite is equally abundant in other places within the same crystalline area, and it is to be regretted that the position is so far from Jabalpur—over 30 miles by the direct road, which is very bad for carts in the portion between Bagaraji and Sundarpur.

Pegmatite veins are of common, and in many places of profuse, occurrence throughout the gneissose area which extends from the Mahanaddi eastwards to near Umaria. It is unnecessary to describe those in the western part of this area, firstly, because they are generally inferior as a source of felspar to those further east, and secondly, because felspar is to be had in abundance close to the railway. Thus on the right bank of the Narsara naddi, just below the railway bridge, there is a vein 40 feet thick, in which there is not much quartz, and little or no schorl or mica. A very large supply of felspar could be obtained there. A considerable amount could also be procured at the eastern end of the hill, $\frac{1}{3}$ of a mile north-north-west of Majgama; and in the railway cutting north of this village, between the 32nd and 33rd milestones, several veins are exposed in section, the largest of which are 2, 3, and 5 yards thick. Many other localities might be mentioned, the veins being so numerous as to furnish an inexhaustible supply. But those just noticed, which are close to the railway, and within about 4 miles of Umaria, are not likely to be worked out for many years to come. It is very probable that by searching the hills south of Koilari felspar might be obtained within an even shorter distance from the station than that just mentioned.

STEATITE.

As this mineral, in admixture with fire-clay, is said to form the material for fire-bricks of a very refractory kind, reference may be made here to the steatite

which occurs in pockets through the dolomite of the Marble Rocks. It is described in more detail at page 64 of the present volume.

QUARTZ.

Although nodules of flint are known to occur in India,¹ similar to those of the English chalk formation, which are so largely used in the home potteries, none such exist in the Jabalpur district, or anywhere near it. The nearest analogues from a geological point of view, that is to say, with reference to mode of origin, are the cherty bands which occur in the Lameta limestone and transition dolomites. Those in the first-named formation are very irregular, the chert and limestone often interpenetrating, so that even if the former were sufficiently pure, and otherwise suitable for pottery, it would be difficult to extract it, and to obtain it free from carbonate of lime. The siliceous layers of the dolomite vary in mineral character from dark chert, through flint, to white translucent quartz indistinguishable, in hand specimens, from ordinary vein quartz. But the same objections apply as in the case of the Lameta chert.

The qualities which render chalk-flint suitable for pottery purposes are its freedom from a deleterious amount of iron or other impurity, and the fact that calcination renders it so brittle that it can be readily ground to the finest powder. Both these advantages are shared by the chalcedony which occurs so abundantly, in geodes and nodules, through the Deccan trap. Like flint it becomes white, opaque, and easily crushed, after being calcined at a red heat.² A large quantity could be collected off the surface of the trap in some areas, while in other places the mineral is comparatively uncommon. But it is in the beds of the larger streams, flowing from the trappean region, that the most ample supply is to be obtained, and there is the further advantage that the pebbles are washed clean, so that the selection of the purest chalcedony is much facilitated. The main constituent of the river gravel in the Narbada, where it passes to the south of Jabalpur (about 5 miles distant) is trap, but next to it chalcedony is most abundant, the other pebbles met with being rock-crystal, jasper, and other varieties of Deccan trap quartz, with a few of zeolite and of vein quartz.³ A large quantity of chalcedony could be collected, and, as the gravel is re-sorted every rains, when the river is in flood, the supply would be unfailing. Some rock-crystal is associated with it, often in the same geodes, but this mineral also becomes opaque and brittle after calcination.

Besides the loose gravel just mentioned, there are some gravel beds intercalated in the alluvium, and exposed in the river-banks. But as the pebbles are of the same character, and do not include a greater proportion of chalcedony, these beds could not be profitably worked.

¹ In the Trichinopoly district, for instance, and near Sakkar and Rohri, on the Indus (Manual, Geology of India, pt. IV, p. 74).

² The disintegration in both cases is probably due, in a great measure, to the substance being a mixture of crystalline and (more or less hydrated) amorphous silica.

³ These last doubtless come from some small area of gneiss; one pebble of the latter rock was observed.

Chalcedony is also obtainable in the same way from the Mahanaddi, the most convenient portion of the river for collecting it being that west of Chandia, the first railway station from Umaria. Although the mineral is decidedly less abundant than in the Narbada, I think there would be no difficulty in obtaining a sufficient supply. But more care would be required in collecting it, owing to the numerous pebbles of vein quartz, from the metamorphic rocks, which are also mixed in the gravel.

Beautifully white vein quartz occurs in both the transition and crystalline rocks, and would afford an exceedingly pure form of silica, were it not for the difficulty of crushing and grinding it,—a difficulty, however, which is diminished by calcination. Such veins may be seen in the mica schists of the Narbada below Lameta Ghát; there is a strangulated mass just west of the railway, $1\frac{1}{2}$ miles north of Chota Simla Hill; and they are very common in the gneiss near Umaria. The ballast used on the line about there is mostly quartz of this kind.

Some portions of the Jabalpur sandstones are composed almost entirely of quartzose grains, with some felspar, and very little iron, and are therefore nearly white in colour. The sand derived from the disintegration of such rocks is naturally highly quartzose, and, being free from much iron, might perhaps be found capable of utilization in connection with pottery; as an ingredient of fire-bricks for instance. A sample of glass was made from sand of this kind, in the laboratory, but although the greenish tinge, due to iron, was not very pronounced, it was still too marked to allow of such glass being used for any but very common purposes.

COLOURING MATERIALS.

As colouring materials for pottery, it is unnecessary here to do more than allude to the manganese oxides, and manganiferous hematite, of Gosalpur, and the iron ore of Jauli, Sarroli, Agaria, and other places, as these have been fully described in previous volumes of these Records.¹

LAMETA COAL.

The publications of the Survey do not appear to include any notice of this coal beyond the mere mention of its occurrence,² hence it may be well to place on record here the details of a section which has been exposed by recent workings. The quarry is situated near the right bank of the Narbada, at the bend of the river south-south-west of Lameta village, and about 9 miles west-south-west from Jabalpur.

Descending.	Ft.	Ins.
Surface (alluvial) clay, about	25	0
Pale gray, whitish, and yellowish shale, with some sandstone, about	12	0
Carbonaceous shale	0	2
Soft sandstone	1	0
Coal	0	2
Gray shale	0	2

¹ Vol. XVI, pp. 94, 116; Vol. XXI, p. 71.

² Memoirs, G. S. I., Vol. X, p. 142; Manual of the Geology of India, pt. I. p. 215.

	Descending.	Ft.	Ins.
Coal	.	0	2
Gray shale	.	0	3
Pale gray shale	.	0	3
Soft sandstone	.	0	10
{ Coal	.	0	7
{ Gray shale	.	0	2
{ Coal and Coaly shale	.	1	0
{ Light gray shale	.	0	6
{ Coal	.	0	8
Gray shale (seen)	.	0	7

The seam, therefore, is 2 feet 11 inches in thickness, of which 2 feet 3 inches is coal, divided into three bands by two partings of shale which aggregate 8 inches. The least depth of overburden in the quarry is about 30 feet and the greatest 40. The excavation had been just abandoned when I saw it, and a new one was being sunk alongside (in contact with) it. The overburden, however, will be still greater there, owing to the dip of the coal at about 15° towards the south-east.

On the opposite bank of the river another quarry was being worked. The section exhibited 13 feet of Lameta limestone, resting unconformably on about 15 feet of shale and sandstone, of the same character as in the last section. Beneath was the coal, but owing to its forming the floor of the quarry, and being partly flooded with water, the details were not ascertainable. The seam dips here towards the south-south-east at 5°.

The coal, as seen in both quarries, and also in a heap of several tons stacked near the latter, was very poor stuff. Some layers are good enough, consisting of bright jetty coal, breaking with a semi-conchoidal fracture, but these are interbanded with a very large proportion of shaly coal and carbonaceous shale. There is also a considerable amount of pyrites present. A picked sample (above the average) gave, on assay by Mr. Blyth.

Moisture	12'28
Volatile matter, exclusive of moisture	30'28
Fixed carbon	37'28
Ash (grayish-red)	20'16
	100'00

The coal was being used for brick-burning at Jabalpur. I should have supposed that it would be cheaper to get small-coal from Umari, or Mopáni, than to work such a thin inferior seam, with such a depth of overburden. Although of course there is a *possibility* that the coal may improve towards the deep, there is no reason to anticipate that it will, and even if it should, perchance, do so, it would be necessary to working by mining, which would involve skilled superintendence, and an expense which the results likely to be obtained could scarcely be expected to cover.

It may be noted here that coal, on approximately the same horizon, was found at a depth of 70 feet, in a well in the old jail compound at Jabalpur.¹ It is not necessary to remind geologists that the Lameta coal is in the Upper Gondwana strata (Jabalpur group), and is therefore quite distinct from, and younger than, the Barákar

¹ Memoirs, G. S. I., Vol. X, p. 142.

coal of Umaria and Mopáni. It differs from the latter in the jetty appearance of the purer layers, and, as the above-quoted assay would seem to indicate, in the large proportion of water it contains.

RELATIVE ADVANTAGES OF JABALPUR AND UMARIA.

In comparing the relative advantages of Jabalpur and Umaria, with reference to the supply of the raw materials, it may be noticed that the Gondwána clays are to be had on the spot at the former station, while chalcedony can be obtained within 5 miles. But, on the other hand, felspar is not known to occur within the district nearer than Selondi. Should it be proved not to exist in the crystalline area north-east of Sundarpur, it would be necessary to bring it from Umaria, whence also, or from Mopáni, coal must be procured.

Turning to Umaria, the Gondwána clay is known to occur within 12 miles, and there is a considerable probability that it would be found much nearer if looked for. While coal and fire-clay are to be had on the spot, felspar is obtainable within 4 miles or less, and chalcedony may be collected in the Mahanaddi near Chandia, the first railway station from the colliery.

But the question is already beyond the range of discussion. Since the greater portion of these notes were written, Messrs. Burn and Company, who have, I believe, experimented most successfully with the Gondwána clay at their Ránigunj potteries, and who have for some time past entertained the idea of starting pottery works in the Central Provinces, have finally decided on Jabalpur as the site, and have been granted land for the purpose. To Mr. Glass it must be a source of gratification that his exertions in bringing the Jabalpur clays into notice are about to lead to so satisfactory a result.

RECORDS
OF
THE GEOLOGICAL SURVEY OF INDIA.

Part 3.]

1889.

[August.

Abstract Report *on the Coal outcrops in the Sharigh Valley, Baluchistan, by the Director, Geological Survey of India.*

Mr. E. J. Jones has examined the whole of the system of valleys between Kach and Spintangi traversed by the Sind-Pishin Railway, on the Harnai route; and the conclusion he has come to, and in which I now thoroughly concur, whatever may have been my expectation regarding the immediate neighbourhood of Sharigh, is that the Khost locality is the most promising, and the one which consequently should be thoroughly tested by the mining exploration now going on under the superintendence of Mr. Morris.

Details of Outcrops.—The outcrops, taking them from Kach east-north-eastwards as far as Sunri, are:—

- (1) Just south of Mudgorge Railway Station and below the conspicuous limestone band on the face of the hill. Thin seams of coal are seen at three places in the neighbourhood, the best of these having an aggregate thickness of about 2 feet, generally much crushed. At one of these places, where the coal has been dug out, there is 1' 10" of good coal; from which about 1,000 tons might be extracted.
- (2) About 3 miles to the west of Dirgi Station: inferior coal, thickness 1' 6"; and again at another place 1' of coal. Dip very high. Also many other very thin seams or strings.
- (3) Near Khila Hakim Khan, about a mile from the railway, coal can be traced for about $\frac{1}{4}$ mile along the face of the hill. Headings have been driven in this coal to test its quality and mode of occurrence. Near centre of line of outcrops there are 2' of coal, of which 11" are jetty coal; and another giving 1' 2" of flaky coal. At the south-east end of section, the two seams just mentioned seem to occur in thicknesses of 10" and 1' respectively. On the whole, the thicknesses of coal are very variable; and, leaving the distance from the railway out of consideration, this does not seem a favourable locality for working.
- (4) The next marked outcrops are on the hill face, a little south of west from the Khost rest-house. Landslips obscure the succession, but coal is

B

- seen in five seams: coal and shale (mostly shale) 6'; good bright coal 1'; coal 9"; coal and shale mixed 2' 2"; coal 3".
- (5) The next locality is the neighbourhood of Khost Railway Station, concerning which details will be given further on.
 - (6) North of Khost, and near to Haji Kats; very thin seam of coal, much crushed.
 - (7) Khila Ali Khan, 2 miles south-east of Khost; coal, probably extensions of the Khost seams (interval obscured by landslips), exposed along hill-side. Much crushed; often crushed out altogether, or squeezed laterally until in places it looks to be 6 or 7 feet thick.
 - (8) A short distance beyond the bridge at telegraph pole 210—4, there is an exposure of 1' to 1½' of coal dipping 60° north-east.
 - (9) In the hill to south-west of Sharigh; a one foot seam of coal, above which, with intervals of sandstone, comes another seam of 6", and then a third of 1' which however ultimately thickens into two of a foot each with 4' of shale between. The valley between this and the main hill is full of contorted and vertical shales and sandstones, among which lie the layers of coal worked for local purposes at Sharigh. These are, however, mostly under a foot in thickness; while they are not fit for anything but surface workings. They are besides, some 3 miles, by path, from the Railway. The best seam, which is 2 feet in thickness, might be worth exploiting provided Khost were worked out.
 - (10) About a mile from the station of Sharigh, along the military road to Sibi (between the 75th and 76th miles from Sibi), there are some low hills of shale, giving four thin seams of coal; below which, to the north of the road, is a 4' seam. Though the locality is very convenient, the dip of the coal is high, and it is situated in a region of much stratigraphical disturbance.

Beyond the Sharigh neighbourhood and on towards Nasik (Nakis) by Harnai, there are frequent outcrops showing several thin seams or layers of coal; but these are all generally so thin, or so rolled about in repeated folds, while any horizontal intervals are so short and few, that the prospects of any workable coal being found in this part of the country are altogether too unfavourable to justify exploitation as long as the prospects of Khost, or even Sharigh, remain.

General mode of occurrence of coal in Baluchistan.—From what has been stated so far, it is clear that here, in the Harnai valley system, there is a belt sometimes very well exposed, oftener not so well exposed, much twisted or folded over a good part of the country, repeated by dislocation, and very seldom lying in a flat way, of very thin seams of coal; one or even two seams of which appear however to be tolerably persistent in the Khost region. This is the general style of the thickness of the Eocene or Tertiary coal in the Baluchistan country, and indeed in the Punjab also and notably in the Salt Range: and were it not that our Railway system has now been brought into close proximity with these coal outcrops, they would never have been thought of as worth working except for the rare local requirements which might arise in such inhospitable regions. As it is, even now that railways have run alongside or across these coal outcrops, it still remains a question whether coal of such thickness can be profitably worked.

Certainly, it has yet to be shown that the original views of the Survey with regard to the capabilities of the Salt Range coal need be at all altered or qualified.

The problem before us is not so much:—can two feet, or even 1 foot 6 inches of coal be profitably worked; as:—are the conditions attaching to this occurrence of such thin seams such as shall not militate against their profitable extraction? Sir Warrington W. Smyth, in his "*Rudimentary Treatise on coal and coal-mining*," writing of the Bristol and Bath District, says:—"It is observable that the *mode of working adopted* in the southern part of this district, *coupled with certain advantages*, has rendered it possible to work coal seams of little more than one foot thick; nay, in one of the little veins, I have measured the height to be only 11 inches of coal."¹

The first drawback in the working of the Baluchistan coal—thinness being characteristic—is the uncertainty of the continuity of the seams. The next is the awkward lie: the dip being seldom low enough to allow of the coal being extracted according to ordinary methods; while the deeper one goes in the seam, the more laborious, as a rule, the extraction becomes.

These drawbacks are reported by Mr. Jones as being least developed in the Khost region; in fact, in the very field which has so far been experimented on by the North-West Railway Administration: so it is clear that all well-considered efforts must be directed to that exploitation.

The Khost seams.—The coal or the carbonaceous shale outcrops of Khost occur in the slope of the hill range a short distance to the south-west of, and running tolerably parallel with, the line of railway.

There are traces of several outcrops of more or less carbonaceous seams, some of which are merely repetitions displayed in surface slips; but a particular seam of coal has been traced longitudinally, or along the strike for nearly two miles, the absolute longitudinal continuity of which for the entire two miles can scarcely be questioned. We only know of its continuation on the dip, that is down at an angle of 50° or so into the body or mass of the hill range, by its occurrence on the spurs and in the small valleys between; or by the drifts, adits, and headings which have been made from time to time in the half-hearted way in which exploration or working has hitherto been conducted, though improved search has lately been adopted. There seems little doubt, however, that the coal extends into the hill to a considerable depth even below the level of the railway valley.

One good, though thin seam.—The seam to be exploited consists of two layers of coal, the upper being 10 inches thick, and the lower 1 foot 4½ inches on the average, with a layer of from 2 inches to 1 foot 4 inches of shale between. In other words, the seam may be said to be *one* having an average thickness of 2' 2½", with a band of shale; the minimum thickness of coal being 1 foot 8 inches, and the maximum 3 feet 3½ inches.

The dip, or inclination, near the outcrop is very variable, being from 15° to 50° south-westwards: the variations are, however, due to local straining or bending from the weight of the superincumbent rocks along the outcrop; the true dip being about 50°.

Some 50 headings or drifts have been put down in the coal from the outcrop;

¹ The italics are mine.—W. K.

besides 4 adits which have been driven in from the face of the hill-slope to meet the coal at various points.

There is no reason to fear that the coal will fail before reaching the level of the river (in the railway valley); and judging by its constancy along the strike at the outcrop, scarcely any apprehension need be entertained of its failing for another 500 feet of vertical depth, beyond which it perhaps may die out. It must always be remembered that this occurrence may be merely the remains of a large patch of coal; and that thus though it is 2 miles or more in length, it may be only narrow and have only moderate width.

This, of course, can only be settled by continuing one of the headings well down to the deep: boring will not do, and workable coal will always be procurable from such a heading. At the same time, nothing certain can be said as to the probable area of coal until such a heading is driven.

If, however, the coal do continue to the deep for 1,000 feet along the dip, we may form such an estimate as the following. The coal retaining an average thickness of 2' 2"; and taking 79℔ of coal to the cubic foot, 28.35 cub. ft. = 1 ton: there should be a total of 22,872,960 cub. ft. or 806,806 tons. Deducting 30% for waste, we get 564,764 tons of available coal, or say 565,000 tons; a quantity not to be treated lightly in a country like Baluchistan, where fuel—barring the possibilities of petroleum—is so scarce.

Besides this, there are indications of another seam a few feet above that described, which however needs further exploration.

The following assays of the coal have been made at various times:—

KHOST COAL.						
	Close to outcrop.	NEAR OUTCROP.		Lower layer, bottom of present working.	Upper layer, bottom of working.	Hitch, i.e. crushed coal.
		Upper layer.	Lower layer.			
Moisture	2'08	2'20	1'72	2'30	1'80	2'70
Volatile matter	42'08	36'50	45'63	43'80	39'30	41'70
Fixed Carbon	45'48	50'27	48'40	45'50	39'80	49'60
Ash	9'46	11'03	4'25	8'30	19'00	6'00
	100'00	100'00	100'00	99'90	99'90	100'00

The coal contains a large quantity of pyrites; and this, as well as the shaly partings, or layers, will have to be removed by some sifting or washing process.

The coal makes an excellent coke; and though there is a large loss in weight (40 to 50%) the heating power is much improved and, weight for weight, much more work can be got out of the coke than from the untreated coal.

A special advantage lies, last of all, in the fact that this coal is in comparatively close proximity to the line of railway.

Profitable working still doubtful.—Nevertheless, the problem remains as to whether the coal extraction is to be continued on that simple and certainly ready

method of grubbing it from the outcrops on the face of the hill slope to the south of the railway line, which method can of course only last for a short time; or that it should be worked by a necessarily very expensive system of permanent and progressive colliery operations.

The subject, however, of the most advantageous form of working such a coal-field is one on which I refrain from offering an opinion, however much my own training as an engineer and experience of the *entourage* and structure of collieries, as well as that of other officers of the Survey, may qualify this Department for such discussion. I would, however, relying on the experience gained in this exploitation, go so far as to say, and I do so advisedly, that it is extremely doubtful whether this work can be carried one stage further with the staff employed at present.

Within the last year, the exploitation has been carried on by a (presumably certificated) miner from England, of good experience in coal-fields of the regulation type at home; but ill-adapted for co-operation with an Executive Engineer in charge who is not a specialist at colliery work. The miner is very badly paid (₹150 a month, I think). The Executive Engineer is only on the spot at intervals, he having in fact to look after Khost, Dandot, and the coal outcrops away beyond Rawalpindi.

I say emphatically that the working of such a field, if it is not to be a failure, must be entrusted to a Colliery Superintendent of experience in high-dipping coal, with a good English miner under him.

It would be of the last importance also that the final judgment as to the systematic mining of the field, or its abandonment, should wait an inspection and report by Mr. Maughan (Central Provinces Government Coal-fields) who is one of the few official colliery authorities with the Government experienced in high-dipping coals.

The problem of opening up this field or not is an exceedingly difficult one, requiring the gravest and most wide discussion: but it is not a new one, because we have the experience gained at the Dandot Colliery in the working of a thin seam of coal of the same age. On that experience, such as I know of it myself, I can say that though the promise held forth by the conditions of the Khost coal-field is not very encouraging, still it is more encouraging than that of the Dandot field ever was, or even now is; while the working of it will involve much less costly supplementary plant and machinery, and will be, above all, less dangerous.

WILL. KING,
Director, Geological Survey of India.

June 1889.

Note on the Discovery of Trilobites by Dr. H. WARTH in the *Neobolus* beds of the Salt-Range; by the Director, Geological Survey of India.

On the 15th January last I received a letter from Dr. Warth, informing me that among very many specimens of other fossils which he had found in the *Neobolus* beds during a late excursion in the Salt-Range, and which he had then just forwarded to Dr. W. Waagen at Prague, were some rock specimens with shells and three minute

fragments which he suspected were possibly Trilobites. He had so little expectation of finding such organisms that, only when he got back to Dehra and had looked over the collection, did the suspicion arise that he had perhaps after all got them. The exact *habitat* of the fossils will of course need confirmation by other finds; but Dr. Warth's conviction, which need scarcely be doubted, is that they were from the Neobolus beds.

This was so interesting and remarkable a discovery, where we had so long looked on those beds as of Silurian age, even though this age had been strongly contested and, in point of fact, had been virtually decreed against by Dr. Waagen in the Preface to the first volume of the "Salt-Range Fossils"; that we could only wait patiently for the Salt-Range Palæontologist's opinion.

In due course Dr. Waagen's letter arrived, wherein he writes:—"The Trilobites have now arrived from Dr. Warth, and I see that there are two determinable species. One is a *Conocephalites*, very nearly related to *Con. formosus*, Hartt. from the St. John's group, and the other is probably an *Olenus*. The beds in which such forms occur cannot be anything but Cambrian, and they must probably be classed as referable to the upper region of the Lower Cambrian."

I should indeed have preferred that Dr. Waagen had announced the discovery himself in a preliminary paper for these Records, as was done in the case of the find (1886) of *Conulariæ* and other fossils in the Boulder-bed¹; but his desire is that the subject be discussed in all its bearings in forthcoming parts of Vol. IV of the Salt-Range Fossils, now being prepared for publication. There will be some delay in the appearance of these parts; so, rather than that there should be any further holding back of the news of this discovery, or of Dr. Waagen's preliminary treatment of its bearings on his "geological results," as they are to appear in the *Palæontologia Indica*, I take the liberty of now giving the following extract from his manuscript:—

"In the Introduction to the first volume of the present work in 1879 I have introduced the following grouping founded on the *data* then available:—

UPPER SERIES. (Newer Mesozoic formations.)	{ 10 Olive group.
	{ 9 Variegated group.
MIDDLE SERIES. (Ceratite beds.)	{ 7 Ceratite beds.
	{ 6 Lower limestone of Salt-Range.
LOWER SERIES. (Productus limestone.)	{ 5 Speckled sandstone.
	{ 4 Magnesian sandstone.
	{ 3 Obolus or Siphonotreta beds.
Not included in any series.	{ 2 Purple sandstone.
	{ 1 Saline series.

"This can, however, no longer be retained, as several new facts have come to light which cause me to take another view of the matter."

"With regard to the Lower Series there has been detected in the meantime not only the great discordance which cuts just through the middle of the division; but, just while I write these lines, I have a letter from Dr. Warth announcing to me his discovery of Trilobites in the Neobolus beds—specimens which seem to be very nearly related to *Conocephalites*. Thus, it is no longer possible that the beds below the great unconformity should form one series with the more recent strata above the unconformity, which are of Permian and topmost carboniferous

¹ Rec. G. S. of I., Vol. XIX, p. 22.

age; and therefore the 'Lower Series (Productus-limestone)' of former times will have to be cut up in two.

"Such a proceeding has been advocated already by Mr. Medlicott, and in fact Mr. Wynne always termed the *Neobolus* beds 'Silurian.' His reasons, however, for so doing were restricted to the statement of Dr. Stoliczka and myself, that the *Neobolus* beds contained '*Obolus* or *Siphonotreta*.' As soon as the *Obolus* or *Siphonotreta* disappeared, there were no further reasons for considering these beds as Silurian.

"When I commenced the description of the Salt-Range fossils, there were the following data as to the age of the *Neobolus* beds at my disposal:—

- (1) The lower limestones of the Salt-Range, that had been considered as carboniferous by Mr. Wynne, proved to be of Permian age.
- (2) That the *Neobolus* beds followed a few hundred feet below the Permian, without any trace of an unconformity, was admitted by Mr. Wynne. In point of fact, there seemed to exist a perfect transition from above downward.
- (3) In the Magnesian sandstone, following immediately above the *Neobolus* beds, and being most intimately connected with them, the specimen of *Sigmoidus*, described in Volume I of the present work, had been found, which certainly nobody would expect to collect in lower, or even upper, Silurian beds.
- (4) Specimens and drawings of the *Obolus*-like fossils contained in the *Neobolus* beds were shown by me to Statsrath Valerin-o-Möller of St. Petersburg, now in Tiflis, and later on to Mr. Davidson of Brighton; and both declared most decidedly that there were no forms among them identical with things hitherto described out of Cambrian or Silurian beds, and Mr. Davidson especially advised me to make new genera out of these things.
- (5) At last there was collected by my own hands a fossil in the *Neobolus* beds which is to all appearance a *Fenestella*, with large fenestules—a form which had never been observed previously in beds lower in the series than carboniferous.

"All this combined to cause me to consider these beds as probably of lower carboniferous age. After Mr. R. D. Oldham, however, had proved the existence of a great unconformity, the matter appeared in a new light, though the existence of the unconformity alone was not sufficient to settle the age of the *Neobolus* beds. Nobody in the world could have put forward the opinion that beds on which Permian and topmost carboniferous were unconformably deposited, could possibly be equivalent in age to the mountain limestone, but had necessarily to be considered as Silurian. Therefore I hesitated, even after Mr. Oldham's discovery, to give up an opinion to which all available palæontological data seemed to point, and thus I reiterated in the Preface to the 1st volume my formerly-expressed opinion, that the *Neobolus* beds were of lower carboniferous age.

"Nevertheless, the case seemed to be worthy of further investigation, and seeing that it was impossible to arrive at any better results as long as no new data were forthcoming, I wrote to Dr. Warth, who was then in the Salt-Range, to search for more fossils in the *Neobolus* beds, at the same time indicating some localities where a close search would be most promising. Dr. Warth, however, was then prevented from making his investigations and for about two years the case seemed rather hopeless, when all of a sudden the letter from Dr. Warth arrived announcing his discovery of lower palæozoic *Trilobites* in the *Neobolus* beds. Now at last the truth seems to be arrived at, and the great unconformity now seems really to indicate a great break in the succession of strata in the Salt-Range.

"According to these considerations it seems now necessary to divide the lower series, formerly adopted by me, into two different series, though both be of palæozoic age; a lower palæozoic one, which will have to include all the beds below the great unconformity, and an upper palæozoic one, which comprises the beds above the unconformity and to which the name 'Productus-limestone' must be restricted.

"With regard to the middle series, the ceratite beds, no change seems necessary. The palæontological and stratigraphical data relating to these beds were already so clear and well settled when I commenced the present work, that any mistakes about their age or relations were excluded.

"The case is again different with regard to the upper series comprising the newer mesozoic formations. It has been stated above that the 'Olive series' of Mr. Wynne can no longer be retained, but that it is partly identical with his speckled sandstone, while the rest of it goes to form a new group for which I introduce the designation 'Carbonaceous group or *Cardita beaumonti* beds.' Whether this latter really has to be considered as of mesozoic age has become somewhat doubtful, and, therefore, I hesitate to include it again in the upper series.

"Thus we arrive at the following grouping, which, however, applies only to the large series. Within these series smaller groups can yet be distinguished, as will appear in the sequence. In order to give a general idea of the grouping of the rocks in the Salt-Range, I append a tabular view, in which I insert for general reference also the probable equivalents of the Salt-Range rocks with those of Peninsular India and of Europe, with the distinct proviso however that these equivalents must not be taken as definitively settled, but solely as the most probable ones as far as our knowledge reaches up to this moment."

Tabular view of the rock-groups represented in the Salt-Range, with indication of their probable equivalents.

Larger Series.	Rock-groups.	PROBABLE EQUIVALENTS.		
		In Peninsular India.	Elsewhere.	
	19 Nummulitic.			
?	18 Carbonaceous group (<i>Cardita beaumonti</i> beds.)	Deccan Traps (part).		
	<i>Unconformity.</i>	<i>Break.</i>		
Newer Mesozoic formations.	17 Dark green pisolitic sandstones (Neocomian).	Kachh.	Neocomian.	
	16 Upper jurassic limestones.	Jabalpur.	Upper and Middle Jurassic.	
	15 Variegated group.		Lower Jurassic and perhaps Rhætic.	
	<i>Overlap.</i>			
Ceratite beds.	14 Grey and yellow dolomites.	? Rajmahal.	? Upper.	
	13 Grey bivalve limestones.	Panchet.	? Middle.	
	12 Ceratite beds.		? Lower.	
Upper palaeozoic series (Productus-limestone).	Siliceous limestone group.	11 Upper Productus-limestone.	Damuda.	Permian.
		10 Siliceous limestone (Middle Productus-limestone).		
	Speckled sandstone group.	9 Lower Productus-limestone.	Talchir.	? Lowest Permian. or ? Topmost Carboniferous.
		8 Speckled sandstone.		
Lower palaeozoic series.	Magnesian sandstone group.	<i>Unconformity.</i>	? Vindhyan.	Lower Palaeozoic. (? Sinic formation, Riehthofen: China, Vol. II.)
		7 Red shaly zone (Salt-pseudomorph zone).		
		6 Magnesian sandstone.		
	Purple sandstone group.	5 Dark shaly zone (Neobolus beds).	Vindhyan.	
		4 Upper Purple sandstone (Purple sandstone).		
		3 Rock-salt and red Gypsum group.		
		2 Grey Gypsum group.		
		1 Lower Purple sandstone.		

NOTE.—Salt-Range Fossils, Vol. I, Pal. Indica, Ser. XIII.

Geological Notes by C. L. GRIESBACH, C.I.E., *Deputy Superintendent, Geological Survey of India.*

THE SEQUENCE OF FORMATIONS IN SPITI.

Under the title "*The Sequence and Correlation of the Pre-Tertiary Sedimentary formations of the Simla Region of the Lower Himalayas*"¹, Mr. R. D. Oldham discusses the sequence of rock systems not only of the Simla region, but also of the Himalayas of Kashmir and Spiti. This paper is followed by another,² in which Mr. Oldham, under the heading of "Spiti," describes also the crystalline groups of the country between Simla and the Babeh pass.

Mr. Oldham, when visiting Spiti, was *en route* to the Zanskar area I believe. His zeal to complete during a single season's rapid travels a complete geological reconnaissance of ground, which to study has required years of labour of more than one geologist, may partly account for the incomplete view of the geological structure of Spiti, which is revealed in the pages quoted.

Spiti is classic ground; it had been visited and described by our eminent and late colleague Dr. F. Stoliczka,³ his published sections have been until recently considered crucial ones for the geology of the North-West Himalayas, and his nomenclature had been largely applied to the geological structure of other regions of the Himalayas. It would therefore have been well if Mr. Oldham had been able to afford more time for a careful study of the sequence of rocks of Spiti, in order to see in how far Stoliczka's first classification of rocks should be modified, and in how far the correlation of formations with those of other areas is admissible. I have myself no doubt, that had Stoliczka been able to revisit Spiti, he would have modified his views on some points, and would perhaps have recognized certain horizons which he had overlooked. My own work in the Central Himalayas was brought to a close in 1883 with the examination of the southern and eastern part of Spiti; but unfortunately, the publication of the results of my labours in those regions has been delayed owing to long periods spent in Afghanistan and on the frontier, and although now nearly ready for the press, it will be many months before it can be issued. I think, therefore, the preliminary sketch of the geological structure of the southern part of Spiti contained in the following pages may clear up some points which Mr. Oldham has left doubtful. I may mention here, that I possessed the great advantage when visiting Spiti, of having slowly worked through the sections of the high ranges of Kumaun, Garhwal and the adjoining portions of Thibet; so that I had no difficulty in tracing out all the rock-groups of the Central Himalayas in the Spiti area. This was all the more easy, since most of the rocks of the latter ground have yielded fossils, as all the formations in the eastern sections have done.

I entered the Spiti drainage by the Babeh pass, returning into the Sutlej valley by the Manirang pass. By doing so, I traversed the palaeozoic and the mesozoic groups, up to the upper rhætic system.

¹ Records, XXI., pp. 130 ff.

² Do., do., do. 149 ff.

³ Mem. G. S. I., Vol. V.

Stoliczka's Sequence.—I have to differ in some few points from the original interpretation given by Dr. Stoliczka. He grouped the sedimentary formations below the jurassic "Spiti" shales into the following divisions:—

Upper Tagling		Lias.
Tagling limestone }		Rhætic.
Para do. }		
Lilang Series		Trias.
Kuling Series		Carboniferous.
Muth Series } Upper }		
Babeh do. } Lower }		Silurian.

Trias.—I have little to say in this paper concerning the mesozoic rocks: the general grouping as shown by Stoliczka is according to facts, and I have only to add that the Trias (Muschelkalk horizon) does not rest upon carboniferous; but there is a series of beds, underlying the former conformably, ranging through the upper productus shales (Permian), the Otoceras (passage) beds and thin limestones with lower Trias brachiopods, which series comprises the lowest Trias (Bunter) of Central Europe, but reaching down even to the Upper Permian. The series is not of great thickness, but is well exposed both at Muth and in sections north of it (Kuling, &c.), but Stoliczka has apparently included it in the *Kuling beds*.

The chief changes which should now be made in the correlation and nomenclature of the Spiti formations concern the palæozoic group.

When I speak of silurian, carboniferous, etc., in these pages, I understand these terms homotaxially; though, as I shall endeavour to show later on in my full report in the Central Himalayas, the various marine systems are closely connected with those of Eastern and South-Eastern Europe.

The route descending from the Babeh pass down the Pin river, traverses a fairly good section of the entire palæozoic group, and I shall therefore describe it as it appears along this line.

Cambrian.—*Babeh series, Stol. = Asoic, Strachey = Cambrian.*—Between the metamorphic rocks south of the Babeh pass and the lower silurian exposed near Buldur (of the map), a thickly-developed system of rocks is seen, which I have identified with pre-silurian rocks of the Central Himalayas, called by General R. Strachey ¹ *Asoic series*. The beds composing this system are conformably overlaid by the lower silurian; and this, coupled with the fact that it has not proved devoid of organic traces, has induced me to correlate it with the cambrian of other regions. The term "*Babeh*" system might have stood with some modification of its meaning, had I not already worked out the Central Himalayan pre-silurian rocks before recognizing in them Stoliczka's Babeh series. But, as under that name some members of the silurian have also been included, I prefer to retain also in this paper the term "*Cambrian*."

This rock system consists, in the Spiti area, of a succession of chiefly quartzitic rocks; I did not study it in detail, but found similarly as in the Garhwal sections, a purple semi-metamorphic quartzite predominant. Associated with it are silicious shales, and a largely developed conglomerate or rather boulder-bed which is a most characteristic rock, and traceable from Spiti to the Nepal frontier. It is such a

¹ Q. Jour. Geol. Soc., VII, p. 292.

constant factor in this system, that once seen it will always easily be recognized. In its constancy it reminds me of the ever-recurring boulder bed near the base of the Talchirs. These dark purplish quartzites and conglomerates form usually thick beds, and are associated with greenish talcose slates and semi-metamorphic schists which I found near the boundary of the gneissose series south of the Babehe pass, and again near the upper boundary of the system. In these same greenish schists, fossil traces (*Bellerophon*?) were found in the Niti sections. Strata of thinner-bedded purple and brown silicious rocks are not absent, which also here show extensive and often very typical ripple-marking, quite distinct from the wrinkling into which the beds have been contorted.

As far as I have observed, the contact between the gneissic rocks of the south side of the Babehe pass with the overlying slates (Babehe series = Cambrian) is not sharply defined. Intrusive granite obscures the boundary, and it is most probable that it will be found to enter the slate series in the same manner as seen in the north-eastern extension of the belt of cambrian rocks seen near Shipki in Hundes, and further east in the Nilang area.

The system shares in the extensive folding which has crumpled the entire succession of marine sedimentary rocks of this and the neighbouring sections of the Himalayas. The folds are generally very close, reversed flexures with their longer shoulders falling to the north and north-east.

The thickness of the system I have not been able to ascertain, but it will probably be found to be not less than that of the cambrians of the north-eastern and eastern sections, where I estimate it as from 3,000 to 4,000 feet.

Near the camping-ground of Buldur (of the map), the beds form a deep synclinal, strike nearly east and west, enclosing a portion of the silurian system. Conspicuous from afar, a band of bright red to purple silicious shale shows the deeply-bent curve of the synclinal, and at the same time forms the lower boundary of the silurians. The streams which join near this camping-ground from the south-west have eroded through the synclinal at nearly right angles and so exposed the structure. Dark limestone, and above chiefly flesh-coloured quartzites, are inclosed in this synclinal; they form respectively the lower and upper silurian, which, however, are seen much better lower down the Pin river valley.

Between this synclinal and the village of Muth a perfect section of the palæozoic group¹ may be studied. The structure is simple, though the entire sequence of beds is a good deal folded. Down in the valley along which the road passes, little or nothing is seen. The track from the pass leads almost wholly over moraine matter, and over the enormous fans descending from the numerous small side ravines. The high and rugged ranges which enclose the valley have to be ascended before much of the true structure of the rocks can be made out. I think, on the whole, the range

¹ Mr. Griesbach uses the term 'group' throughout this paper in a way which is not accepted generally by English geologists. See *postea*; Notice of Presidential Address, Geol. Soc. Lond., p. 180.—Ed.

of hills forming the left side of the valley is perhaps the easier of the two, and enough of the beds forming it are exposed for the interpretation of the structure. I found it to consist entirely of palæozoic rocks, much crumpled; though, thanks to several very characteristic horizons, the structure is not difficult to unravel.

The southern end of the range is formed by the cambrians as already described; they are conformably overlaid by the silurian system, which occupies the central portion of the range, followed, near its northern extension, south of Muth, by the devonian and carboniferous systems. The enormous succession of formations between the base of the cambrians and the upper carboniferous quartzites near Muth shows one conformable whole; with great variations in lithological character of its component beds, but no *sharply* defined boundaries anywhere, rather unmistakeable gradations from one into the other series of beds.

The first break occurs above the upper carboniferous, upon which the black "Kuling" shales, with many *producti*, rest unconformably.

This is the most important point connected with the structure of Spiti as will be seen later on.

Sequence of palæozoic divisions.—The divisions of the palæozoic rocks of the Pin valley are therefore as follows:—

With trias-rhætic resting conformably on:—

10. Black productus (Kuling) shales	Permian.
<i>Unconformity.</i>	
9. Dark flaggy limestone	} Carboniferous.
8. White quartzite series (Muth quartzite)	
7. Red crinoid limestone	
6. Earthy, dark-grey limestone	} Devonian.
5. Hard, dark, concretionary Coral limestone with splintery shales	
4. Dirty flesh-coloured to brown quartzites alternating with grey and greenish shales	} Silurian.
3. Coral limestone series	
2. Bright red quartz-shales	} Cambrian.
1. Slate, quartzites and conglomerate series, seemingly conformable on: Gneissose Series.	

The divisions 1 to 4 correspond exactly with the silurian and pre-silurian sections of the Hundès and Central Himalayan ground. Fossils occur in nearly all the beds but they are not very well preserved, and I did not devote much time to the search for them in Spiti. The rocks are so characteristic, and the lithological similarity to the eastern section is so complete, that I could pass on to the carboniferous rocks without hesitation.

The red quartz-shales (2), are as constant a termination to the cambrians as in Kumaun and Garhwal, and although the thickness is only from 200 to 300 feet, the bright red tint of the bed marks the boundary as if with a red thread.

The overlying coral-limestone (3) averages 300 feet in most sections, and consists principally of thin-bedded coral-limestone of dark grey colour, with occasional intercalations of silicious and shaly beds of greenish and pink colour. Near its junction with the red quartz-shales,

beds of dark (fossiliferous) coral-limestone alternate with the red shales, which are there often replaced by greenish-grey beds of otherwise similar lithological character. This alternation near its upper boundary would alone have induced me to include the quartz-shales (2) with the lower silurian, but the horizon seems more closely connected with the underlying quartzitic cambrians into which it passes gradually; so that I felt the red quartz-shales must rather be considered as structurally to belong to the underlying system. In the coral-limestone series (3) fossils are very common, though fine specimens are not easily got out. Corals and brachiopods of lower silurian type are frequent.

This series passes upwards into the flesh-coloured quartzite series (4), which is ever present in all the upper silurian sections of the Central Himalayas. The thickness of it may here be from 1,500 to 2,000 feet, though I am inclined to think that it will be found to be rather below this estimate in less disturbed sections. Within these crushed flexures jointing amounting often to considerable faulting, is so common, that a true estimate of thickness is not easy. The passage from the lower silurian coral-limestone (3) into this series is gradual: beds of dirty greyish flesh-coloured quartzite make their appearance between the dark coral-limestone low down in the latter series, increase in frequency higher up, until finally is developed a distinct series which is roughly characterized as being an alternation of flesh-coloured to brown often speckled quartzite and grayish-green shales with fucoïd marks. The latter often show imperfect cleavage, and near the upper boundary increase in thickness. Fossils and casts of such are frequent throughout the formation; they are nearly all brachiopods; *Orthis* sp. and corals with types of the upper silurian are found throughout.

I believe that Dr. Stoliczka has rightly recognized this quartzitic series as silurian, fossils being common in it, especially on its weathered surfaces.

Descending the valley, he came up with the white quartzites near the village of Muth, which are further on overlaid by the black "Kuling" shales; and I think he must have believed that it and the silurian quartzite belonged to one formation.

But there is no silurian rock near Muth itself; and the white quartzite near that village is upper carboniferous, as will be seen further on.

The upper silurian (4), is conformably overlaid by a thickness of from 700 to 800 feet of a very dark, hard limestone (5), concretionary in parts, alternating with dark splintery shales. This series also has a wide geographical distribution, from the Nepal frontier in Byans, where it attains much greater thickness, to Spiti, little if at all varying in lithological character and containing few fossils. I found none in Spiti, and those met with in the eastern section might either be lowest carboniferous or devonian. Studying it connectedly with the adjoining horizons, its geological position at the base of the carboniferous is apparent; and then the uniform lithological character of the horizon over an extensive area is striking, but little could be gained by simple lithological identification in the field unaided by a clear view of its geotectonic conditions. Almost identically, the same rock may be met with in higher horizons.

I think it is very probable that this same series extends far into Kashmir, as shown by Lydekker,¹ who places it in the carboniferous system. Lithologically simi-

¹ Mem. Geol. Sur. Ind., Vol. XXII, 1883.

lar rock occupies a carboniferous horizon in the Hindu Kush sections and in the prolongation of this mountain chain through North-Western Afghanistan and North-Eastern Persia, where it probably thickens out and runs into upper carboniferous. I am induced to correlate it with devonian rather than carboniferous; the fossils found in it in the Central Himalayan sections, as far as I have been able to examine them up to this, might be characteristic of either devonian or lower carboniferous, but its evident connection through passage-beds and alternations of strata with the underlying upper silurians indicate that at all events between the upper portion of the series (4) and the true carboniferous rocks (6 to 9) all intervening horizons from upper silurian to lower carboniferous must be included. Sharp boundaries there are none, and the whole represents an unbroken succession of deposits.

The carboniferous system is much more fully represented in the Spiti area than in the sections eastwards. Not only are the several series of formations composing it represented in great thickness, but the sequence of horizons is more complete than is the case in Garhwal and Kumaun. The divisions of the system in Spiti are as shown on page 161; the limestone (9) is wanting in all the eastern sections,—eroded I believe before the black *productus* shales were laid down on it. The lower boundary between this system and the underlying dark coral limestone (5) is not well defined.

The lowest horizon which I take to belong already to the lower carboniferous is an earthy grey limestone (6) of irregular thickness and not very conspicuous. It might easily be altogether overlooked or considered part of the underlying coral-limestone (5), if I had not observed it in the Dharma section more amply developed. Here as there, it is characterized by the presence of crinoid remains, which are found throughout this and the succeeding division. The passage from this grey limestone into the

overlying red crinoid limestone (7) is gradual, and the former seems altogether a local development only of the latter. Together, the two series may be from 600 to 800 feet in thickness. With the exception of badly-preserved *orthoceras* fragments, nothing but crinoid remains were found in this series; but the rock is so constant over the entire area of the Central Himalayas that a mistake is absolutely impossible. Its colour, a brownish red (Indian red), distinguishes it everywhere and often helped me in making out the structure of the upper palæozoics in mountain tracts which were only partially accessible to me. Its intense colouring, coupled with the fact that it is nearly invariably overlaid by the glaring white quartzite (8), serves as an unerring guide in such cases. Besides the red cambrian quartz-shales (2), it is the only red formation: a patchy red bed occurs in the rhætic and a semi-metamorphic red bed amongst the nummulitic series, but with neither can the red crinoid limestone be confounded.

It is overlaid by the white quartzite (8), the Muth quartzite of Stoliczka. This also is an old friend, met with in the Garhwal and Kumaun area, where I established its upper carboniferous age;¹ it seems one of the most widely distributed of Himalayan formations, for Mr. Lydekker has shown that it also occurs in Kashmir near the base of the Kuling shales.²

¹ Rec., XIII, p. 85.

² Mem. Geol. Surv. Ind., Vol. XXII.

The junction with the underlying red crinoid limestone is well defined, although several irregularly intercalated beds of the latter are found in the white quartzite near the boundary.

The main mass of the series is formed of fine-grained white quartzite in thick solid beds; in its upper portion the quartzite becomes occasionally a silicious sandstone, and there are now and then some thin limestone beds intercalated in the more eastern sections. Near Muth village in the Pin river valley the total thickness of it is about 500 feet. Some fossil traces, chiefly of brachiopods, are found on the weathered surfaces of the rock, rarely in good preservation, and are indicative of the carboniferous age of the series.

Oldham has correctly correlated the Muth quartzite with the carboniferous white quartzite of Kashmir,¹ but he does not seem to have noticed the carboniferous beds which both underlie and overlie the formation.

It is overlaid conformably by a hard, splintery grey limestone (9) in flaggy beds, of a total thickness of about 70 feet, which has yielded numerous fossils, though few in species. Amongst them are several *producti*, *Athyris royssii* and *corals*. Its evident connection with the white quartzite (8) and fossils define its upper carboniferous age.

The small ravine which descends near the village of Muth marks the upper boundary of the carboniferous system. The strata forming it are there seen to dip about 45° to 50° below the Permo-trias, forming a great synclinal fold between Muth and Tiling which is splendidly exposed in the hill west of Khar.

It will therefore be seen that the Spiti carboniferous, so far from being "*not well exposed*,"² is well represented and even more fully than in the sections eastwards. If I had only seen the sections in Spiti, where the beds of the Permo-trias seem to rest conformably on the carboniferous, I would unhesitatingly have considered the small thickness of *productus* shales (10) at the base of the lower trias also as carboniferous. But I have traced this contact from the frontier of Nepal, from Byans through the entire range of the Central Himalayas to Spiti, and found that whilst the *productus* shales are never absent from the base of the trias, forming with it as it were one great system of beds, they overlap in succession the various horizons of the carboniferous system in the different areas. • For instance, the Permo-trias rests on white quartzite in Dharma and Byans on an eroded surface of white quartzite; in other sections on red crinoid limestone in the Niti area; and here in Spiti on a limestone with carboniferous fossils not seen in the eastern sections. The inference

therefore is that the Permo-trias represents one continuous whole, which overlaps the several horizons of the carboniferous, and that the contact is unconformable—in fact represents a break between the two systems. I can only again assert my conviction, strengthened by many observations all pointing to the same conclusions, that there are grounds for supposing that great physical changes have occurred in late carboniferous times, or at the beginning of the Permian era. I expressed this belief after my first examination of the Niti sections in 1879 in the paper above quoted.

¹ Rec., XXI, p. 151-3.

² *Ib.*

As I have already said, a great synclinal fold forms the belt between Muth and Tilling, followed by an anticlinal near the arch of which the village of Khar is situated. The ranges north of Khar to Muth. Synclinal north of Muth. Dangkhar are a succession of more or less complicated flexures. The carboniferous rocks are therefore generally seen near the base of the ranges and in the valleys, whilst the higher cliffs are formed of the overlying Permo-trias. But the best section of the carboniferous, which I have so far seen, is the one exposed along the jagged ridges of the chains of hills on both sides of the Pin valley and south of Muth.

Near Muth village, and on both sides of the valley, I found above the upper carboniferous limestone (9) an unbroken succession of beds ranging from the Permian *productus* shales (10) to beds with *Terebratula gregaria* and *Rhynchonella austriaca* (Upper Rhætic); and, as I have already shown, this system of strata must be considered as being unconformable to those below. The trias with the permian *productus* shales at their base overlap the entire series of the upper carboniferous in the Central Himalayas; and I think therefore on stratigraphical grounds the division between the palæozoic group and the next following should in the Himalayas be made at the end of the upper carboniferous rather than the permian.

The permian *productus* shales (10) are about 150 to 200 feet in thickness, mostly densely black, crumbling and soft, divided by strings of ferruginous concretions and layers of splintery shales. Permian *productus* shales. Occasionally an irregular bed of dark grey to olive-coloured sandstone, weathering dark brown, divides the formation and is generally full of fossils, chiefly *producti*. The shales also yielded many specimens of *producti* and a few other *brachiopods*.

These shales are evidently Stoliczka's typical Kuling beds. They are well exposed near Tilling, Khar, Kuling, and may easily be traced as a black band near the base of the hills north of Kuling. They again are visible in the Spiti river valley west of Dangkhar, below the wooden bridge above the junction with the Pin river. They yielded fossils wherever met and are invariably passing upwards into beds, which

Stoliczka failed to distinguish. These are dark limestone beds alternating with black friable shales, of about 200 feet in thickness and closely resembling the *productus* shales below. But these beds have yielded, in all sections which I have hitherto examined, a fauna totally distinct from that found in the beds below. Numerous species of *cephalopods*, chiefly of *Xenodiscus*, *Otoceras*, and a little higher up of *Ceratites*, may be picked up. *Producti* have disappeared, and in the uppermost beds of the series *brachiopods* are found which I cannot distinguish from species found in the lowest trias of the Alps.

This succession of beds is well seen near Kuling, north-west of the village, where it is conformably overlaid by limestone with *Muschelkalk* species, followed by the remaining trias horizons.

In a former paper¹ I have correlated this series and also the black *productus* shales below with the Werfen beds of the Eastern Alps, and the succeeding divisions

¹ Rec., XIII, p. 99 *et seq.*

with certain other zones found in the Alpine trias. This, however, I find untenable; though in general features and in the main divisions there is no doubt that the trias of the Central Himalayas is closely related to the trias of the Eastern Alps.

The beds with *Otoceras woodwardi* form a true passage-bed from the permian productus shales into the lowest trias. Its exact homotaxis can now be established, for beds containing a fauna nearly related to the Himalayan one have been found in both Western Asia (Araxes) and in Sicily within the last few years. The fact of the disappearance of the *producti*, and of the general habitus of the *cephalopod* fauna reminding one of triassic horizons, have determined me to class the *Otoceras* zone—a passage stage—with the trias, while it may be probably correlated with the lowest formations of the Bunter; but there is really no sharply-defined boundary, no stratigraphical distinction between any division from the permian productus beds (10) to the uppermost rhætic strata, the entire range of beds in fact belonging to one unbroken system of deposits.

I will not here enter into a detailed description of the remaining trias and rhætic beds in Spiti, but shall only give a table showing the Sequence of trias in Spiti. main divisions of the succession of strata.

In descending order:—

20. Bituminous, sometimes oolitic limestone of a few feet in thickness, with liassic fossils	Lias.
19. Limestone with many fossils; <i>Rhynch. austriaca</i> , <i>Ter. gregaria</i>	} Rhætic.
18. <i>Lithodendron</i> limestone	
17. Limestone with <i>Megalodon</i> sp.	} upper.
16. Dolomites; great thickness	
15. Limestone and shales with fossils	} Trias.
14. <i>Daonella</i> limestone; great thickness	
13. Light grey limestone; <i>Ptychites gerardi</i> and other • Muschelkalk forms	
12. <i>Brachiopod</i> limestone	} lower.
11. <i>Otoceras</i> beds (passage-bed)	
10. <i>Productus</i> shales	Permian.

This sequence of beds is well seen between Muth and Tilling, west of Khar, between the Spiti river and the Manirang pass, etc. It forms a large part of the Spiti area, and in places shows immense flexures and reversions. In my forthcoming "memoir" I shall give a description of the various triassic sections seen in Spiti.

From the above sketch of the formations in Spiti it appears that Stoliczka's views with regard to them must be modified in the following points:—

- (1) The silurian closes with the flesh-coloured quartzite series (4) and not with the "Muth quartzite" (8), which is carboniferous; already correctly surmised by Oldham.
- (2) A dark limestone (5) may be either lowest carboniferous or devonian; probably the latter.
- (3) The carboniferous is in great force and reaches up into the fossiliferous limestone (9).

- (4) The black *productus* shales (10), the Kuling shales of Stoliczka, belong structurally to the group of beds which ends with the rhætic and lias limestones, and they are probably of permian age.
- (5) The middle trias (Muschelkalk) does not rest immediately on carboniferous as Stoliczka thought that it did ; but at Muth, at Kuling, and other localities in Spiti it rests on beds with lower trias fossils, which again are linked through the *Otoceras* passage-beds with the permian *productus* shales.

Mazâr-i-Sharif,
Afghan Turkistán,
11th March 1889.

Report on the Cherra Poonjee Coal-Field, in the Khasia Hills ; by TOM.
D. LA TOUCHE, B.A., Deputy Superintendent, Geological Survey
of India. (With a plan.)

The coal of Cherra Poonjee occurs near the top of an isolated ridge, between the station of Cherra and the village of Maomlu, steeply scarped on nearly every side, and rising to about 300 feet above the general level of the plateau on which the station is built. A bed of limestone, about 75 feet thick, resting immediately upon the sandstones composing the plateau, forms the base of the ridge, and upon this rest several beds of sandstone and shale, containing one seam of coal which occurs at from 10 to 15 feet above the limestone. The whole of these beds, including the limestone and the sandstones of the plateau, are nearly horizontal, having a slight inclination to the south or south-west ; so that the seam of coal, which, with the beds accompanying it, was formerly of much greater extent, is cut off on every side by the steeply scarped hill-side, and its outcrop, if not concealed by jungle or débris fallen from above, would form a continuous ribbon, following the contour of the hill. It is thus an easy matter, by measuring along this contour line, and ascertaining the thickness of the seam wherever it is exposed, to arrive at an approximate estimate of the total amount of coal contained in the hill.

2. The coal appears to have been first worked in the year 1840, when Colonel Lister was Political Agent for the Khasia Hills, and obtained a perpetual lease of the mines from the Raja of Cherra, to whom the ground belongs. Considerable energy seems to have been shown in opening out the field, as I find from Dr. Oldham's account of it in Vol. I, pt. II of the Memoirs, Geological Survey of India, published in 1858, that during the four years succeeding 1840, about 8,500 tons of coal were sent down by Colonel Lister to Calcutta and other places. But since then the mines have been in the hands of private companies or individuals, and in the 44 years that have elapsed since 1844, the amount of coal extracted has actually been less than that mined in the four years they were under Colonel Lister's management. Probably the want of a market nearer than Calcutta would account for this

for in those days the tea gardens of Sylhet were in their infancy, and there were no steamers running on the rivers of the district. But this has all been changed of late years. So important was the field considered at that time, that Lieutenant Yule, R.E., was commissioned to draw up a scheme for carrying down the coal to the plains. After careful surveys he proposed the construction of self-acting railed inclines; a project which was revived some years ago, and carried nearly to completion by the late Major Willans, R.E., though the bringing down of coal from Cherra was apparently not the main reason for the undertaking, owing perhaps to a mistaken idea that the coal had been nearly exhausted. This project, I firmly believe, only requires the expenditure of a little energy, such as animated the pioneers in the working of the coal-field, to become a complete success. As it is, the remark made by Dr. Oldham in his memoir thirty years ago still remains true,—“And to the present day any coal brought down from these mines is carried on coolies’ backs, as at the first.”

3. The idea to which I have alluded, that the coal is already nearly exhausted, may be partly due to an error made by Dr. Oldham in estimating the total amount of coal: he took the area of the field to be one third of a square mile, which is not very far from the truth, according to my survey; but in making his calculation he altered this to one third of a mile square, or one ninth of a square mile, thus making the total quantity of coal only 387,000 to 447,000 tons, instead of from 1,200,000 to 1,370,000. Besides this, the manner in which the coal is worked by the Khasias might also give rise to the idea that the supply is nearly exhausted; for as soon as they have driven a gallery some 100 or 120 feet in from the outcrop, they abandon it, partly because it is easier to begin a fresh one than to continue digging at such a distance from the surface that lights become necessary, and partly from superstitious reasons, but on no account because they have come to an end of the seam. Thus, the numerous old workings along the outcrop would lead one to think that a much larger amount of coal has been extracted than is really the case. I measured all the mines, both old and new, that could be entered, as carefully as possible, and found that the amount already extracted is only about 6,500 tons; to which should be added that extracted in Colonel Lister’s time, for the mines then being worked were on the eastern face of the hill, towards the station of Cherra, as appears from a wood-cut in Dr. Oldham’s memoir. This would make the total quantity of coal removed since 1840 only 15,000 tons, the insignificance of which may be imagined when it is considered that a difference of only *1 inch* more or less in the average thickness of the seam over the whole area estimated for, would make a difference in the total amount of coal, one way or the other, of over 21,000 tons. And I need hardly say that it would be simply impossible to estimate the thickness correctly within such narrow limits. Or, to put it in another way, the amount hitherto removed, if we assume the thickness of the seam to be 6 feet, would occupy less than two of the 200 feet squares shown on the plan.

4. The survey of the coal-field that I have lately carried out has been made as carefully as the nature of the ground would permit; the greater part of it is covered with very dense scrub jungle, through which it was extremely difficult to follow the line of outcrop; but the number of times that we came upon coal in places where even the natives did not know that outcrops existed lead me to think that the line

I have drawn is not very far from correct. The outcrop at the point marked X on the plan on the western side of the field, is in a rather anomalous position, and I am inclined to think that a fault running from north to south through this point, with a down-throw of about 40 feet to the east, occurs here. Such a fault is mentioned by Dr. Oldham as occurring on the western side of the field, but his map is too small to show its position. In any case it does not affect the quantity of coal to any great extent. It is probably due to a sinking in of the surface to the east, caused by removal of the underlying limestone in solution by water, as has happened in many other places in the neighbourhood. In some cases, where the limestone beneath has been largely removed, the surface beds have fallen in, forming circular depressions or swallow-holes, which sometimes extend down to the seam. A large one, surrounded with a fringe of mines now being worked, occurs close to the G. T. S. station of Ranzsanobo, and is shown on the plan.

5. It will be seen from the plan that the thickness of the seam is by no means constant, though it rarely seems to be less than 3 feet, while in places it reaches as much as 9 feet. It is therefore difficult to form a reliable estimate of its average thickness over the whole area, and I have preferred to divide this into smaller areas, taking what I considered to be a fair average thickness for each. When the cubic contents of each of these are added together, and assuming that one cubic foot of the coal weighs one maund (of 27 to the ton), which is very nearly its exact weight, the total is found to be 1,184,369 tons, which must be taken as only an approximation, the real amount being rather more or less, according as I have over or underestimated the average thickness of the seam.

6. Owing to the manner in which the coal is distributed, as a nearly horizontal seam cropping out all round the sides of detached hills, and at no great distance, not more than 150 feet or so, vertically below the highest point of the hills, it should be possible to extract nearly the whole of the coal, if the mining is carried on upon correct principles and under efficient supervision. At present the Khasias, as I said before, follow their own devices, opening fresh galleries as soon as they have driven those they are at work upon to a certain distance, and capriciously abandoning many even before they have reached such a depth from the surface as to necessitate the use of lights. They hardly ever make any attempt to work out the coal between adjoining galleries, as this would oblige them to use props for the roof, and the coal forming the sides of these galleries, as well as that in the abandoned workings, must be slowly, but surely, deteriorating in quality, exposed as it is to the air and the excessive dampness of the Cherra climate. The small coal also, which must be produced in the operation of hewing the coal, which would form excellent coke, or could be used on the spot for lime-burning, as there is an inexhaustible supply of limestone immediately below the coal-beds, is either thrown away or burnt and entirely wasted, the coolies only taking the larger blocks, which are easily carried on their backs. A competent practical miner could soon instruct the Khasias how to work the mines in a systematic way, and as they are not unintelligent, his services would not, I imagine, be required for a very long period. At present they are only carrying on the methods shown them when the mines were first opened, and they do not improve merely because they have been taught no better plan of working. As the mines are extended further towards the

centre of the hill, it may become necessary to sink shafts to meet the seam, but none of these need be more than 100 feet deep, and no expensive winding machinery will be necessary to bring the coal to the surface. Nor is any pumping machinery required, as the workings can always be constructed, so as to drain themselves, owing to the slight inclination of the seam to the south, and the position of its outcrop, above the drainage level of the surrounding plateau. Another advantage is, that the outcrop on the eastern side of the field, where the seam is from 4 to 7 feet thick, is within a few hundred yards of the tramway between the Cherra terminus and Maosmai, and the coal could be lowered directly from the pit's mouth into the trucks below, either through a wooden shoot, or by means of a short branch incline: while the remainder of the field is altogether above the level of the tramway, so that loaded trucks could be sent from any point down an incline to reach it.

7. But there is not much use in having so fine a seam of coal, possessing so many advantages, available, unless some better arrangements are made for its carriage to the plains than those which now exist. Perhaps some 30 or 40 maunds are now being taken down per day, where at least as many tons should be carried; and there is little doubt that a large and steady supply would meet with a ready sale in the tea districts of Sylhet, and on the steamer lines of the Surma valley;—not to mention the fact that this is one of the few Indian coals that can be used on board ocean-going steam-ships, and that it would very likely be possible to obtain a contract for supplying some of these vessels in Calcutta, if a steady supply were forthcoming. To carry such an amount of course the completion of the nearly finished tramway would be necessary, and for my part, speaking of course as an amateur on such a question, I cannot see where the great difficulty lies in completing it. I have seen many of such tramways in the west of England, several of much rougher construction than this, and no difficulty occurred in working them. One in particular I would mention, at the Clee Hills in Shropshire, which is used for bringing down "Dhu stone," a basalt much used for pavements and road metal, and about three times as heavy, bulk for bulk, as the Cherra coal, from the top of the hill. It is nearly a mile long, and built on the ordinary gauge of English railways, so that it is much larger than any of those at Cherra. Three or four trucks, full of stone, descend at each journey, pulling up the same number of *empty* ones, the brake power being trusted to prevent the descending trucks running away. Now at Cherra, I believe, in any experiments that have been made, the descending trucks have been arranged so as to only slightly overbalance the ascending, no reliance being placed on the extremely powerful brakes, one an automatic hydraulic brake, and the other applied by hand, to prevent their exceeding a certain velocity; and naturally, when the descending truck is on a less inclined portion of the tramway than the ascending, the whole arrangement ceases to move. I should like to see, say, two or more trucks full of coal or limestone drawing up empty trucks sent down each incline in turn, and I believe the result would be entirely satisfactory. Want of experience, in such a special form of engineering, probably accounts for the failure, and the remedy is obvious.

8. The length of time that the coal-field will last, will of course depend upon the carrying capacity of the tramway and the amount of labour employed in mining; but, supposing that the tramway can carry down 1,000 tons per month, or 12,000 tons a

PLAN

of the

N. II COAL-FIELD

year, the coal, allowing 5 per cent. for wastage, should last at least ninety years. The amount derived from the sale of the coal and coke should be all clear profit, as its weight would be used to bring up goods from the plains, the freight on which should suffice to pay for maintenance, supervision, &c., of the mines and tramway.

9. There is one point which was noticed by Dr. Oldham, and which calls for consideration,—namely, the clause in the lease of the mines given by the Raja of Cherra to the Government in 1840, whereby the subjects of the Raja are not to be prevented from working the coal seam on their own account. This clause, if carried out, would effectually prevent any systematic plan of working the mines being successful, as is pointed out very forcibly by Dr. Oldham, to whose remarks on the subject I would draw attention.¹ But, if it is decided to work the mines properly, the present Raja might be induced to agree that any works carried on by his subjects should be placed under the same supervision as the remainder of the mines.

10. The geological age of the Cherra coal is determined by the fact that it rests conformably upon limestones which are known by the fossils (Nummulites and others) they contain to belong to the Eocene or lowest division of the Tertiary period. To this period also belong several of the other small coal-fields of these hills, and the large seams near Makum in Upper Assam are also referred to it. The analyses of the coal given below show that it could be used with advantage either as a steam coal or for the production of gas, while its toughness renders it suitable for stowage on board steamers or locomotives, though from the absence of definite jointing it is somewhat inferior in this respect to good English coal.

Analyses of the Cherra coal.

1. By Mr. James Prinsep—

{ Volatile matter	37·1
{ Carbon	62·0
{ Ash | . . . . .	0·9
	<u>100·0</u>
Water	7·0

2. By Captain James—

Description.	Sp. Gr.	Cubic feet of gas per ton.	Percentage of coke.	Illuminating power of gas in candles.	Sp. Gr. of gas.	REMARKS.
Massive, fracture irregular in all directions, streak dark brown, decrepitates slightly, swells and fuses.	1·278	10·200	58·	15·	·424	{ A capital coal for steamers, being difficult to break, and would stow tolerably well; the coke is good and the gas particularly clear and white.

¹ Mem., G. S. I., Vol. I, Pt. II, p. 197.

Note on a Cobaltiferous Matt from Nepál. By E. J. JONES, A.R.S.M.,
Deputy Superintendent, Geological Survey of India.

Early in 1878 a specimen of a smelted substance from Nepál was examined by Mr. F. R. Mallet, and found to be a cobaltiferous matt, containing 11 per cent. of cobalt. Nothing was ascertained as to the origin of this undoubtedly artificial product (Manual of Geology of India, III, p. 325), and nothing more was heard of it till February 1888, when the Resident in Nepál forwarded some of what is evidently the same substance for examination. This specimen was obtained from Mr. Duncan Ricketts, who states that he was informed by the natives who supplied him with it, "that there are several smelting mines of the stuff, and that it is only obtained close by the copper mines in Nepál. The name of the locality is Kachipatar Argah, Zillah Sowrobhar, about 80 miles north of Doolha. The price on the spot is ₹30 to ₹35 per maund, and they sell it here (Doolha) at from ₹40 to ₹50 per maund." Doolha appears to be near Birdpore in Basti. After some correspondence, a further small supply was obtained, which I examined. The substance was in the form of a round flat cake, $6\frac{1}{2}$ inches in diameter and $\frac{1}{2}$ inch thick, of a dark-brown, partly black, colour outside; the upper surface being fairly smooth and flat, while the under surface was covered with irregularities, as though it had been run out on an uneven surface in a liquid or viscous state and allowed to solidify. The fracture is dull grey metallic; and the upper half is filled with air cavities. In the original specimen examined by Mr. Mallet, there were two layers, a light and dark grey, but, though this can be seen in some of the more recent specimens, it is not so in all. It is slightly magnetic.

On analysis the newer specimen proved to consist chiefly of sulphide of iron.

Analysis.

Loss at 100° C.	0.40
Insoluble in acids	0.70
Sulphur	20.41
Cobalt	13.97
Iron	62.82
	98.30

together with traces of copper, antimony, and lime.

On polishing a fractured surface, particles with a bright metallic lustre are seen to be irregularly distributed through the grey mass; and on treating with sulphate of copper, metallic copper was deposited.

The substance, therefore, probably consists in great part of a mixture of FeS and Fe₂S, together with free cobalt and possibly iron, produced by a process of concentration analogous to the concentration smelting of nickel ores for the production of matt; though Mr. Ricketts' statement about the proximity of the copper mines would seem to indicate that it may be a by-product of the copper-smelting. Mr. Mallet states in a note that "cobalt is principally used in the state of oxide for colouring pottery and glass, and 13.97 of the metal is equivalent to 16.69 of oxide. Assuming therefore that the specimen analysed is a fair average sample, the 'cheep' would yield nearly a

fifth of its weight of cobalt oxide. It appears from the mineral resources of the United States for 1886 (the last available)¹ that 14,215 pounds of cobalt oxide were imported in that year, valued at \$22,757, which is at the rate of £717 per ton. According to Mr. Ricketts' information, the cheep is sold at Kachipatar, the place of production, at ₹30 to ₹35 per maund, and at Doolha at ₹40 to ₹50. These prices are equivalent (taking the rupee at 1s. 4d. and 27·22 maunds as equal to one ton) to £54 to £64 and £73 to £91 a ton. As 5 tons of cheep therefore (containing 1 ton of cobalt oxide) would be worth at the above prices £270, £320, £365 and £455, and the cobalt oxide would be worth, after extracting, about £700 (to £650) (1), there would appear to be a fair margin to allow of the cheep being exported to England and treated there; that is to say if it is obtainable in sufficient quantity. The metallurgical treatment of cobalt ores being rather difficult, it does not seem probable that the natives of Nepal are acquainted with any process by which a fairly pure oxide can be obtained."

No information was received with the specimens as to the mode of occurrence, quantity, or treatment of the original ore.

NOTICE.

The President of the Geological Society of London on the International Geological Congress of 1888.²

Dr. W. T. Blanford having already in these Records³ given reports on the International Geological Congress at Bologna (1881) and at Berlin (1884), at which meetings he then represented the Geological Survey of India officially, he has, in his second year of the Presidentship of the Geological Society, made the subject of the Congress in London the theme of his Address. To geologists in India, and particularly to the Survey, many of whom look upon our old colleague as their master and guide in the study of Indian Geology, the reproduction in a further accessible form of so much of the address must be of interest and great use; and as such, the liberty has been taken of reprinting it in full in our Records.

"To English geologists generally, and especially to the Fellows of the Geological Society of London, the most interesting occurrence of the past year in connexion with our science has been the meeting of the International Geological Congress in this city. The history of that body is so well known that it is unnecessary for me to recapitulate it further than to remind you that the idea of a Congress originated in the United States of America, at the Buffalo Meeting of the American Association for the Advancement of Science, in 1876, and that meetings of the Congress have since been held at Paris in 1878, Bologna in 1881, Berlin in 1885, and London in 1888.

¹ In the volume for 1887, since received, the imports for that year are given at 28,681 lb, valued at \$42,034, which is at the rate of £657 per ton (£1 = \$5).

² Address *delivered at the Anniversary Meeting of the Geological Society of London, on the 15th of February, 1889; by W. T. Blanford, LL.D., F.R.S., President of the Society.*

³ Records, Geological Survey of India, XV, pp. 64-76; XIX, pp. 13-22.

"But although the history of the Congress itself has been related in some detail on more than one occasion, and recently by Prof. Prestwich in his opening address to the London Congress, I have met with no general account in English of the work done by the Congress and its committees. As I have had the advantage of taking part in the last three Congresses, and as I have attended most of the meetings of the International Committee for the unification of nomenclature since 1881, I may perhaps be able to give to the Fellows of this Society a few additional details, and thence to pass to the consideration of the question how far the action of the Congress hitherto has fulfilled the expectations of its founders.

"In order to explain the subject to those who have not followed the history of the Congress closely, it will be necessary to go into some detail, and I must ask the Fellows of the Geological Society to bear in mind that in treating of a body mainly composed of European geologists, I occupy to some extent an alien position. At Bologna and at Berlin I attended the Congress as the official representative of the Geological Survey of India, and it is probable that on several questions English geologists hold views differing materially from mine, whilst if the Reports of the British Sub-Committees on classification and nomenclature, and the Preface by Prof. Hughes, as presented to last year's Congress, faithfully represent the opinions of British geologists, I am obliged to dissent in some respects, as I will endeavour to explain hereafter.

"I must also point out that several of the subjects to which I propose to refer, have been treated with great clearness by Prof. G. K. Gilbert in his able address read at New York in August 1887, to Section E of the American Association. In the majority of Prof. Gilbert's views I heartily agree, and like myself he regards the whole question from an extra-European standpoint.

"There may be some difficulty in ascertaining what were the expectations of the geologists who originally suggested the idea of the Congress, and it may even be questioned whether the anticipations of all who assisted in the conception of that body were similar. The object of the Congress, as expressed in the resolution passed by the meeting of the American Association in 1876, was 'for the purpose of getting together comparative collections, maps, and sections, and for the settling of many obscure points relating to geological classification and nomenclature,' &c.; and this object was further defined and, so far as it is possible to judge, correctly defined at the Paris Meeting, where two International Committees were appointed, the one to deal with the unification of geological nomenclature, the other to propose a general system of coloration and signs for geological maps. A third committee, composed entirely of French members, was formed to consider the rules of palæontological and mineralogical nomenclature.

"Of the subjects referred to the third committee, one, and that the only one upon which a report was presented and action was taken, was clearly beyond the scope of a Geological Congress. Palæontology, so far as the nomenclature is concerned, is purely a branch of biology, and palæontologists must adhere to the rules of nomenclature already established in zoology and botany.

"Unfortunately zoological rules have not the same general acceptance as botanical; some zoologists are men with but little scientific training and imperfectly informed, and a few refuse to submit to any rules but those of their own caprice; consequently, as palæontology depends more upon zoological than on botanical nomenclature, there is much excuse for the offences against the rules of nomenclature in which it must be admitted that a few palæontologists indulge. This eccentricity in nomenclature on the part of a few palæontologists doubtless led to the nomination of a committee and to the proposal of a set of rules which, after discussion and amendment, were adopted by the Bologna Congress. These rules differ in no important respect from the Stricklandian Code of the British Association, adopted by a large majority of English and by many foreign zoologists. Although, as has already been said, the subject is not one on which a Congress of geologists is entitled to speak with authority, it is but right to say that the discussion at Bologna was left entirely in the hands of biologists, and was closer, more to the point, and more free from intervention by unqualified speakers, than any other discussions that took place at that meeting; in fact, coming at the conclusion of the week's proceedings, the sittings were only attended by those who were interested in the question. The conclusions are therefore well worthy of the attention of palæontologists.

Amongst the most important are the exclusive acceptance of binomial terms and of the rules of Latin orthography, and the rejection of pre-Linnæan names. The rule that in future no palæontological specific names should be recognized as valid unless the species is figured as well as described, is also of great importance. One minor point, the recognition, under the name of 'mutations,' of geological varieties, or forms, in strata of different age, corresponding to the geographical varieties or races inhabiting different areas on the earth's surface, was a useful addition to palæontological terms.

"The two more legitimate undertakings of the Bologna Congress have had a longer and more checkered history, and the story of the two has become much interwoven. Originally, as most geologists will remember, the two international committees, that for geological maps and that for nomenclature, were composed of a number of geologists, fourteen in the first case, fifteen in the second, each of whom represented his own country, and each of whom was expected to form, in that country, a national committee who should report to the general or international one. In the majority of cases such national committees were formed; but, as might be expected, several sent in no reports, whilst the recommendations of others were received too late to be noticed in the General Report drawn up by the Secretary of each international committee and laid before the Congress.

"The result was, that the General Report on the unification of map-colouration and signs, drawn up by Prof. Renevier, the Secretary of the International Committee, was founded on reports from Russia, Switzerland, France, Italy, Spain and Portugal (combined), and Belgium. No reports had at that time been received from the committees formed in Germany, Austria, Great Britain, Scandinavia, or the United States. A Report from the English Committee was received at the Bologna Congress, but was never before the members in a printed form. In short, of the fourteen countries represented on the international committee, the views of less than one-half were in the hands of the Secretary when he drew up his General Report.

"The question of map-colouration was, however, not only important but urgent. It is easy to look back now and to see that the Bologna Congress would have acted with greater wisdom had it postponed several of the questions on which a decision was taken; but it might fairly have been urged, on the other hand, that the crucial experiment of deciding scientific questions by the vote of a Congress was worth trying. Failure might have been foreseen; but as there were many believers in the wisdom of majorities, it was well that they should have an opportunity of being undeceived. At all events a proposal was made by Prof. Renevier to establish a colour-scale for geological maps, and it is possible that, had his proposals been adopted as they stood, the scale would have had a better chance of being generally accepted than has that employed in the map of Europe. As Professor Renevier's original scheme has been to a great extent forgotten, it may be as well to recall it.

"The whole of the sedimentary rocks were classed in four 'series' (this was, of course, before a different signification had been allotted to the term), archæic, palæozoic, mesozoic, and cænozoic; and each of the three latter was divided into three parts, to each of which a distinct tint was assigned. It was proposed that recent formations should be left white, and that the other sedimentary strata should be coloured as in the following list:—

CÆNOZOIC.	{	Pliocene (including Pleistocene).	Pale sepia-yellow tinted orange.
		Miocene.	Brownish yellow (Jaune chamois).
		Eocene.	Gamboge-yellow.
MESOZOIC.	{	Cretaceous.	Green.
		Jurassic.	Blue.
		Trias.	Brick-red.
PALÆOZOIC.	{	Permo-carboniferous.	Dark Grey.
		Devonian.	Brown.
		Silurian (including Cambrian).	Violet.
ARCHÆIC.			Pink.

"With regard to igneous rocks no recommendations were made, the subject being regarded as not sufficiently studied. To one of the observations, however, which appears to me very important, I shall revert presently.

"The Bologna Congress, it will be recollected, only decided upon the colours for Pre-Cambrian and Mesozoic rocks, and in doing so accepted Prof. Renevier's proposals, with the exception that, on his own recommendation, violet was adopted for Trias instead of brick-red,

as had been proposed in the printed report. Yellow tints were accepted for Tertiary systems, the higher beds to be represented by paler shades. The selection of hues for Palæozoic rocks and the whole question of the coloration to be adopted for igneous formations, were referred to a committee appointed to arrange for the publication of a geological map of Europe.

"There can be little doubt that the adoption, almost without discussion, of a different colour from that originally recommended for the Trias, was one of the greatest mistakes made by the Congress. The question should have been postponed. But, in point of fact, the question of the colours to be adopted for maps is one of which very few geologists have any wide experience, and it is consequently one which a congress of geologists is ill-qualified to discuss.

"Before passing away from Prof. Renevier's Report, it is as well to call attention to the circumstance that some very useful proposals were accepted unanimously by the Congress. These were:—(1) that different shades of a colour (or, as some express it, different tones of a hue) should be adopted for subdivisions of a system, the darkest shade being employed for the oldest subdivision; (2) that the lettering or literal notation for sedimentary rocks in general should be founded on the Latin alphabet, and that for igneous rocks on the Greek; (3) that each sedimentary system should be represented by a corresponding capital letter (*e.g.*, Jurassic by J), principal subdivisions of each system by the addition of a small initial letter (Portlandian by Jp), and the minor subdivisions by figures (Jp¹, Jp², &c.), the most ancient of the latter being represented by the lowest figure.

"One other contribution to the question of map-coloration and signs was furnished by the essays sent in to the Congress to compete for the prize of 5000 francs (£200) offered by the King of Italy for the best memoir on these subjects. Although not one of the papers offered was deemed worthy of the full prize, three received awards and were published in the General Report of the Congress. All of these—and especially the first, by M. Heim, of Zurich—contain useful suggestions.

"The principal result of the whole discussion in the various Committees and in the Congress was, however, a resolution to publish, under the auspices of the Congress, a general geological map of Europe, on a scale of 1/1,500,000 (between 23 and 24 miles to the inch). It was arranged that the map should be prepared in Berlin under the direction of Prof. Beyrich and Mr. Hauhecorne, and the superintendence was entrusted to a Committee composed, in addition to the Directors and the Secretary (Prof. Renevier), of representatives of France, Italy, Russia, Austria, and Great Britain. This Committee has gradually become a kind of general referee, to which all difficulties and contested points have been left for solution.

"The second International Committee already noticed—that for unification of geological nomenclature—should have been first mentioned, if the various subjects presented for consideration to the Bologna Congress were arranged in the order of their relative importance. I have, however, left it for the last, because it appears to me to be the subject in which the smallest result was obtained. The National Committees certainly began at the beginning, but for the most part they unfortunately ended their labours before arriving at any conclusions of scientific importance. It may fairly be doubted whether the American founders of the Congress contemplated laying down rules for the abstract terms to be applied to subdivisions of strata or of geological time. But congresses, unlike men, do change their minds when they cross the ocean, and the geological ideas of Paris were naturally very different from those of Buffalo. It was only natural that the first two Congresses being held amongst people of the Latin races, terms should be treated with the precision essential in the language employed at the Congress. Another consideration to be borne in mind is, that a very large proportion of the leading geologists are engaged in teaching students, and are consequently inclined to attach great—possibly, in some cases, too great—importance to an exact definition of the terms to be used.

"It is scarcely necessary to recall to your recollection the geological terms agreed upon by the Bologna Congress—how the words *rock* and *formation* were defined; how it was resolved to divide the whole geological sequence of strata into *groups, systems, series, stages*, and '*assises*,' and to employ as terms of duration equivalent to the first four the words *era, period, epoch*, and *age*. Unfortunately these terms, when adopted, were, by the nature of the case, by no means rigorously defined, as it was impossible to say what was the relation in magnitude between, for instance, an epoch and a period; and although no difficulty was found in the division of all sedimentary rocks into great groups, and of geological time into great eras, the

case was different when an attempt was made to divide the Palæozoic, Mesozoic, and Cænozoic groups or eras into systems or periods and series. This took place at a subsequent stage.

"As in Paris, so in Bologna, the consideration of the further steps to be taken towards the establishment of uniformity in geological nomenclature was entrusted to a Committee composed, on this occasion, of 17 members, each representing a separate country. Meetings of this Committee, and of that for the geological map of Europe, were held together in September 1882 at Foix in the Pyrenees, and in August 1883 at Zurich in Switzerland. Both meetings, considering that the members of the Committees came for the most part from distant parts of Europe, were well attended. Of the 17 members of the Nomenclature Committee, 8 attended at Foix and 9 at Zurich; whilst of 8 members of the Committee for the preparation of a geological map of Europe, 5 were present on each occasion and took part in the discussions on nomenclature. These were mainly devoted to a classification of sedimentary and igneous rocks to be recommended to the Geological Congress of Berlin for adoption in the geological map of Europe. Questions relating to the coloration of the map were discussed by the Map Committee sitting by itself. Thus the whole question of unification, both of maps and of nomenclature proper, between the Bologna Congress of 1881 and the Berlin Congress of 1885 (and I think more real progress was made during this period than either before or after), was mainly limited to a thoroughly practical undertaking—the general classification of rocks, and the general system of coloration for adoption in the geological map of Europe. But although there were many advantages attending the practical form that the question of unification had taken, there was a serious disadvantage in the limitation of the discussion to Europe; and, in fact, this change involved a complete departure, unless I am much mistaken, from the intentions of the geologists by whom the original scheme of a congress was proposed.

"A scheme of classification in groups, systems, and series was drawn up by a committee of German geologists and submitted to the International Committee for approval. It may be useful to quote side by side the original list and that which was finally accepted for the map:—

1. Gneiss and Protogine.	{ Gneiss.
2. Crystalline schists.	{ Crystalline schists.
3. Phyllites.	{ Azoic schists.
4. Cambrian.	Cambrian.
5. Lower Silurian.	{ Lower Silurian.
6. Upper Silurian.	{ Upper Silurian.
7. Lower Devonian.	{ Lower Devonian.
8. Middle Devonian.	{ Middle Devonian.
9. Upper Devonian.	{ Upper Devonian.
10. Lower Carboniferous.	{ Lower Carboniferous.
11. Upper Carboniferous.	{ Upper Carboniferous.
12. Lower Permian. }	Permian.
13. Upper Permian. }	
14. Lower Trias.	{ Lower Trias.
15. Middle Trias.	{ Middle Trias.
16. Upper Trias.	{ Upper Trias.
16'. Rhetian.	
17. Lower Jurassic.	{ Lower Jurassic.
18. Middle Jurassic.	{ Middle Jurassic.
19. Upper Jurassic.	{ Upper Jurassic.
20. Lower Cretaceous.	{ Lower Cretaceous.
20'. Gault.	{ Upper Cretaceous.
21. Upper Cretaceous.	
22. Eocene.	{ Eocene.
22'. Flysch.	{ Oligocene.
23. Oligocene.	{ Miocene.
24. Miocene.	{ Pliocene.
25. Pliocene.	
26. Diluvium.	Quaternary. ¹
27. Alluvium.	Modern.

¹ From a note by Prof. Renevier, I learn that this term will be replaced in the published map by Pleistocene.

"On the classification of both sedimentary and plutonic formations many reports were received from different National Committees. Several of these reports contained replies to particular questions that had been circulated as to the classification of certain subdivisions, such as Gault and Rhætic and the method of dealing with strata of indefinite or transitional age, such as the Flysch.

"One very important proposition was brought before both meetings by Prof. Neumayr—that of the publication of a '*Nomenclator Palæontologicus*,' to contain a complete list, with full references to description, locality, and stratigraphical position, of all fossil species of animals and plants described up to the date of publication. The plan was approved by the Committee and received most favourably by the Congress of Berlin. Unfortunately, financial difficulties have hitherto prevented the scheme from being carried out. This is greatly to be regretted; it is difficult to name an undertaking that would prove a greater benefit to palæontology, or one that would afford greater aid towards carrying out a uniform nomenclature.

"The meeting of the Berlin Congress, which was originally to have been held in 1884, was postponed for a year, because it was thought by the Committee of Organization that the existence of cholera in Southern Europe in the first year might seriously interfere with the attendance of geologists. The Congress met at the end of September 1885, and was well attended, 166 German members and 86 of other nationalities being present. The number of inscribed members absent or present was 456.

"It was evident from the very beginning that there was a marked contrast between the Berlin meeting and that of Bologna. How far this was due to a change of scene, and to the fact that the bulk of the assembly belonged in one case to the Latin and in the other to the Teutonic race, it is difficult to say. These cannot have been the sole causes of the differences, for most of the principal actors were unchanged, and the questions of nomenclature brought before the meeting were susceptible of treatment precisely similar to that employed at the Congress of Bologna. There can, however, be no doubt that a strong reaction had set in against the attempt to decide scientific questions by the vote of a majority; and in one instance, at least, on which opinions were greatly divided, the question as to whether the Permian should be regarded as a distinct system or united to the Carboniferous, the assembly deliberately abstained from voting. This question had already been discussed in the Nomenclature Committee at Zurich, and the numbers who voted on each side were equal.

"It may here be pointed out that there is a great difference between a vote in a body consisting almost entirely of geologists familiar with the subject and of varying nationalities, as are those composing the Committee of Nomenclature, and a vote in a body of which the large majority belongs to one nationality and is composed to a great extent of those who have not paid particular attention to the details under discussion.

"As a result of the meetings in Berlin, the proposals of the Map Committee for the classification of both sedimentary and igneous rocks were accepted with a few modifications. Two questions, however, were especially left over to the next Congress, which was appointed to be held in London last year. These questions were, the arrangement to be adopted for the Lower Palæozoic system or systems beneath the Devonian, and the classification of the Tertiary and (if admitted) Quaternary groups as a whole.

"A considerable proportion of the time devoted to the work of the Congress at Berlin was occupied by the reading of papers on various geological subjects, several of them not relating to the questions before the Congress. Similar papers were sent to Bologna, but were not read, though they were inserted in the General Report.

"The reports from the British Sub-Committees on geological classification and nomenclature were presented at Berlin as a whole (some had been previously distributed), but without the preface subsequently added in the edition of 1888. These reports differed materially from any that had previously been presented. They were far more detailed, and contained a history of each stratigraphical subdivision, and much information concerning the distribution and relations to each other of the various series, stages, and sub-stages, so as to afford an epitome, in detail, of the stratigraphy of the sedimentary rocks occurring in Great Britain and Ireland. To the consideration of these reports I shall return in the sequel.

"The Committees for nomenclature and for the map of Europe were reappointed, with but trifling alterations, at Berlin; but the meetings between 1885 and 1888 were comparatively un-

important. Five members only of the Nomenclature Committee, out of the full number (20), met at Geneva in 1886, and eight at Manchester in 1887. Some of the conclusions arrived at by the first meeting, with regard to the modification of the Bologna decisions, met with disapproval at the second—a circumstance mainly due to the difficulty of adopting the same terms in all languages.

“Finally, the fourth Congress was held last year in this city, and brought together a larger body of geologists than any previous meeting. The whole number of members was 830; of these 407 were present, 256 being from the British Isles and 151 from other countries. It must, however, be remembered that for the first time ladies were admitted. The number of well-known geologists was large; as an instance, it may be mentioned that 9 of the Society's foreign members and 13 foreign correspondents attended the meeting.

“A fresh change took place in the method of procedure. At Bologna the reports drawn up by the Secretaries of the different Committees were discussed paragraph by paragraph, and accepted, modified, or rejected after a regular discussion. At Berlin certain parts of the reports were accepted with little or no modification, others postponed. In London the reports were almost ignored, and only three subjects were discussed; two of these were the questions already mentioned, relating to the classification of Lower Palæozoic and of Post-Secondary rocks, and the third was a fresh subject of discussion—the origin and history of the crystalline schists—brought forward by the Organizing Committee and treated in a novel manner, by obtaining and printing beforehand dissertations from several specialists. On none of the subjects named was there any attempt to arrive at a decision: there was simply a discussion. It may be added that, whereas in one of the stratigraphical questions—the Cambrian and Silurian—there was some approach to a general agreement about the principal facts, and in the other a majority of the speakers were in favour of a particular view, the subject of the crystalline schists was left as chaotic as ever, or as, according to some of the disputants, were the conditions of the geological era when the schists themselves were formed. So far the discussion has scarcely tended towards unification of either nomenclature or views; the Neoneptunists still stand widely apart from the Neoplutonists; nor does there appear to be any prospect of agreement between those who pin their faith on gradual chemical or hydrothermic action and those who believe in violent movements of the earth's crust, or between those who contend that the ‘Urgneiss’ could only have been deposited in the Archæan era and in the depths of the primæval ocean, and those who urge that gneiss absolutely undistinguishable from its pre-Cambrian type has been formed in all geological epochs, and may be forming at the present day under favourable circumstances of heat and pressure.

“The discussion on Tertiary classification, too, was almost confined to one point—the distinction of the Quaternary as an era apart from the Tertiary. The important question as to whether some better classification could not be adopted than that into Eocene, Oligocene, Miocene, and Pliocene, the limits of the different systems, and the desirability of subdivision, at all events in the case of the Eocene, were scarcely mentioned.

“Besides the papers on crystalline schists and the second edition, with the preface, of the British Sub-Committee's reports on classification and nomenclature, there was presented to the London Congress a series of reports by American Sub-Committees on the classification of the sedimentary formations of North America. The importance of this work is due primarily to the fact that it does not refer to the portion of the world that has of necessity been accepted as the standard of comparison for the geological scale; and, secondly, to the circumstance that much of the information has been accumulated very recently, and has not found its way into text-books. A summary of the conclusions, drawn up by Dr. Persifer Frazer and translated by Prof. Dewalque, was circulated separately. It is to be regretted that a similar *résumé* of the reports of the British Sub-Committees was not prepared.

“The history of the Congress, it will thus be seen, up to the present time, is the history of an undertaking begun with great, if somewhat misdirected, zeal and energy, and gradually descending in its aims, till, from attempting to establish an universal geological language, and to regulate the coloration, signs, and scale of geological maps in general, it has contented itself with supervising the issue of a map of Europe in which both classification and colour are admittedly tentative; whilst, instead of deciding points of primary importance by votes, it discusses questions, sometimes of secondary importance, without attempting to lay down any law. In passing from

Bologna to Berlin, and from Berlin to London, there has certainly been a tendency on the part of the Congress to abdicate its early pretensions, to collect information, and to cease from issuing edicts. It now remains to be seen what will be the effects of the meeting of 1891 in Philadelphia; whether the Congress will rise again, Antæus-like, in its pristine vigour, from contact with its native soil; or whether it will resolve itself into the intercalation of a little mild academic discussion between much more largely developed schemes of social amusement—a fashion not unknown in other scientific meetings, especially when ladies are admitted.

“In considering how far the institution of a triennial Congress has hitherto fulfilled the expectations of its founders, it becomes necessary to discuss the apparent results hitherto obtained. These are:—

1. The terms adopted at Bologna;
2. The subdivisions and colouring adopted on the geological map of Europe;
3. The various reports from different national and international Committees, and all other documents published in connexion with the Congress.
4. The exhibition of maps and specimens.

On each of these a few words may be added.

“1. The various terms for strata and time adopted at Bologna have been accepted to a considerable extent abroad, but have as yet found but small favour with English geologists. Even in the reports of the British Sub-Committees on classification and nomenclature there is a complete disregard of all restrictions upon the use of terms.

“It is quite true that the number of kinds of subdivisions made in both stratigraphy and time by the Bologna Congress was rather greater than was necessary, and that the restriction of the two words *group* and *series* to particular subdivisions in the scale renders it very difficult to write upon stratigraphy in English, owing to the poverty of the language in geological terms and to the fact that these two words have been used for every kind of subdivision indiscriminately. The use of *group* for so large a division as Palæozoic and Mesozoic is quite opposed to our habit, as the word has hitherto been more frequently used in the sense of the French *étage* than for any larger division. The proposal repeatedly made by the French and other Committees to transpose the words *group* and *series*, and to apply the latter to great divisions like Palæozoic, and the former to divisions of the third order, would be an improvement; but it would be far preferable to diminish the number of subdivisions, and to eliminate both words, *group* and *series*, from the restricted list—to revert, in fact, to the original proposal of the English Committee in this respect. Professor Hughes calls attention to a suggestion of Professor Sedgwick's, to use *class* for the largest divisions. I had made the same suggestion myself, in ignorance of Professor Sedgwick's employment of the word, when writing on the subject for the International Committee meeting in Geneva; and I think if English geologists would agree to employ the term *class*, or, as Professor Cope has suggested, *realm*, as the English equivalent of *group*, and to omit *series* and *assise* altogether, as unnecessary, we should have three words left—*class* or *realm*, *system*, and *stage*—two of which are additions to our very poor list of English terms. I cannot agree with Professor Hughes in objecting to the word *stage* because it is not exactly the equivalent of *étage*; it appears to me a great advantage to have an English word to fit precisely where a term is peculiarly wanted. I feel sure that if English geologists will condescend to try the term they will find it extremely useful. If intermediate or inferior subdivisional names are needed, the terms sub-class, sub-system, and sub-stage might be employed.

“The distinction drawn at Bologna between stratification- and time- words is one of very great importance, and I believe English writers would do wisely and would aid in the progress of the science by adopting the reformed nomenclature. Until there are clear ideas on the subject, and until the distinction of the two categories is rightly appreciated, there is but little hope of any sound classification.

“There is, however, one of the time- words adopted at Bologna that must in English be left for unrestricted use, for the simple reason that we cannot replace it. This is *age*. It is impossible to avoid writing of strata and fossils as of Palæozoic age, of Jurassic age, &c.; and although this might be done without ceasing to use the term as the time equivalent of *stage* it would be better to replace the word by another, or, if the number of subdivisional terms is

diminished, to omit *age* altogether. I would suggest to British geologists for consideration some such scheme as the following:—

<i>Stratification.</i>	<i>Time.</i>	<i>Example.</i>
Class.	Era.	Palæozoic.
System.	Period.	Jurassic.
Stage.	Epoch.	Oxford Clay (Oxfordian).

If this or some corresponding plan were adopted, there would be no necessity for the adoption of the word *terrene* proposed by Professor Gilbert to be used for a stratigraphical subdivision of any magnitude, though the language would gain by the employment of such a term.

"It must not be forgotten that if, as already noticed, the Bologna Congress failed to define the subdivisions that it sanctioned, the failure depended very much on the inherent impossibility of the task. There is absolutely no scale by which periods or epochs can be measured; all that can be done is to enumerate certain divisions of geological time as represented by particular strata and enact that such subdivisions shall rank as periods or epochs. As the stratigraphical divisions are utterly dissimilar in different countries, the determination for one region will afford but little aid in another. All that can be done, in short, is, as has been admirably pointed out by Professor Gilbert, to adopt an admittedly arbitrary and empirical scale of systems for the sedimentary rocks of Western Europe, as being the best known, and to employ this scale for comparison in other countries.

"The classification of the geological sequence has, in fact, been founded on no recognised system, but has grown up gradually. Just as in a newly-discovered country, or in a barbarous continent in process of annexation by more civilised peoples, a colony has been founded here and there, until by irregular growth, depending for its progress on various circumstances, the borders of the different territories have come into contact and require to be defined. If good natural barriers, such as a mountain-range or a broad river, intervene, these have generally been taken as frontiers; but if not, frequently after much dispute, some less defined line has been adopted. Substitute for colonies strata and for the physical boundaries of rivers and mountains the equally well marked limits corresponding to petrological change, often accompanied by unconformity, and the history of the repartition of the stratigraphical sequence into systems and stages corresponds to the subdivision of geographical areas into states. The story is a story of haphazard, in which scientific induction has played a subordinate part, and the idea of rendering the divisions equal has probably never occurred to any one.

"There is, however, this difference between countries and strata. The mapping out of the former covers the whole area, whilst the latter in any and every country can only represent a certain portion, probably a very small portion, of geological time. The gaps that are unrepresented are an unknown quantity, but are undoubtedly in any given area in excess of that portion of the scale that is represented by strata. Therefore, even if the thickness of strata in any subdivision were directly proportional to the duration of time occupied in the formation of that subdivision—in other words, if the thickness of a system varied directly with the duration of the corresponding period, which it most certainly does not—the duration of the corresponding division on the time-scale would still be unknown, as the time corresponding to the breaks in the sequence is undeterminable.

"2. Under these circumstances, and seeing that anything like an equalized scale is hopeless at present, there is a fair reason for accepting, as has been done in the map of Europe, those periods that are best known. In the Mesozoic era, for instance, in which the relations of the periods are simpler than in the Cænozoic or Palæozoic, there can be very little question that a division of both Cretaceous and Jurassic into two would produce periods much more nearly equal to the Trias in palæontological importance (the only approach to a time-test that we possess) than are the great Cretaceous and Jurassic periods as at present usually adopted. This subdivision of the Mesozoic era into five periods—Cretaceous, Infra-cretaceous, Oolitic, Liassic, and Triassic—has been adopted by several geologists, amongst others by Renevier and by De Lapparent in his 'Traité de Géologie.' It would, however, have required a much more general agreement than exists amongst European geologists to have justified so marked an innovation in the map of Europe. The same remark applies to the acceptance of the Permian as a distinct subdivision, although it is not only inferior in importance to the Trias, but is palæontologically an integral part of the Carboniferous. To reduce such periods as Cretaceous, Jurassic,

Silurian, and Cambrian into a form in which they would represent, even approximately, divisions of the same duration as Pleistocene, Pliocene, and Permian, would involve a complete rearrangement of the whole geological succession. Before an attempt is made at such a rearrangement, it is desirable that a larger area than Western Europe should be selected for the field of experiment.

"When, however, we pass from the systems of the map to their subdivisions, it is difficult to avoid feeling some degree of doubt as to whether a more equable arrangement might not have been adopted, even for European rocks. The Trias is divided into three series, the far more important Cretaceous system into only two, and the Eocene and Cambrian are undivided. It is impossible to avoid regretting that the relative local importance of particular subdivisions has led to the raising of a comparatively unimportant stage like the Muschelkalk to a rank equal to that of Neocomian and Gault combined, or to that of the Lias, together with the Rhætic in many localities, or to that of the whole Cambrian. The fact, of course, is that in this case deference has been paid to a time-honoured classification peculiar to part of Germany and a small area in France. This is an illustration of the evil produced by merely local classifications and by the misleading name under which the Triassic system is known, a name derived from the local subdivision of the system into three well-marked stages, two of which are, in the main, subærial, fluvatile, or lacustrine, and the third alone marine. The latter, moreover, contained a peculiar local fauna which probably inhabited an inland sea, and differed materially from the true marine Triassic fauna which has now been traced from the Alps and Spitzbergen to Chili and New Zealand. In short, the so-called typical Trias is altogether an exceptional and abnormal system, and useless for purposes of comparison.

"The coloration of the sedimentary rocks in the map of Europe has the very common defect that the colours are in large measure too dark and too opaque; but it is understood that this will be altered to some extent. The system of colours does not give satisfaction in America, nor, so far as is known, elsewhere. It is to be regretted that violet was not kept for Silurian, as proposed by several of the National Committees, and brick-red for Trias, as advocated by almost all; and no doubt the change in this respect has done something to render the system adopted unsatisfactory. Violet between grey (Carboniferous) and blue (Jurassic) is open to the objection that the paler shades are not sufficiently easy to distinguish, whilst brick-red (impure orange) is distinct in all shades.

"It may, indeed, be doubted whether any scheme of coloration could be devised that is free from objection. Much has been said of the advantage of a system based upon the solar spectrum, and, indeed, in the plan adopted there are some lingering traces of a spectral system,—blue, green, and yellow succeeding each other in the Upper Mesozoic and Cænozoic groups. Professor Gilbert has suggested a very ingenious and apparently simple plan of dividing the spectrum into hues defined by their wave-lengths, or, which comes to the same, by their position on the Kirchhoff scale. He is of opinion that from fifteen to twenty sufficiently distinct hues can be thus selected, and these, with the purples which are not contained in the spectrum, would suffice for the different periods. He would then allot brown to igneous rocks.

"This plan has, I believe, one fatal objection. If the adjacent spectral hues are in contact on the map, even though the full tones or shades be distinct, the paler tones will not be so. The only remedy would be to alternate colours from different parts of the spectrum, and then the orderliness of the plan, its principal recommendation, would disappear.

"The fact is that the distinctness of colours adjacent to each other is an essential requirement of any efficient system, though but few of those who have treated of map-coloration in connexion with the Congress have referred to this important point. It must be remembered that all hues in contact should remain sufficiently distinct after a certain amount of fading from exposure, and that all should be easily distinguished by artificial light.

"The classification and coloration of the igneous rocks on the map of Europe is very unsatisfactory, and I shall probably have the hearty concurrence of English geologists in general in condemning the system proposed as impracticable. In the first place, as was pointed out by Professor Renevier some years ago, it is illogical to arrange the sedimentary rocks entirely by their geological date, irrespective of petrological character, and the igneous rocks entirely by petrological characters irrespective of their date of origin. No doubt, in the map of Europe, a petrological distinction is made which is supposed to be connected with

geological age, when diabase and melaphyre are distinguished from basalts, and porphyry from trachyte and its allies; but the supposed connexion between geological antiquity and mineral characters in the case of these rocks is held by the best English petrologists, and on sound evidence, to be erroneous. It is difficult to see why the igneous rocks of which the period is known cannot be represented by the colour of the period to which they belong, but deep and opaque, the petrological character, if it is considered essential, being represented by the monogram; whilst some simple convention might be used for outbursts of unknown period. Or all igneous rocks might be represented by one conspicuous colour, the monogram serving to distinguish the kind of rock. It is difficult to understand why in a map in which no colour-distinction is drawn between limestone and sandstone, chalk and slate, rock-salt and coal, clay and iron-ore, quartzite and gneiss, except that due to geological age, it is essential to distinguish by colour between granite and porphyry, melaphyre and basalts, peridotite and serpentine, although several of these are so inextricably mixed in places that their outcrops could not be disentangled on a map with a scale 100 times larger than that of the map of Europe. It is reasonable to suppose that the assignment of one colour to the lavas of active or extinct volcanoes, another to the ashes and scorix, and a third to 'stratified tufts,' was proposed by geologists who had not much personal experience of volcanoes of either kind. Really the proposal to map the three apart on a scale of 24 miles to the inch sounds like a joke.

"But even accepting the fact that what has been done hitherto must be done in the future, and that the geologists of Western Europe insist on colouring the igneous rocks on a system radically distinct from that employed for sedimentary formations, it is still difficult to understand the advantages of so many subdivisions as have been adopted in the map of Europe, or to understand how it will be possible to colour the numerous outcrops of igneous rocks that are intermediate between two of the ill-defined groups established, or composed of two kinds belonging each to a separate group. Surely, if petrological characters must be the guide in coloration, some simple division, as into basic and acid rocks, would suffice. There would be difficulty even in this, as when trachytic lavas are interstratified with basaltic, or when a rock occurs containing a percentage of silica on the artificial limit between acid and basic rocks; but all difficulties of this kind increase in geometrical ratio with the numbers of groups into which an attempt is made to classify the various rocks.

"Whilst thus criticising some of the details of the map, it would be unfair not to recognise the fact that the Directors have worked under considerable difficulties, having, in fact, been obliged to act very largely on their own responsibility. In all probability no map of Europe would have been produced had not Professor Beyrich and Mr. Hauchecorne undertaken the direction of the work, and all geologists owe a debt of gratitude to those gentlemen. Although it is not likely that this map will determine the questions of coloration and nomenclature, it will doubtless contribute largely to their being settled.

"3. It is probable that the published accounts of the different meetings of the Congress form the most important contribution made by it to Geological Science. The reports from the various National Committees are naturally very unequal in importance, but many of them are excellent, and all of them suggestive.

"In this connexion it will be, I hope, not impertinent if I call attention to the British Sub-Committees' reports. In the preface these reports are held up as a model on which those of other countries should be framed, and it is claimed that 'the greatest advance in the work proposed to be done has, so far, been made in practical England.' A claim of this kind invites criticism, and as the writer is the President of the National Committee, and therefore the representative of English geology, his views are doubtless those of many British geologists. As already noticed, these reports contain an epitome of the detailed stratigraphy of the British Isles, arranged in convenient divisions, the report on each division being written by one or two authors. The history of the various names employed for the different subdivisions in which the strata were classed is given, and the views of the principal observers as to the correlation and classification of the beds in various parts of the country are recorded. There is naturally some inequality; slight differences are, however, to be expected, and taking the work as a whole, there appears to be every reason to believe that the authors have carried out very thoroughly that which they undertook, *vis.*, to give the history, synonymy, and detailed classification of British sedimentary rocks.

"But the question which has occurred to me, and, I think, probably to some of the foreign geologists who have had occasion to consult the 178 pages of details, is this:—In what way does all this work contribute to the Unification of Geological Nomenclature? It is easy to see that the reports under consideration will facilitate the work of those who have to fit the geology of the British Isles to the map of Europe, though even for this purpose some knowledge of the correlation between British and continental strata is necessary. Undoubtedly, too, the information given in these reports will be most useful to compilers of general works on Geology, whilst to all British geologists it will be of advantage to have within reasonable compass so general an account of the British stratified rocks. But unless I am much mistaken, the object supposed to be in view is the establishment of a general classification for the strata of the world, or at all events of Europe, and for this the careful and elaborate details upon which so much labour has been expended by the reporters appear superfluous. As the British strata have been very largely taken as types, especially in the Cretaceous, Jurassic, Silurian, and Cambrian systems, the history of the names is important; but a general table of the beds from top to bottom, arranged according to the latest information available, would have been sufficient for purposes of comparison with the strata of other countries. If comparison with the systems and stages of distant countries was contemplated, far more complete information as to palæontology should have been given. In short, I venture, with some diffidence, to suggest that the work may produce upon those who, like myself, approach the question from a foreign point of view, the impression that there is too much of data that are of little or no use except to local geologists, and too little of the information that would be useful for comparison with the geology of other countries.

"It may be assumed that the principles upon which the work has been compiled are those stated in Professor Hughes' preface. In this he urges the adoption of a natural, as opposed to an artificial system, and points out that the characters of greatest value in the classification of the sedimentary rocks are obviously those which indicate changes of condition affecting sedimentation and life. He then proceeds to explain what he means by an artificial system; and here I would venture to suggest that a different view may be taken of the matter.

"If Professor Hughes had confined himself to urging that in classifying the rocks of any limited region, or even of a country the size of the British Isles, the breaks in stratigraphy, whether petrological or palæontological, must first receive attention, and that such breaks must be accepted as limits of the subdivisions in which the strata are arranged,—if, in short, it were urged that a local classification must depend upon different considerations from those deemed of primary importance in a general classification, his views would necessarily deserve acceptance, since he would only recapitulate the facts upon which all local classifications have been based. But, if I understand him rightly, this is not the position he takes. He contends that palæontological classification, and especially a classification by marine or "pelagic" types of life, is artificial, and that the only natural classification is founded upon local breaks in sedimentation or in life. I am unable to agree with any of the above contentions, and I must say that I shall be very much surprised if in these points Professor Hughes represents the views of British geologists in general. Indeed, in some of the reports that follow his preface, for instance in the remarks by Messrs. Jukes-Browne and Topley on the Purbeck beds (p. 73), I find precisely the opinions put forward with regard to the part played by marine faunas in classification that I have hitherto understood to be generally held amongst geologists throughout the world.

"There can be no question that all breaks in stratigraphy are local, and that such breaks are or may be represented elsewhere by beds. Moreover, local breaks are very often misleading, because the amount of change, and especially of unconformity, is not proportionate to the lapse of time, but depends on phenomena often confined to a limited area, and which may have been of no great duration or real importance. Thus the great break and unconformity between the Coal-measures and Permian in Great Britain is shown to be representative of but little lapse of time by the fact that no change of any importance took place in the marine fauna, the alteration in which between the Carboniferous Limestone that preceded the Coal-measures, and the Permian magnesian limestone, is actually less than that between Devonian and Carboniferous, which are not separated by any important stratigraphical break. If any great lapse of time, or any widespread physical changes, corresponded to the local break between

Carboniferous and Permian in England, it may reasonably be assumed that a great change in marine life would have taken place in the interval.

"The argument to which Professor Hughes naturally refers, that identity of marine fossils in distant localities does not prove synchronism, but rather suggests that the strata were not of contemporaneous origin, as time would be needed for migration, is one on which perhaps too much stress is laid by English geologists. In the course probably of a geological age, certainly of a geological period, there must be ample time for the migration of marine forms, whether pelagic or littoral, throughout all seas that are in connexion. If the marine fauna of the present day be examined, it will be found that many marine genera, both of vertebrata and invertebrata, are of world-wide range, and that still more are distributed in wide belts stretching round the world. This will be found to be the case with littoral quite as much as with pelagic forms, though there may be more specific variety in the former. Still a host of littoral genera, such as, amongst the Mollusca, *Littorina*, *Patella*, *Purpura*, *Nassa*, *Natica*, *Chiton*, *Mytilus*, *Cardium*, *Solen*, *Maetra*, and *Pholas*, are found on almost every coast in the world.

"Now the identification of the age, or still more of the period, to which a fossil fauna should be referred does not necessarily depend upon all or any of the species being identical with those in a known deposit. Complete identity, when the deposits are far apart, seldom or never occurs except amongst pelagic types, the occurrence of a few identical or allied species, and a similar association of particular genera and subgenera, being the evidence usually adduced in favour of contemporaneous origin. Thus the faunas of marine deposits in America or Asia compared with those of the same geological age in Europe, will be found to exhibit much the same resemblance to each other as do the faunas of the present seas taken from two equally distant parts of the earth's surface. There is one possible exception to be borne in mind. It is probable, though not absolutely proved, that the present temperature of the Arctic regions is much lower than it has been on an average in past times—it is certainly lower than it was in some epochs—and that consequently not only the Arctic fauna, but also that continuation of the Arctic fauna which extends from pole to pole at the bottom of the deep sea, differs more from the tropical and subtropical faunas than has been the case throughout the greater portion of geological time.

"Still, despite this disadvantage, if the living marine fauna of any part of the ocean, including Vertebrata, Mollusca, Crustacea, Echinodermata, Foraminifera, &c., is compared with that of the early Tertiaries (Oligocene or Eocene), a great generic difference will be found, fairly comparable to the distinction between Eocene and Cretaceous life. Comparison of the recent forms with Miocene types would show a distinct, but less well-marked, difference, and if recent and Pliocene faunas were compared, the distinction would be still smaller; but all the newer Tertiaries, commencing with the Miocene, form but one period with recent times, if the marine faunas are taken as the test; and it may be doubted whether the Pliocene could even be separated as a different geological age from the Recent.

"So far I have merely ventured to express a different opinion from Professor Hughes. But on one point I think he is mistaken, and it is very important to call attention to the mistake, because the idea expressed may be widely spread amongst geologists. Professor Hughes says that 'we are every day reminded by the work of specialists that the result of applying the botanical measure often differs considerably from that obtained in the present state of our knowledge from a consideration of the included animal remains. . . . This does not destroy our confidence in the value of palæontological evidence. We have no doubt that when all the fossil evidence, botanical and zoological, has been adduced it will be consistent.'

"Now I think that it will be found that the real contrast in the indication of palæontological age is not between botany and zoology, but between land or fresh-water faunas and floras on the one hand, and marine faunas on the other. So far as is known, there is not a single well-marked case of the inversion of marine faunas, the only instance of any importance ever brought forward, that of Barrande's colonies, in which an Upper Silurian fauna was supposed to occur in beds intercalated amongst others with Lower Silurian types, having, I believe, been conclusively shown to be founded on a mistake in observation. This fact, the absence of all evidence of inversion, is of itself a proof that similarity of pelagic forms does signify practical synchronism; because, if the similarity implied difference of time due to migration, some cases of inversion

must occur.¹ But in land faunas and floras cases of inversion and of the association of types characteristic of different epochs and even periods in the same beds are numerous. Thus we find the Miocene mammals of the Pikermi beds resting upon Pliocene marine strata in Greece; a Middle Jurassic flora in beds interstratified with others containing a Carboniferous marine fauna in New South Wales; similar strata with Middle Jurassic plants in India overlain by beds with Triassic, and by others with Rhætic plants, and these again succeeded by others with Triassic reptiles; Middle Jurassic plants intercalated between Neocomian and Tithonian beds in Cutch, and Tertiary plants associated in the same strata with Cretaceous Dinosaurs in the Laramie beds of North America. Such cases are explained by the circumstance that the distribution of the land fauna and flora at the present day is very much less uniform than that of the sea; that a terrestrial zoological genus of anything like world-wide distribution scarcely exists; and that even under the same parallels of latitude, amongst the terrestrial genera in America, Africa, and Australia, for instance, only a small percentage are the same, whilst many of the families and some of the orders are peculiar, all testifying to isolation from great antiquity.

"There is, moreover, evidence that the recent fauna is sometimes descended from that which inhabited the tract in Tertiary times, sometimes from an immigrant fauna. Thus, as has been pointed out by Prof. Huxley, by Mr. Wallace, and others, the Mammalian fauna of Central and Southern Africa at the present day is descended from the Miocene (and Pliocene) life of Europe. If a bed were found in Southern Africa containing bones of giraffes and certain antelopes, naturalists only acquainted with European fossil faunas would class it as Miocene (or Pliocene), although it might rest upon strata with Pleistocene marine fossils.

"Again, the recent Mammalian fauna of Australia and New Guinea is Mesozoic rather than Tertiary in its affinities. Nevertheless it is by no means improbable that the gigantic migrations produced by the cold of the Pleistocene epoch have rendered the earth's terrestrial fauna and flora more uniform than was the case in past times; and it may be doubted if anywhere in the world at present there is so wonderful a contrast as that between the Carboniferous flora of Australia and the contemporaneous vegetation of Europe and North America.

"It may be possible, when far more is known than is the case at present, to make out the history of the terrestrial faunas and floras of different subdivisions of the earth's surface. But when the history is known, it is safe to predict, from the little already ascertained, that the tale of the land will not coincide with that of the sea, nor will the story of one terrestrial region be the same as that of another. So far as our present information goes, we must, I believe, in mapping out geological periods and epochs, rely upon what Professor Huxley has called "sea-reckoning" alone.

"4. There is one other feature of each Congress that has hitherto produced a sensibly beneficial effect; this is the exhibition of maps and specimens. This was one of the objects for which the Congress was originally constituted, and one the usefulness of which is unquestionable. At every meeting many geological maps from various countries have been exhibited, and have afforded an opportunity for the comparison of different systems of coloration, signs, &c. Many specimens of general scientific interest, too, have been brought to the notice of those present at the Congress; for instance, the Trilobites and Corals in crystalline schist from Norway, exhibited by Prof. Reusch in Berlin, the Belemnites in metamorphic rock from the Alps, shown by Prof. Heim, and the striated fragments (apparently showing glacial markings) from Carboniferous beds in the Punjab, exhibited by Mr. Oldham in London.

"Comparing the performance of the Congress with the objects of its founders, it may briefly be said that the Congress has succeeded, to a certain extent, in getting together comparative collections, maps, and sections, but that it has not settled many obscure points relating to geological classification and nomenclature.

"There remains one other subject to consider—the probable effect of the Congress upon the progress of Geological Science. This, I believe, has already been much greater than is commonly supposed, but in a direction quite apart from that leading to the geological millen-

¹ This may be shown thus: let there be two areas, one inhabited by a fauna A, the other by another fauna B. Now let A migrate into the area occupied by B, and *vice versa*. We should then find in the one area B fauna in the upper bed, A in the lower; in the other area A in the upper, B in the lower. Of course the relations would in all probability be more complicated, but the results would be the same.

nium which was anticipated when we should have achieved a uniform geological nomenclature and system of representation by maps. The principal result so far has been the bringing together many geologists from different countries, and affording them an opportunity of becoming personally known to each other. The effect upon the diffusion of geological research, and the consequent reaction of one observer's discoveries upon another who is inquiring into a cognate subject in a distant country, is very great, and is likely to increase. By this means a much greater step will be made towards unification of nomenclature and maps than would result from the appeal to a majority at a Congress.

"Another advantage is the bringing together and publishing the views of different men who have paid attention to particular points connected with the progress of the science. When the views differ so widely as in the case of the crystalline schists, but small progress towards unanimity can be expected; whereas in another matter discussed at the London Congress, the division of the Lower Palæozoic rocks, there was a general agreement as to the partition into three of the Cambrian and Silurian complex, and this really settles the question; for it is evident that on palæontological grounds the lowest division or Cambrian must be classed apart from the other two. There can be no doubt, too, that the wide dissemination of the discussion on a geological question has a good effect, as even if it leads to no results, it produces thought and study in fresh directions.

"I have already expressed my grave doubt as to whether a vote in any Congress can be accepted as the opinion of a qualified majority, and I am inclined to believe that many, perhaps all, of the questions proposed for solution are beyond the scientific range of a considerable proportion of the members. The first objection to the method of voting was that the natives of the country in which the Congress was held outnumbered all others present, and thus, that foreigners, many of whom were representative men, and some of whom were especially sent to represent scientific bodies in their own countries, were hopelessly outvoted. An arrangement adopted at the London Congress will obviate this difficulty in part, it having been decided that whenever a vote is taken the members belonging to the country where the Congress is held and the foreigners shall vote separately, and unless there is a majority in each class of members, the vote shall be null and void. With this improvement a vote may occasionally be taken, but its value, unless the agreement is almost unanimous, will be small, unless the personal composition of the minority is known.

"Membership of the Congress in Bologna was limited to authors of memoirs on geology, palæontology, or mining, university professors, teachers of natural history in public schools and technical institutes, doctors of natural science and mining engineers; but still the opinions of theological, classical, mathematical, or chemical professors on geological nomenclature, or of mining engineers, on the colours to be used in geological maps, could scarcely be considered as authoritative. Where, as in London, the qualification for membership began and ended with the payment of ten shillings, the idea of deciding scientific questions by a majority would have been absurd. As in the case of the British Association, the methods of which are being largely followed by the Geological Congress, the latter must, if voting becomes necessary, select an inner body or committee, and even in a body of experts it must be borne in mind that no one is equally informed in all branches. The opinion of a geologist who has devoted his life to Palæozoic strata would not be of much value if it were sought to draw a line between Eocene and Miocene, and he would be even less competent to decide on questions of petrological nomenclature, whilst a petrologist with a world-wide reputation may never in his life have had to colour a geological map or have thought over the principles involved.

"One good effect the Congress has had already. It has set itself steadily against the adoption and even the discussion of sundry visionary and impracticable suggestions, and the number of these has steadily decreased. An admirable example has been set in the case of what are termed by many geologists homophonic terminations. It was proposed that all names of systems should end in -ic, series in -ian, &c. The proposal found no favour with Teutonic-speaking peoples, and was therefore unsuited for a Congress in which various languages were represented; but it happened to be a favourite project with some of the members of the Nomenclature Committee, and it has consequently been brought forward prominently in the report presented to three Congresses in succession. It is not, I think, likely to reappear."

Tin-mining in Mergui District. By T. W. HUGHES HUGHES, A.R.S.M., F.G.S., Superintendent, Geological Survey of India. (With a plan.)

I.—PREFACE.

Since the publication of Mr. W. T. Hall's Report on Tin-mining in Perak and in Burma, dated the 31st December 1888, to which was attached a fly-sheet by myself entitled *Preliminary Sketch of the Mining Industry of Perak and Burma*, I have been continuously engaged in endeavouring to gauge the physical conditions under which tin ore occurs in the Mergui district and also in setting at rest the misgivings as to whether the present languid character of mining operations is due to the original poverty of the mineral deposits now being dealt with.

I am glad to say that my observations, which are recorded in detail further on, lead me to acquiesce in the views entertained by my predecessors, and, I think, we must seek an explanation in causes other than deficiency and inaccessibility of ore for the feeble tone that marks the mining spirit of the district. Without ore there could of course, be no hope of solid improvement either in the method or amount of work now being carried on, but on this point there is no valid cause of apprehension, and I am sanguine that if the joint recommendations of Mr. Hall and myself are carried out, and if there be no serious fall in the price of metallic tin during the next five years, we shall witness a cheering amendment in the output of our mineral products.

II.—REGISTER OF OBSERVATIONS.

Kahan.—Early in January 1889, and so soon as the difficulties had been overcome which usually beset those to whom a country and a language are both new, I started up the Tenasserim river to visit Kahan hill, a classic fragment near Zedawun, situated about 12 miles from the civil station of Mergui, or Beik¹ as it is termed by Burmans. Each of the chief contributors to the literature on the mineral resources of the Tenasserim province—Captain Tremenheere, Dr. Oldham, and Mr. Mark Fryar—spent some little time in the examination of this locality, but the first writer appears to be the only one who entertained a favourable opinion of its productiveness.

Without entering minutely into the reasons that have influenced my own judgment I am inclined to say that the evidence is not sufficient to justify any vivid hopes of successful lode-mining.

Quoting from Captain Tremenheere's report he states :—" This locality appears to be of a very promising description and I have little doubt that, if the work were aided by ordinary skill and means, a tin mine here would be productive. The Kahan hill is, I conceive, an indication of a valuable repository of tin."

In 1872 Mr. Mark Fryar appears to have instituted a careful series of trial pits and costeaning trenches, and the conclusion he arrived at was that no such thing existed as a vein bearing ore, but

¹ In writing the name is converted into Myeikmyo, a metamorphism that I do not understand, but which my interpreter assures me is understood in Burma.

that a bed of micaceous felspar, of from 4 to 6 feet in thickness, occurred near the top of the hill, and that scattered through it were specks of black tin in very irregular and meagre amount. By the disintegration of this bed he thought that some of the ore was freed and small quantities dispersed through the lowland at the base of the hill.

The period since these prospecting operations were brought to a close has permitted the obliterating hand of time to assert itself, and I could see nothing more than vestiges of the explorations that had been carried out. Ranging about, however, as well as circumstances would allow me, and accepting such indications as were *en evidence*, I am of opinion that Mr. Fryar's views are the correct ones.

Leaving Kahan hill, which is close to the river, and going inland there is a promising spread of country in which I would most certainly recommend search being made for deposits of stream tin that seem to be of almost invariable occurrence in the vicinity of high land. The conditions under which stream tin is known to have its origin imply this of course, and in making the foregoing remark I am stating nothing novel; but it is a significant fact when framing our probabilities and the estimate of our local riches.

Zedawun.—The position near and around Zedawun offers great facilities of approach for boats and steamers, and if tin ore should haply be found in paying quantity it possesses all the natural advantages for the establishment of a new town, good river frontage, no foreshore, sweet water, excellent building-sites, and pleasant scenery. Indeed I might parenthetically remark that if the insalubrity of Mergui should necessitate the removal of the civil offices to another locality, Zedawun would be a very eligible situation.

Tharapôn.—The next place visited was Tharapôn, 32 miles from Mergui and situated, like Kahan, on the right bank of the Great Tenasserim. It so happened that I could not see any place where I could conveniently wash for ore, neither could I elicit any information as to ancient or modern workings in the neighbourhood. From the conformation of the ground, however, there is a fair chance of meeting stanniferous deposits, and this statement applies with equal force to localities north and south of the point.

From Tharapôn I had to hurry back to Mergui in order to secure a passage by the S. S. *Mergui* for one of the southern ports of the district. No understanding had been arrived at to enable me to detain the steamer where, for the convenience of my investigations, I might have found it advantageous to do so, and I was dependent on the cordial temper of the commander for such extension of time as he could wrest from his published time-table.

Bôkpyin.—Being anxious to inspect some of the mines of the Lenya township I disembarked at outer Bôkpyin, where we cast anchor the day after leaving Mergui. From here to inner Bôkpyin, where there is a police station, the journey had to be undertaken in a disreputable-looking, leaky, and cranky boat obtained as a great favour after an exasperating amount of solicitation.

Not knowing the capabilities of a Burman dug-out I quite expected a catastrophe

before reaching our destination, seeing that the whole of my camp equipage had to be stowed where there seemed room for only a couple of stools and a gun-case. By some art which is a puzzle to me to this day we managed to get under way with all the baggage and, taking advantage of the flood at 4 in the evening, we alternately drifted and paddled up-stream, doing the distance of 7 to 8 miles in something under three hours. We found comfortable quarters for the night at the guard-house, and with the stirring experiences of the afternoon we felt we had earned our rest.

On the morrow and the succeeding day I partly fulfilled the purpose of my trip and saw two of the principal stream workings owned by Sit Sin. There were only five men employed at the time of my visit, but during the rains I was informed that occupation could be found for a much larger number. I was not so concerned, however, with the statistics regarding labour as anxious to satisfy myself that tin ore occurred and that it existed in sufficient quantity to pay for extraction. Both these

Tin ore plentiful. conditions were amply fulfilled, and I have no hesitation in setting aside as untruthful the statements made to me by the proprietor that it was no longer worth his while to renew the leases which he held. Strong objection was raised to my visiting the mines, and I had to compound my desire for knowledge by agreeing not to go down into the workings, but to be content

Objection raised to visiting mines. with skirting their edges and taking a bird's eye view. This limitation was most repugnant to my feelings, but it having been represented to me that the period for the renewal of the mining licenses was just at hand, and that it would be advisable not to disregard prejudices which if offended might lead to the renunciation of all the mining-leases in the district, I grudgingly allowed myself to be swayed. The influence that could be brought to bear on the different proprietors through the power of the secret societies to combine in viewing me as a desolating *nat* was said to be absolute and, as it was of no great moment that I should personally make observation in workings actually proceeding, the District Surveyor (Maung Maung) took the necessary notes.

The superstitions of the Chinese appear to be both numerous and weird, but I am inclined to suspect that many of them are enlisted as safeguards against the interference of Government officials, and the acquisition of information on their part that might lead to the enhancement of the dues already levied from mine-owners.

Ore-bed, 5 to 6 feet. The ore-bed in the cuttings varied between 5 and 6 feet in thickness and was overlaid by 10 feet of top soil which had to be removed and thrown away as useless. Considerable ingenuity was displayed in the coursing of the drains, so that the full benefit of such natural stream power as existed was obtained without the expense entailed by mechanical appliances. Under these circumstances work must have been carried on very economically and certainly to a profit.

Two furnaces. The produce of the different mines in the vicinity of Bôkpyin is all smelted at the furnaces, of which there are two, owned by Sit Sin, a Chinaman. Mr. Mark Fryar refers to one small furnace only in 1871, so that the output of ore has apparently increased at Bôkpyin since his report was written.

To show how the industry now stands, I give below a list of workings compiled by the District Surveyor. The nationalities of the various mine-owners and proprietors are indicated, and the number of hands employed during the rains and dry season are given:—

Locality of the mines.	Owner's name.	Nationality.	NUMBER OF MEN EMPLOYED IN		Ground-rent.	Remarks.
			Rains.	Dry season.		
					R	
Bôkpyin creek	{ Sit Sin . . .	Chinese	32	6	120	Three mines.
Lelan Hill	{ Sit Hauk . . .		9	2	25	
Bôkpyin creek	{ Sit Pôk . . .		28	6	75	
Bôkpyin	{ Ashôk Sat . . .		5	...	25	
Bôkpyin creek	{ Sit Kein . . .		14	...	25	
Wulsan	{ Sit Sein . . .		12	...	25	
Bôkpyin creek	{ Mi Wun . . .	Siamese	35	7	145	
Shwe Payôn creek	{ Pi Than . . .		30	7	110	
Taung Kamit	{ Mi Kyaw . . .		13	2	25	
Kyaung Kinppa	{ Hnin Dit . . .		7	...	25	
Kawin south	{ Apyôn . . .		15	...	25	
Bôkpyin creek	{ Hnin Han . . .		12	...	25	
Pit Tauk south	{ Awîn . . .		6	...	25	
Kôkngôn creek	{ Hnin Pan . . .		3	...	25	
Rytaing	{ Mi Shat . . .		4	1	25	
Bôkpyin creek	{ Mi Kyaw . . .		8	...	25	
Wutsan	{ Pi Rat . . .		5	...	25	
	{ Nga Dan . . .		7	2	25	
	TOTAL .		245	33	...	

Wages seem to be the same now as they were a quarter of a century ago, but though greater facilities exist than formerly for procuring labour from Penang, complaints are rife as to the unsatisfactory character of the men who offer themselves. This is an old story, however, and no doubt if the miners were asked for an opinion, they would utter disparaging remarks about their masters.

I had only two days to devote to Bôkpyin as the S. S. *Mergui* was due on her return voyage after that interval, and consequently a large extent of country could not be covered. It was almost impracticable to leave a track except where it passed through or skirted a patch of cultivation, as the jungle was either too tangled to penetrate or the ground too swampy to walk over, but the evidence of ore was very clear in three or four small streams which were washed, and there is little doubt as to its general occurrence where the physical conditions required are answered.

The forest and undergrowth is something marvellous, and unless there are axemen to clear a path by hacking and felling, it is sheer waste of energy and temper endeavouring to force one's way through it. One learns the full significance of the word jungle by an experience of Lower Burma.

From inner Bôkpyin to outer Bôkpyin a road, 3 miles long, has been constructed. This I walked over on my return to the steamer to judge of its present condition and to observe the geological section that it might expose. It requires putting

Road from outer to in order, but it will repay expenditure on it, as it is well laid inner Bôkpyin. out and is a means of direct and easy communication between the mining district and the sea-board. It might indeed be extended to where the stream works are busiest, but this suggestion may be more appropriately considered when final action in respect to prospecting has been declared.

While referring to Bôkpyin I would recommend the erection of a small refuge house for storing Government property and as a shelter in inclement weather. Refuge house required.

On the 16th January Mergui was reached at 7 in the evening. Here three days were occupied in negotiating the hire of two river boats with the requisite crews, and in the purchase of rice and other stores for my camp, and we again started for the Great Tenasserim.

Tônbyaw.—My first halt was at Tônbyaw, 26 miles up the Tônbyaw creek, a tributary of the Great Tenasserim. Several places were shown to me as having furnished considerable quantities of tin stone during the old Burman rule when tribute had to be partly paid in ore. It is quite possible that my information was correct, but I could not confirm what I heard by finding any myself. Here, however, as elsewhere, deeper prospecting than surface washing may prove the occurrence of mineral deposits. Rain fell heavily for two days.

Thabawleik.—On the 22nd I arrived at the old town of Tenasserim, and having made up my mind to see the Thabawleik mines I sought to obtain information from the native magistrate (*Myoðk*) which might be of use to me. Unfortunately he knew less than myself, and said that he had never had any wish to see them, as they were situated in a wild and dangerous part of the district. An old Mussulman gentleman who had travelled informed me that the Chinese are very averse to anyone, except their own people, going there, and that their *nats* had tigers on the road to waylay the inquisitive and crocodiles in the rivers to bite off the hands of those who incautiously put them into the water. I mention these assurances as another illustration of the superstitions that surround the Chinese.

Further inquiries at Tenasserim being useless we proceeded up the Little Tenasserim river to the mouth of the Thagyet creek, where we found it necessary to exchange our boats for much smaller ones. We reached the village of Thagyeth-

Thagyethlèzeik, 24th lèzeik on the 24th January, and then had to make preparations for proceeding overland to the Thabawleik mines. No coolies could be procured for carrying our baggage and the boatmen had to be impressed for this service. They grumbled considerably at doing what they considered was *kulla's* work, and their dignity was very much hurt.

The road was represented as being impassable, the distance as varying between 18 and 24 miles, and halting-places as unknown. The truth, as I proved, was that an excellent fair-weather cart track had been cleared by the proprietor of the mines from his work to

Road to Thabawleik,
13 miles.

the river-side, which, shaded by magnificent trees and bamboos, made our march an exceedingly cool and easy duty. Instead of 24 miles the distance was under 13, and the road passes by three small-villages and skirts a fine sheet of water adorned with teal and other wild birds.

The Chinese camp at Thabawleik is placed on the hill-side overlooking some abandoned workings in the bed of the river.

The more recent operations are conducted lower down the stream, and from their size it is evident that, as in Dr. Oldham's day and in Mr. Fryar's time (1871) they are found to be profitable.

Unlike my experience at Bôkpyin no objection was offered to an examination of the mines. I accordingly took advantage of this tolerance, and on measuring the section in the upper cutting found a barren top soil varying in thickness from 6 to 10 feet, and then a strong pebble and boulder bed of slate and sedimentary rocks with highly-charged staniferous clay, 8 feet. Below this I was told no ore occurred, which is the general rule, and may be accepted as true in this case. Quartz fragments are much rarer in the pebble bed here than at Taiping, Renông, and Bôkpyin.

26th January 1889.

Ore bed 8 feet.

The mining of the ore is carried on exactly as described by Mr. Fryar, a suitable place and a convenient width of ground being selected, the non-paying earth removed, and the stream water led in such manner that it economises the operation of excavating and acts as a disintegrator. The miners are principally Chinamen, but there are a few Siamese. The cooly range is a building of considerable size, as it has to accommodate a large number of men working on the co-operative system during the busy season, but it was in a sickening state of defilement.

The ore is smelted on the spot in the ordinary open furnace (about 5 feet high) in use amongst the Chinese. The fuel is charcoal and the air-blast is supplied by a cylindrical bellows fitted with a piston and worked by manual power.

In endeavouring to arrive at an appreciation of the wants and wishes of the mine-holders I had a laboured conversation with the Resident Manager, Sit Saw, through the medium of the District Surveyor, who acted as interpreter. The difficulties he had to contend with, he said, were want of capital,

Difficulties complained of.

want of water, and inability to control refractory coolies. There was no deficiency of ore. There were reserves lower down the valley in which they were located; and they have prospected and found tin stone in other places adjacent, both on this side and on the other side of the hills on which their camp is pitched. As to the *want of capital*, this appears to be the normal condition of every Chinaman whom one addresses, and must be accepted with such reservation of belief as one entertains in the truthfulness of the speaker. The term as implying restriction of development owing to limitation of means is perhaps applicable to every undertaking, but it is too often urged to cover errors of commission and omission. This much appeared clear, that the present lessee of the Thabawleik mines had no wish to open out extensively, as

by so doing others might be attracted to the district and conflicting interests arise showing little respect for the prescriptive rights that his long tenancy has enabled him to claim.

Want of water was true only in the sense that sufficient means had not been adopted for controlling the resources they had in such manner that operations might be carried on throughout the year, or nearly the whole of the year. This difficulty has been met and practically overcome in the mining districts of Perak by the introduction of steam power, and the same measure might be adopted here.

Refractory coolies.—There seems to be fair ground for complaint under this head. An intractable cooly or a malingerer, or one who deserts, is a perplexing fellow in the absence of facilities for enforcing the obligations of his contracts. The evidence of such law as exists is too far removed to have any moral effect, and the application of it is too tedious a process to indulge in. Examples of successful insubordination demoralize the other workers. The malingerer invites imitation and the deserter is usually a loss in money as well as of labour. The remedy, I presume, is a more effective act which will protect the interests of employers.

From Thabawleik I returned to Tenasserim and proceeded up the Great Tenasserim river as far as Tagu. Examining such intermediate localities as were accessible, namely, Banlaw, Wunna, and Thamihla, I obtained no indication of tin stone, but this is probably due to the very little time that I could spare for investigation at each place.

Captain Tremenheere in his report of 1841 mentions the discovery of several old pits above Tagu, and this is evidence enough that tin ground occurs. Messrs. Melosch, Holman & Co., also carried on work for a short time at Theindaw.

Had leisure offered it was my intention to have explored the whole length of the Great Tenasserim valley as far as the boundary of the Tavoy district, but I had to prepare immediately for the downward journey to Mergui to again take advantage of the opportunity afforded by the monthly steamer of reaching Victoria Point, and thence going up the Pakchan river whilst there was enough water to bear me to the Banhuni¹ mines, which had the reputation of being the richest in the Maliwun township. There was a further inducement to visit them in the fact that they had never been reported on by any of my literary predecessors, and that nothing very definite was known about them.

Banhuni.—As difficulty was anticipated in procuring transport, the Deputy Commissioner (Colonel Alexander), who had some extradition cases with Siam to inquire into, proposed accompanying me as far as Nalingsan and seeing that the necessary arrangements were made for furthering my object. We quitted Mergui on the 7th February and reached Victoria Point and Nalingsan² (where the circuit-house of the Pakchan district is situated) five days afterwards. Mr. Leslie, Inspector of Police, who had been attached in that capacity for the last quarter of a century to the Maliwun frontier guard, and whose knowledge of the country is unique, was placed in

Mr. Leslie, Inspector
of Police.

¹ Ban = village, hu = ear, ni = gibbon.

² Pronounced and written Nalingchan in Siamese. Na = field, ling = steep, chan = bank.

charge of my party. Through his influence with the Siamese, who regard him as

Preparations for journey to Banhuni.

de facto representing British rule, the necessary number of light-draught canoes and their crews were secured. The

boats required four men each to handle them as there were known to be a succession of shoals and rapids through which they would have to be pushed or over which they would have to be carried; and, further, we had the current to contend with for nearly 60 miles. The racing canoe of Nalingsan, so nicely balanced that it accepted the slightest excuse for canting, was set apart for my use; Mr. Leslie occupied another. The provisions were placed in a third, and two policemen and two servants who could all row had a fourth. With this fleet we got

14th February 1889.

under way at daybreak on the 14th, and passed the last sign of habitation at Lonpaw, 10 miles beyond Nalingsan.

Thence to Banhuni the course of the river was through an almost unbroken stretch of forest and of silence. Our crews showed a spirit that amazed me after the disparaging remarks I had heard of Siamese activity and energy, for they plied their

Halt at Klôm sandbank.

paddles and their oars steadily until we had covered 29 miles.

We rested for the night on the Klôm¹ sandbank and ran up a slight screen of bamboos and leaves as shelter against the dew. It was good enough for the purpose it was intended for, but unfortunately we were overtaken by a heavy downpour of rain and as a consequence of getting wet, I had a touch of my old enemy,—gout.

On the following morning the men breakfasted before starting. By allowing them to do this they were fitted to keep steadily at work the whole day. They had a very rough task, jumping in and out of the boats times innumerable to lighten them, then guiding them through swirling rapids, avoiding dangerous juts of rock, and dragging them over shoals that multiplied in number as the day wore and when their exertions had begun to tell on their endurance. The last 10 miles after entering the Banhuni stream, which we recognized by its discoloured water, were very trying, and to my inexperienced eye it seemed an impossibility that our boats could make any progress amongst the detached blocks of rock, fallen trees, and snags that barred our way. Mr. Leslie, however, made light of my misgivings, and as evening fell I was glad to see that Banhuni was reached and that our men's labours were over.

The mines big and small at present worked are seven² in number, owned by the undermentioned proprietors, who employ between them about 200 men, Chinese and Siamese:—

Proprietor.	Number of men employed in the rains.
Meng Hong	120
Nu Noi	4
Chen Tain	7
Chek Yók	6
Chek Hoe	4
Chek Pein	3
Chek Wan Chu	3

¹ Klôm, the name of a murdered man.

² In the Akunwun's office the returns give 22 mining licenses for 1888-89. I can but repeat what was told to me. My acquaintance with the Siamese language is summed up in the words 'go on' and 'water.' I am most positive Mr. Leslie said that seven mines only were in progress and I entered that number in my note-book.

They have been opened out in the land lying along the base of the Banhuni range of hills where the conditions are exceptionally favourable for the Chinese system of working. There is a very full supply of water, and the ore-bed is 6 to 8 feet in thickness and of sufficient richness to repay the trouble of getting it. The locality well deserves the reputation that it possesses, and it is capable of considerable development. Here, as at Bôkpyin, I was asked not to go into the cuttings, but at the same time I was informed that, if I wished to disregard the request, no opposition would be offered. As I was anxious to be on good terms with the people and to encourage them to express their views freely with regard to tin, I thought it politic to fall in with their desire and, for the second time, I gave way to superstition.

On this occasion Mr. Leslie was my interpreter and conversation was carried on in Siamese. I inquired why objection was raised to my inspecting the workings, and the reply was that the guardian spirit of the mine would be offended if any one trespassed on the limit of his watch who failed to pay him respect, and as it was not expected that I would either offer joss-sticks at his shrine or doff my shoes to him, the best course was for me to pass by and not hurt his feelings. Any falling off in the outturn of the mine, any calamity arising from sickness, or any unusual occurrence would be ascribed to my want of reverence by the coolies; and the managers said they would certainly have trouble with their men.

Of the advisability of a labour law there was but one opinion amongst the employers, and they asked that the same rules as those prevailing at Renông might be introduced. I believe, however, that the amount of arbitrary administration which is there exercised could scarcely be permitted in English territory, but we might well take the regulations sanctioned in the Perak State as our standard.

As to roads they were somewhat indifferent, the Pakchun river affording them passable communication with Maliwun, Victoria Point, and Renông for eight months in the year during which time they could transport their supplies. A bridge, however, to Karathuri would give them another point at which to reach the sea-board. I finally alluded to the interests of Government, and inquired whether they considered it fair that they should have license to mine and deport tin from British territory without paying anything in the shape of duty or royalty. The answer was that the Siamese Government would not allow them to do so, but the English Chief Commissioner had seen how poor they were and was very sorry for them.

The largest employer of labour and the most successful mine-owner is Meng Hong, a Siamese Chinaman living at Kra, and it certainly struck me as anomalous that Siamese subjects should be allowed to invade English territory, take our tin stone (depriving us of resources that can never be replenished), cut down our trees, waste our lands, and subscribe nothing to our revenue. There is no reason why the ordinary dues should not be levied. The mines at Banhuni are the richest in the whole district of Mergui.

There is probably always an argument in favour of remitting heavy imports or modifying them as circumstances may dictate; but where the trifling claims of Government are found to be a withering burden I think the time to close such mines has arrived, for every acre of land converted into a spoil-heap is rendered useless for cultivation, and neither miner nor husbandman nor the administration is benefited.

The policy of not levying a cess of some sort is wrong as it is the visible sign of the paramount landlord. In a few years every squatter at Banhuni will deem himself the proprietor of the mine he works and of the ground his house stands on; and any attack on his customary immunity will be considered a breach of faith.

Sickness amongst the coolies is said to be very general, fever and skin affections being the most prevalent maladies. Both these diseases will probably exist where so many hardships as those incidental to mining have to be endured.

A miner's life is not an enviable one. In pouring rain and sun, alternately wet and dry, he has to work ankle-deep in slush and water. His food is a constant repetition of rice and salt-fish, interrupted on feast-days only by pork rarely garnished with vegetables. The water he drinks is good or bad as the case may be. He is usually a newly-arrived immigrant. The recollection of his old home is still with him. He has no woman's society. There are no public diversions, and he is encouraged, in the pecuniary interest of his employers, to seek joy in opium, fire-water, and gambling. He becomes lowered in body and mind, more susceptible to disease, and when overtaken by it is less capable of fighting against it. Some of the abscesses on the legs of the coolies at Banhuni were frightful sores, and itch and scurvy had attacked at least 30 per cent. of the men I inspected. The cooly ranges were filthy inside and the uncleanness outside was worse. Men defecated their persons where they pleased from the threshold of the house to the edge of the gutter holding their drinking-water.

Despite a storm brewing the night I stayed I preferred again getting wet to breathing fecal-burdened air, and I declined the invitation of the Manager of Meng Hong's mine to take shelter in the range.

Our return journey with the current in our favour was a moderately easy task; but for the benefit of those officers who may be desirous of going to Banhuni I would warn them not to attempt it after the month of February, as the water in the river falls too low for the passage of canoes. If I understand Mr. Leslie aright, bamboo rafts are used during the dry season, as the owners of boats are unwilling to subject their property to the heavy wear and tear of being dragged through shoals and of being bumped and knocked about in the rapids.

I was glad of a rest at Nalingsan to doctor myself for gout and to get rid of the stiffness induced by having to sit or, more rightly speaking, balance myself for twelve hours every day on a narrow boat's thwart.

Nalingsan.

E

Before ending this reference to my Banhuni trip I wish to acknowledge Mr. Leslie's services. I am told that he is thoroughly acquainted with the whole of the Mergui district, and, if any prospecting parties are organized, he would be a very fit officer to place in charge of one of them. In addition to English he speaks Burmese, Siamese, Chinese, Malay, and Karen; all of which are necessary as mediums of communication,—English and Burmese for official purposes, Siamese and Chinese amongst the miners, Malay for the islands of the Archipelago, and Karen amongst the hill tracts bordering the Great and Little Tenasserim rivers.

To reach Mergui we availed ourselves of the S.S. *Zephyr* on the 22nd February and on the voyage we called at the Marble Islands. They are a small group of detached islets and chiefly valuable for the edible birds' nests that are gathered in the caves formed in the limestone of which they consist. Our run occupied only two days, as we put in at none of the intermediate ports visited by the S.S. *Mergui*. I found orders

awaiting me to hold myself in readiness to proceed to Rangoon and possibly Calcutta, which were afterwards modified to go to Rangoon and then cancelled. Before I could act on the last decision, however, I had started in the mail-boat *Avagye*.

Karathuri.—It was not until the third week in March that I was able to resume field-work by availing myself once more of the S.S. *Mergui*. In the meantime I had coached the District Surveyor in a little geology and taught him how to distinguish tin stone; and a small prospecting party, of which he was to have control, was organized for the double purpose of looking for tin and tracing a route between

Karathuri and Bôkpyin, and Karathuri and Banhuni, which I consider essential for the welfare of the mines. With a Siamese interpreter, two chainmen, two washers, and two policemen, kindly placed at my disposal by Mr. Law, District Superintendent of Police, we left Mergui for Karathuri, making our point of disembarkation (called Kyinmezeik) on the 24th March. It is a rocky promontory (dividing the Karathuri and Chaungtaung creeks) with a small cluster of fishermen's huts on it, which were deserted when we arrived.

By good fortune we discovered a canoe that with patching was made sufficiently water-tight to enable the District Surveyor and a policeman to reach the Karathuri mines. With the additional help of two more boats we compassed our purpose of getting to Karathuri on a neap flood in two hours and a half. This includes the time occupied in walking a mile in the bed of the creek, as there is only water enough to float boats to the mines during spring tides.

I found everything nearly on a pattern scale and a considerable change must have come over the fortune of Karathuri since Mr. Mark Fryar visited it in 1871. For, writing in that year, he states:—
"The yield of mineral has fallen off in recent years, and in the village where formerly there appeared to have been a considerable population no more than five houses are now occupied. From what can be seen from simple

Mr. Leslie qualified to take charge of a prospecting party.

S.S. *Zephyr*, 22nd February 1889. The Marble Islands.

Orders to proceed to Rangoon, 1st March 1889.

Prospecting party organized.

Kyinmezeik, 24th March 1889.

Journey 2½ hours from Kyinmezeik to Karathuri.

Improvement of mines since 1871.

inspection of the places for tin-washing there is an evidence of poverty in yield of the mineral as compared with other places under examination."

The picture is a very different one now; men were busily employed in stripping fresh ground and in working standing-places. The ore-bed in one mine was 8 feet and in another 12 feet thick, of good paying character, and the supply of water was fairly abundant. The coolie range was neat and clean with a palisade around it. A guest-house stood in one corner of the compound, and a lofty shed covered a furnace in which the ore raised was smelted. The store-room was well filled, and on all sides the evidence denoted prosperity.

The lessee, a Chinaman named Sit Pu Shein, was absent, but his wife, Ma Chit Thu, an intelligent and affable Burmese lady of 37, very readily gave me all the information I wanted after assuring her that I had no wish to injure her interests, which I practically proved by acceding to her request not to go down into the workings they were newly opening. She quoted the prevalent belief of the Chinese in the sinister influence of European disregard for the sanctity of their ruling spirit, and told me that a most auspicious destiny for the new mine had been secured by the slaughter of a buffalo. With the object which has constantly been kept in view of fathoming the requirements and needs which, if supplied, might beneficially affect the output of tin, I closely interviewed Ma Chit Thu.

It appeared that next to lack of capital the sorest point was the desertion of coolies. She said there was no remedy against this nuisance. If instances were reported at the police station of Bôkpyin, the sergeant made a note of the complaint and humorously advised them to catch the runaways that he might send the cases to Mergui for trial. Under the most favourable circumstances this would involve such an expenditure of time and money that employers were practically debarred from taking any action and they had to resign themselves to the situation. An English Magistrate at Bôkpyin, she thought, would be a boon, as a Burman was too lazy and indifferent.

On the subject of roads she was very eager that Karathuri should be brought into easier communication with Chaungtanaung and Banhuni on one side and Bôkpyin on the other, more especially, however, with the latter place. Coolies, she told me, could be obtained with ease in Penang for any kind of labour, and she showed me the form of agreement that the men had signed at the offices of the Chinese Protectorate in Penang. Somewhat to my astonishment I read that all the coolies had engaged for plantation work at Kopa. I do not understand the reason of this diplomacy unless it be that wages are less at Kopa than they would be for employment in British territory. The salary was entered at \$42 a year of 360 working days. An advance of \$19.50 had to be made repayable at \$1.62½ cent per mensem. Food free and, in case of sickness, 30 days in the year allowed. I am informed by Mr. Trautmann, the purser of

the S.S. *Mergui*, that they have conveyed coolies brought direct from China, whose wages were \$25 a year instead of \$42. This seems very low remuneration, and I repeat it on the authority of my informant.

Chaungtanaung.—To the south of Karathuri, about 5 miles by land, is the mining circle of Chaungtanaung that has seen better days.

Mining decay. There is only one working registered, but in the course of his prospecting, the District Surveyor tells me he came across places where poaching was evidently carried on in the rains. Setting aside the illegality of this proceeding it was satisfactory to obtain confirmation of the occurrence of ore.

The lessee of the Chaungtanaung mine is Maung Mè, a son of the late Set Shan, who once rented the whole of the Maliwun township from Government. He appears to be in straitened circumstances and employs only four coolies. The stanniferous stratum is not more than 3 feet, and is said to be poor in quality. No work was going on, and the inhabitants of the village seem to derive more profit from the produce of their gardens, for which they have a sale at Karathuri, than from tin-streaming.

Ore-bed. On the 27th the steamer picked me up, but Maung Maung and his men were left behind to trace, as I have mentioned above, a route to Banhuni and Bôkpyin, and to report any finds of tin.

27th March 1889. Prospecting party for Banhuni. My attention was next directed to the islands in the vicinity of Mergui; and in anticipation of threatening weather, which was realized, arrangements had to be made for engaging a better class of boat than we had previously hired. A week passed before we could meet with one, but eventually a light kattoo (belonging to the thugyi of Ye-e circle¹), with a plank-roof cabin, was secured; and on the 7th April we started for Tailangsaing, Tawnaukli, and the southern branch of the Great Tenasserim. I found when too late that the boat was too heavy for the crew when the breeze was against us, so that we had to work entirely with the tides.

Island near Mergui. *Yamon*.—I landed at Nauklè, Pèya, and elsewhere, and attempted to get as far as Yamôn, but there was not water enough in the creek leading to the latter place and I returned to Mergui to wait for a spring flood.

The Yamôn mines are the only ones in progress within the Mergui township, and though their output is insignificant, their position on the answering side of the range of hills bounding the valley of the Tenasserim river is an interesting proof of the occurrence of tin deposits where one would have expected from general reasoning to find them.

Sea-boat required. 7th April 1889. With more efficient means than at my last essay I reached Yamôn on the 16th April. There was nothing doing at this time of year, but in the rains streaming is carried on at three places on a limited scale. The ore-bed where I examined it varied from 2 to 3 feet in thickness, but further prospecting should be encouraged.

Ore-bed 2 to 3 feet, 16th April 1889. The ore is taken to Pyinggè near Zedawun to be smelted, where the lessee of one of the mines, a Yan Shôk, has his family home.

Furnace at Pyinggè.

¹ Ye-e is an island circle of the Mergui township.

On the 19th I made my last voyage to the south to receive the District Surveyor's report of progress and to inspect the Yengan and Sadein mines. At Bôkpyin I obtained intelligence from the Myoôk that all the members of the prospecting party had been invalidated by fever and were on their way back to Mergui. He said they had suffered great hardships, owing to having no shelter when overtaken by rain and that their legs were covered with sores.

The mines at Sadein were too far off for me to visit them in the time the captain of the steamer could spare for the purpose; but those of Yengan were within an easy pull of the ship's boat, and I visited them with Captain Sheldrick¹ as a guide. They presented no novelty and were deserted for the season.

In Mr. Fryar's time no furnace existed at Yengan, and the ore was sold at Bôkpyin. This want has now been supplied, and the tin stone is smelted on the spot. The names of lessees and the number of men employed on the different workings are as follows:—

Locality of the mine.	Owner's name.	Race.	NUMBER OF MEN EMPLOYED IN		Ground-rent.	REMARKS.
			Rains.	Dry season.		
Yengan creek Kawin south Munanôn Munthôn	Maung Shwe Thaw .	Chinese .	8	...	R 25	} Migyaung- chaung.
	A. San Shôk . . .	Do. . .	6	...	25	
	Nga Pyan . . .	Siamese .	5	...	25	
	Maung Hmo . . .	Burmese .	8	...	25	
	Pi Nu	Siamese .	20	3	50	
	TOTAL .		47	3	...	

We reached Mergui on the 26th, and as the Commissioner of the Division, Colonel Plant, was expected for the Sessions, I waited that I might call upon him and secure the benefit of his knowledge of the requirements of the district, which I have found of great value in framing my summary. After his departure for Moulmein I made a traverse of the Tanyet Circle, and toward the close of the month went to Pawa to test the accuracy of a reputed discovery of ore.

Mazaw.—No mining is carried on in the Tanyet circle, and I neither saw nor heard of any old workings, but I am of opinion notwithstanding that tin will be found if the country be inspected at Mazaw. The physical consideration is very suggestive, and there is a closer imitation in outline to Taiping and Renông than I have seen in any of my wanderings.

Maliwun.—The mines at Maliwun have the widest reputation of any in the Mergui district, and the quality of the ore they yield is said to be better than that of Renông. The licenses issued for

¹ Commander of S.S. *Mergui*.

work during 1888-89 under the head of Maliwun are said, according to information derived from the Revenue Office by the District Surveyor, to be 163. The Deputy Commissioner, to whom I applied for an explanation of what struck me as a very large number of applications, states :—"In reply to your letter about mining statistics in Maliwun, I find from the Revenue Office that there are five mines in Banhuni and twelve at Maliwun. These were not rented, but were worked in 1888-89 by 183 men on individual certificates without payment."

Maliwun possesses a melancholy interest from the circumstance that it has been the scene of an abortive attempt on the part of a large English firm to carry on mining. It is said that "the firm made the mistake of importing Bengal¹ coolies who understood nothing of mining, and made a second mistake in attempting to work the veins. After three years of hard work, and after upwards of three lakhs of rupees had been spent, they resigned their lease."

I assume that costly supervision and unnecessary plant may have added to the difficulties of the enterprise. Notwithstanding this disastrous experience I think the Maliwun township will well repay prospecting. I cannot persuade myself that its resources are exhausted.

This brings the detailed record of my observations to a close. There has necessarily been a great deal of repetition, as one place is very like another and one mine is a copy of its neighbour, but throughout my record of inspection I was always buoyed by the hope that some item having a useful bearing on the main inquiry might crop up.

I claim no credit over my predecessors Dr. Oldham and Mr. Mark Fryar. Both appear to have effectively done their work so far as their opportunities allowed; and had they possessed such a standard of comparison as the Perak State, they would doubtless have been able to suggest remedial measures which long ere this would have borne fruit.

They pointed out the widespread existence of ore, which I can fully corroborate, and they bore testimony to its high quality and freedom from injurious ingredients.

Dr. Oldham in his paper says :—"The principal source of the ore is the extensive deposit of stream tin where the degradation of the previously existing source has produced a detritic gravel, broken up and washed down the slopes of the higher ground and accumulated in all the flats and stream courses." And in summing up he expresses astonishment that such valuable deposits of ore should have been neglected by Europeans. This was in 1855, or 34 years ago.

Mr. Mark Fryar, declaring his opinion, writes :—"It may be advisable for me to state generally the opinion I have formed as to the mineraliferous localities in the vicinity of Mergui. What strikes me as being the most remarkable feature as to the mineral of such localities, is the *wonderful* extent of the distribution of stanniferous detritus. In rivers on the mainland and on islands of the sea every small dishful of

¹ Madras.

sandy gravel taken up contains palpable traces of black tin stone." This was in 1871, or 18 years ago.

III.—DEVELOPMENT.

That the progress of mining in this district during the past 15 or 20 years have not answered to the expectations formed of it is a circumstance well known to Government, and I need not waste time in empty remarks about want of enterprise, lack of energy, and so on. The fact is patent that we are stationary, while other countries are pushing on and bringing ever-increasing revenue to their treasuries. Concessions are being granted and companies formed in the states of the Malay Peninsula, while there is not one single inquiry for an acre of land where our rule has been established for 60 years, and where the occurrence of tin-ore has been published to the world time after time. Why is this, and what measures should be introduced for bringing about a change?

Mining progressing in other countries.

Mr. Hall's views have already been published, and they embody so many of my own impressions that I feel at a disadvantage in repeating clearly and forcibly expressed much of what has already been so clearly and forcibly expressed, but there are a few points that I would emphasize and one or two that I would suggest.

As we cannot rush to a perfected condition of prosperity, I think we may advantageously divide our efforts into those on which action should be first taken and those which may be subsequently carried out, and the initiatory steps that I recommend are—

- (a) prospecting and placing of ore;
- (b) circulation of the facts thus obtained and publication of mining terms;
- (c) alignment of bridle-paths;
- (d) survey of the Mergui district.

(a) By prospecting I mean a much more searching investigation than any heretofore undertaken, one which will give us *official assurance* of the full estimate of any selected localities looked at from a miner's point of view. Their accessibility, their ore-bed, and their supply of water should be appraised by our own officers; and when these are satisfied that with ordinary means and suitable appliances success may be guaranteed, the pioneer adventurers can be invited to come up and take possession of the lands. This is no policy of offering bait, but rather the exercise of common care that the object for which we are striving should not be damned by failures that may create an utterly erroneous impression of the resources of this district.

I am strengthened in the recommendations embodied in the above paragraph by the emphatic advice of Sir Hugh Low, who said that whatever measures were contemplated for introducing or attracting Chinese labour to Burma for mining purposes, it was essential to guard against the repentance of those who first embarked their capital, and nothing would so effectually parry this as close and accurate prospecting beforehand.

We have the promise of the Resident that if the terms which the Government of India might be inclined to offer Mr. Scott, the Inspector of Mines for Larut, be acceptable to that officer, he would sanction his deputation on foreign service for a while as a prospector. Apart from Mr. Scott's practical knowledge, his personal acquaintance with the large mine-owners of the Perak State is a valuable factor in a scheme of development.

On the 1st January 1889, in an official communication to Mr. Hall alluding to a prospecting establishment, I recommended that Mr. Scott should be engaged for two years, and that an assistant prospector should be appointed with the possibility of permanent employment in case Mr. Scott reverted at any time to his original post. Three sub-prospectors and twenty miners were to be enlisted, and two interpreters and five peons. The grant for this establishment¹ was estimated at $\text{R}2,495$ a month, as follows:—

		Rate per mensem.	
		<i>R</i>	<i>R</i>
Mr. Scott	{ Salary . . . . .	. 500	} 650
	{ Field allowance . . . . .	. 150	
Assistant Prospector (Englishman)	{ Salary . . . . .	. 300	} 450
	{ Field allowance . . . . .	. 150	
3 Sub-prospectors (Chinese)	Salary . . . . .	. 100	300
20 Miners (Chinese)	{ Wages . . . . .	. 30	} 800
	{ Maintenance . . . . .	. 10	
1 Interpreter (Siamese) . . . . .	. . . . .	. 60	} 110
1 Interpreter (Burmese) . . . . .	. . . . .	. 50	
5 Peons . . . . .	. . . . .	. 15	75
Stationery and Postage . . . . .	. . . . .	. . . . .	10
Contingencies (medicine, huts, &c.) . . . . .	. . . . .	. . . . .	100
TOTAL			<u>2,495</u>

Boring apparatus and a couple of Norton's tubes and petty tools and cradles, basins, surveying instruments, transport and joining fares, would be covered by a trifling sum of $\text{R}3,000$.

I think a hospital assistant should be attached to each party, as outside of the civil station there is not a medical officer in the district. Some of the men will undoubtedly be struck down by sickness, and if there be no present help, they will probably have to be invalided to Mergui, or they will lose heart and desert.

In pointing out the necessity of State prospecting I do not mean that private prospectors should be discouraged. Disappointment at not finding tin stone in some gulley is a small matter. What we have to heed is impulsive mining on insufficient evidence.

(b) The circulation of the facts ascertained by prospecting should be made as wide as possible, and a quarterly return of work might be published in all the local Gazettes of India, those of Penang and Perak, and in the English Mining Journal. At the same time the terms on which leases or concessions are available might be added. These should be of the tenor of those² that have been found to answer in Perak and with which the Straits Chinese are familiar.

¹ Three blacksmiths and bellows-boys and three carpenters ought to have been added.—16th June 1889.

² The forms are printed as appendices to Mr. Hall's Report.

I am of opinion that Government should derive some revenue in the shape of royalty, and to this form of tax the Chinese appear to have no objection. Five per cent. on the market value of metallic tin would be a very light impost. In the Perak State an export duty is charged in place, I believe, of royalty, and in December 1888 this was equivalent to about £150 per ton of metallic tin.

(c) The alignment of bridle-paths between the principal mining camps should be commenced without delay, and their construction as soon as estimates are framed and sanctioned. The almost total absence of roads in the Mergui district strikes me forcibly, but I presume the very free communication by water and lack of funds have retarded engineering efforts in this direction.

If, however, the country is to be opened out, and if mining is to prosper, there must be some roads to and from certain main points. At present I recommend bridle-paths on the score of economy, which eventually can be widened or improved.

The following are the ones most necessary:—

- (1) Maliwun to anchorage of S.S. *Mergui* ;
- (2) Maliwun to mines in its neighbourhood ;
- (3) Karathuri to Bôkpyin ;
- (4) Karathuri to Banhuni ;
- (5) Outer Bôkpyin to mines of inner Bôkpyin.

The pages of the *Perak Gazette*¹ bristle with references to the want and the utility of ways of communication, and I need only quote one passage from the report of Mr. E. J. Bunster, Acting Collector and Magistrate of Kinta, to show the value that Sir Hugh Low, the Resident, attaches to them: "The chief result of this visit was that the Resident sanctioned an expenditure (not in the estimate for 1887) of \$4,600 to make a bridle-path from Tamboom to Cho and Tanjong and Rengkeng with a view to tapping further valleys containing tin." To make roads we must have money, and to make money it appears we must have roads.

(d) Next in importance to the step I have suggested in the preliminary portion of my scheme is a survey of the Mergui district.

In the course of the general survey of the Indian Empire, the Mergui district will of course be embraced by it, but if the request be not an impracticable one, I would ask for the concession of any early advance of its operations in this direction. The present maps of the district are mere riddles for anxious inquirers.

In the second stage of development, assuming that the result of our preliminary endeavours justifies a belief in ultimate success, and admitting that we have to look mainly to an influx of Chinese to supply the requisite labour, it will be advisable—

- (e) to consider whether a labour law should be passed ;
- (f) to frame special regulations for a Chinese mining population ;
- (g) to appoint special officers, one for Chinese affairs and one for mining interests ;
- (h) to improve communication by land, river, and sea ;
- (i) to increase or modify the administrative staff of the district ;
- (j) to ensure the sympathy of every officer.

¹ The *Perak Government Gazette*, dated 22nd February 1889.

List of Tin Mines in the Lenya Township.

Locality of the mine.	Owner's name.	Race.	NUMBER OF MEN EMPLOYED IN		Ground rent.	REMARKS.
			Rains.	Dry season.		
BÔKPYIN CIRCLE.						
<i>Bôkpyin.</i>						B
Bôkpyin creek	{ Sit Sin	Chinese	32	6	120	Three mines.
Lelan Hill	{ Sit Hauk		9	2	25	
	{ Sit Pok		28	6	75	
Bôkpyin creek	{ Ashok Sat		5	...	25	
	{ Sit Kein		14	...	25	
	{ Sit Sein		12	...	25	
Wutsan	{ Mi Wun		35	7	145	
Shwe Payon creek	{ Pi Than		30	7	110	
Taung Kamit	{ Mi Kyaw		13	2	25	
Kyaungkinpya	{ Hnindit		7	...	25	
Kawin south	{ Apyon	15	...	25		
Bôkpyin creek	{ Hnin Han	12	...	25		
Pittauk south	{ Awin	6	...	25		
Kôkngon	{ Hnin Pan	3	...	25		
Rylaing	{ Mi Shat	4	1	25		
Bôkpyin creek	{ Mi Kyaw	8	...	25		
Wutson	{ Pi Rat	5	...	25		
	{ Nga Dan	7	2	25		
	TOTAL . . . . .	...	245	33		
<i>Sadein.</i>						
Sadein creek	{ Tha I Kit	Siamese	16	2	50	
	{ Mi Ket		19	4	90	
	TOTAL . . . . .	...	35	6		
<i>Karathuri.</i>						
Karathuri	{ Sit Pu Shein	Chinese	90	35	100	Three mines.
Kyaukkyi creek	{ Sit Pu Shein		25	4	25	
	{ Kunhein		12	3	25	
	TOTAL . . . . .	...	127	42		
LENYA CIRCLE.						
<i>Yengan.</i>						
Yengan creek	{ Maung Shwe Thaw	Chinese	8	...	25	
	{ A San Shôk		6	...	25	
Kawin south	{ Nga Pyan	Siamese	5	...	25	} Mgyaung- chaung creek.
Munanôn	{ Maung Mo	Burmese	8	...	25	
Munthon	{ Pi Nu	Siamese	20	3	50	
	TOTAL . . . . .	...	47	3		
	GRAND TOTAL . . . . .	...	454	84		

MAUNG MAUNG,
District Surveyor, Mergui.

List of Tin Mines in the Mergui Township.

Locality of the mine.	Owner's name.	Race.	NUMBER OF MEN EMPLOYED IN		Ground rent.	REMARKS.
			Rains.	Dry season.		
Shweat creek, Yamon. Yamôn creek.	Ayan Shók . . .	Chinese	5	...	R 25	
	Anwi Shók . . .		4	...	25	
	TOTAL . . .		9	...		

Tin Mine in the Tenasserim Township.

Locality of the mine.	Owner's name.	Race.	NUMBER OF MEN EMPLOYED IN		Ground rent.	REMARKS.
			Rains.	Dry season.		
Thabawleik . . .	Maung Shwe O. . .	Chinese . . .	60	7	R 125	Two mines.

List of Tin Mines in the Maliwun Township.

Locality of the mine.	Owner's name.	Race.	NUMBER OF MEN EMPLOYED IN		Ground rent.	REMARKS.
			Rains.	Dry season.		
Maliwun . . .	Sit Pôn . . .	Chinese	16	...	No ground rent is levied in the Maliwun township.	The list of mines in the neighbourhood of Maliwun town is incomplete.
	Sit Saw . . .		20	...		
	Sit Lown . . .		22	...		
	Sit Lu . . .		4	...		
	Sit Kwai . . .		3	...		
	Sit Kwan . . .		4	...		
	Saw Taung . . .		4	...		
	Sit Hwat . . .		4	...		
Sit Ban . . .	6		...			
Banhuni . . .	Meng Hong . . .		Siamese	120		
	Chen Tain . . .	7		...		
	Chek Yòk . . .	6		...		
	Chek Hoe . . .	4		...		
	Chek Pein . . .	3		...		
Chek Wan Chu . . .	3	...				
Nu Noi . . .	4	...				
	TOTAL . . .		225	...		

TABLE OF WEIGHTS.
English, Chinese, and Burmese.

Ton.	Bhara.	Pikul.	Pé.	Viss.	Catty.	℔.
1	56	168	1023	6137	1,680	2,240
	1	3	202	1056	300	400
		1	609	365	100	1333
			1	6	1642	219
				1	273	365
					1	133
						1

MAUNG MAUNG,
District Surveyor, Mergui.

Hughes.



RECORDS
OF
THE GEOLOGICAL SURVEY OF INDIA.

Part 4.]

1889.

[November.

On the Land-Tortoises of the Siwaliks, by R. LYDEKKER, B.A.

In the *Palæontologia Indica*¹ I have described certain specimens which appear to indicate the former existence of several species of large land-tortoises in the Siwaliks, although I refrained, for several reasons, from assigning to any of them definite specific names. One of these reasons was the impossibility of determining to which genus they should be referred if the so-called *Manuria emys*, and therefore *Colossochelys atlas*, were regarded as generically distinct from *Testudo*. Since, however, Mr. G. A. Boulenger in his recently published Catalogue of Chelonians² has come to the conclusion that *Manuria* should be included in *Testudo*, there is no sufficient reason to justify the separation of *Colossochelys*, and accordingly one of the reasons against applying specific names to the other Siwalik forms likewise disappears.

The huge tortoise to which Falconer and Cautley applied the name *Colossochelys atlas* may accordingly be henceforth known as *Testudo atlas*. In the notice of this species published in the *Palæontologia Indica* (*loc. cit.*) the dimensions of the shell as restored by Falconer were accepted; the size being partially estimated on a restoration of the humerus. Subsequent observations show, however, that the restoration of that bone was much too long; and that the true length was nearer 20 inches than the 28 inches allowed by Falconer. Moreover, since that notice was written, the fragments of the carapace on which Falconer's restoration is based have been identified; and it appears from these that the restoration is likewise far too large, the interval between the nuchal bone and the inguinal patch being made nearly double its correct length.

Instead, therefore, of the carapace having a length exceeding eight feet in a straight line, a truer estimate would give this length as approximately six feet, or one-third greater than in the recent *Testudo elephantina*. These dimensions would, moreover, accord in relative proportions with the cranium described in the memoir cited, and provisionally referred (on account of its apparent relatively small size) to

¹ Ser. 10, vol. iii, pp. 157-170.

² London, 1889. Published by the British Museum.

a female individual, but which may perfectly well have belonged to a full-grown male. Unfortunately this specimen was not taken as the type of the species, and since there is a possibility that it may have belonged to the large Siwalik tortoise with less produced epiplastrals than *Testudo atlas*, its reference to the latter cannot be regarded as certain. It may, indeed, be observed in passing that it will be well to regard as the actual type of *Testudo atlas* the epiplastrals figured in plate xviii, fig. 1, of the memoir cited, since it is not absolutely certain that all the fragments on which Falconer's restoration is based are really referable to one and the same species. The nuchal bone so employed is characterized by the absence of a nuchal shield; but another large nuchal in the British Museum is characterized by the presence of a nuchal shield, and, therefore, indicates beyond doubt the occurrence of a second large Siwalik species of *Testudo*. If indeed the first-mentioned nuchal be rightly referred to *Testudo atlas*, the second one might well belong to the large tortoise with less produced epiplastrals, as typified by the specimen represented in plate xviii, fig. 4, of the memoir quoted. Since, however, I cannot assure myself that this nuchal may not have belonged to a large individual of the form mentioned below under the name of *T. cauleyi*, it is impossible to be absolutely certain that these epiplastrals do not belong to females of *Testudo atlas*, and I accordingly refrain from assigning a separate name to their owner, although there is great probability that this was really a distinct species.

In describing the above-mentioned cranium (*l. c.* pp. 161-162), it was stated that in the form of the palate it approximated to the giant tortoises of the Aldabra group. Further observations have, indeed, served to show that this resemblance is still more marked than was at first supposed. Thus, in the Aldabra tortoises (fig. 1 *A*), the aperture of the auditory labyrinth forms a wide and irregular opening, the opisthotics are not produced behind the occipital condyle, and the palate is deeply concave. In the Galapagos tortoises, on the other hand (fig. 1 *B*), the aperture of the labyrinth forms a narrow slit, the opisthotics

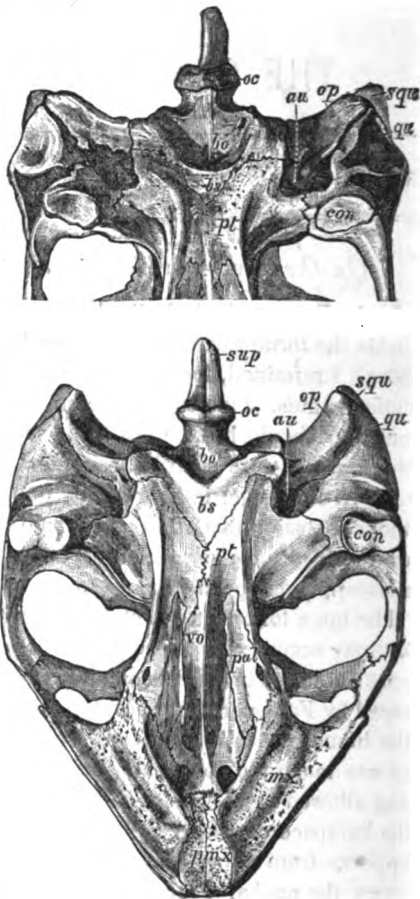


Fig. 1. Posterior part of the palate of *Testudo elephantina* (Aldabra); and palate of *T. microphyes* (Galapagos); both reduced. *au.* aperture of auditory labyrinth; *bo.* basioccipital; *bs.* basisphenoid; *con.* condyle of quadrate; *mx.* maxilla; *oc.* occipital condyle; *op.* opisthotic; *pal.* palatine; *pms.* premaxilla; *pt.* pterygoid; *qu.* quadrate; *squ.* squamosal; *sup.* supraoccipital spine; *vo.* vomer.

are produced considerably behind the occipital condyle, and the palate is much less concave. In the Mascarene tortoises, while the skull is on the whole like the Galapagos type, yet the production of the opisthotics is much less marked. Now, the Siwalik cranium agrees with the Aldabra tortoises not only in the structure of the palate and the form of the aperture of the labyrinth, but apparently also (so far as can be determined) in the relative length of the opisthotics.

A totally different type of Siwalik tortoise is represented by an imperfect skull in the British Museum, of which the hinder part of the palate is shown in fig. 2. In this specimen, which indicates a somewhat smaller form than the preceding one, it will be seen from the figure that the form of the aperture of the labyrinth and the production of the opisthotics is precisely the same as in the Galapagos species. Since, however, I am unable to associate this type of cranium with any specimens of the anterior extremity of the plastron, I do not propose to give it any specific name. The two crania are, however, excessively interesting in showing the existence in the Indian Pliocene of two species of giant tortoises, one of which was allied in cranial characters to the tortoises of Aldabra, and the other to those of the Galapagos islands, and therefore also to those of the Mascarenes. That *T. atlas* and the above-mentioned unnamed tortoise were with shorter epiplastrals widely different in the characters of the shell from all the existing giant tortoises, is, however, shown by the great production of their epiplastrals; while in at least one of these forms the marginals of the carapace had their longer diameter at right angles to the periphery, as in *T. emys*, whereas in the modern giant tortoises the opposite condition obtains.

Leaving now the consideration of the crania and turning to the epiplastrals (which part of the skeleton it is advisable to take as the types of species in this Siwalik group), sufficient evidence is afforded for the foundation of two species in addition to *T. atlas*.

For the first of these species the name *T. cautleyi* may be adopted; and it is represented by the epiplastrals shown in fig. 3, C, which were obtained from the Siwalik hills, and are preserved in the British Museum. They indicate an adult tortoise of the approximate size of *T. elephantina*, and characterized by a similar slight production of the epiplastrals.

The second species, *T. punjabiensis*, is typified by the epiplastrals from the Punjab shown in fig. 3, B, which are described and figured in the Pal. Ind., ser. 10, vol. iii, p. 168, pt. xix, fig. 1. They indicate a species of somewhat smaller dimensions than *T. elephantina*, and are readily characterized by the epiplastrals

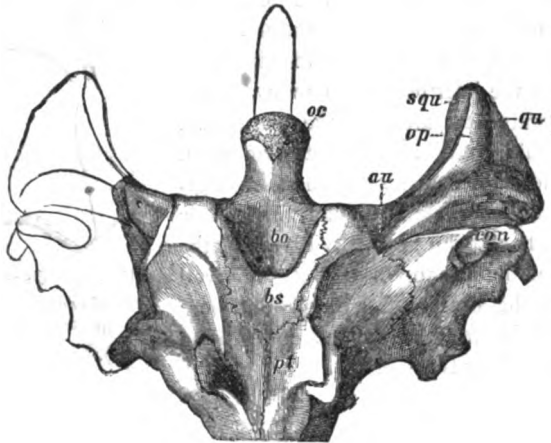


Fig. 2. Posterior portion of the palate of a large species of *Testudo* from the Siwalik Hills. $\frac{1}{2}$ nat. size. Letters as in fig. 1.

being produced after the manner of those of *T. emys* (fig. 3. A), although to a somewhat less extent. It is highly probable that the nuchal and xiphoplastral bones described on p. 169 of the memoir cited are likewise referable to this species; the nuchal has a large nuchal shield.

In conclusion, it may be observed that if we were beginning the description of the Siwalik tortoises with a free field, there would be no hesitation in taking the two skulls mentioned above as types of two distinct species, from both of which *T. cautleyi* would be sufficiently distinguished by its inferior size; but from this course we are now barred. The evidence which is gradually accumulating of the occurrence of large tortoises during the later tertiary in many of the continental areas of the world (*e.g.* India, France, and South America), indicates that these forms were originally very widely spread, but appear to have been gradually driven off the continents, and have only survived to the present day in islands where they were free from the competition of higher types of life.

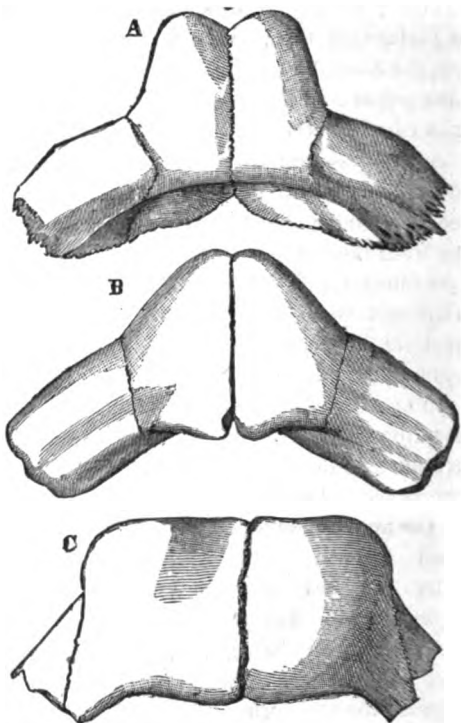


Fig. 3. Dorsal aspect of the epiplastrals of (A) *Testudo emys* (recent); (B) *T. punjabiensis* (Siwaliks of Punjab); and (C) *T. cautleyi* (Siwalik Hills). Reduced.

Note on the Pelvis of a Ruminant from the Siwaliks by
R. LYDEKKER, B.A.

In the year 1887 I gave a preliminary notice in the "Records"¹ of two bones from the Siwaliks, which were labelled by Falconer as being associated, and apparently referable to the same animal. One of these specimens is the imperfect tibio-tarsus of a bird, while I regarded the other as part of the sternum of the same bird; and on the evidence of these two specimens I proposed the name of *Megaloscelornis* for their presumed owner. Subsequently,² by making a section, I found that the tibio-tarsus could not be distinguished from that of *Struthio*, and I accordingly referred it to that genus, of which *Megaloscelornis* may accordingly be reckoned as a synonym.

Having by this time acquired considerable doubt as to the real nature of the

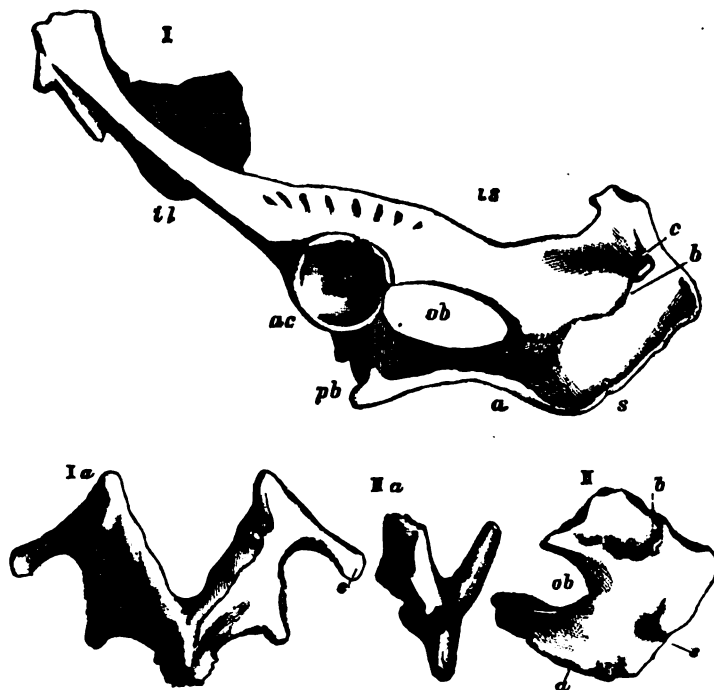
¹ Vol. xii, p. 55.

² Pal. Ind., ser. x, Vol. iii, p. 143 (1894).

so-called sternum, I forwarded the specimen to Prof. Alfred Newton, of Cambridge, who, after examination, replied that, although it presented a certain superficial resemblance to an Avian sternum, yet he was convinced that it was not Avian at all, and he further suggested to me that it was really part of the shell of a Chelonian. This suggested re-determination was mentioned in the description of the tibia of *Struthio*.¹ At a still later date, however, after I made a considerable study of four Chelonia, I had occasion to enter this specimen (Ind. Mus. No. E. 6) in the Catalogue of Siwalik Vertebrata in the Indian Museum, pt. ii, p. 23 (1886), when I remarked as follows: "It has been suggested that the present specimen is part of the shell of a Chelonian, but the writer has been unable to satisfy himself that it is so."

Recently—in the course of cataloguing the fossil Chelonia in the British Museum—the question again arose whether this specimen (as represented by a cast) could be included in the list;—a question which I decided must be answered in the negative. It then occurred to me for the first time that the specimen might be a portion of a Mammalian pelvis, and after comparison with several groups (with the assistance of my friend Mr. O. Thomas, of the Museum) it was found to agree so closely with the hinder portion of the pelvis of the larger bovoid Artiodactyles that there could be no question but that the puzzle had been finally solved.

In the accompanying wood-cut figures are given of the left lateral (I) and posterior



Left lateral (I) and posterior (Ia) aspects of the pelvis of *Oreas canna*; and the corresponding aspects (II, IIa) of the fossil pelvis, $\frac{1}{2}$ nat. size; *il*, ilium; *is*, ischium; *s*, symphysis of do.; *pb*, pubis; *ac*, acetabulum; *ob*, obturator foramen; *a*, epiphysis of ventral symphysis; *b*, muscular ridge; *c*, lateral process of ischial tuberosity.

¹ Pal. Ind., loc. cit.

(Ia) aspects of the pelvis of the Eland (*Oreas*), and also of the corresponding aspects (II, IIa) of the specimen under consideration. It will be seen from these figures that the fossil comprises the posterior portion of the ischia of an animal of rather larger dimensions than that to which the recent pelvis belonged. Below the obturator foramen (*ob.*) the ischia are broken off at their junction with the pubes; while above this foramen they have lost the anterior portion of the bar which enters into the formation of the acetabulum (*ac.*), and posteriorly the whole of the region embracing the tuberosity and its lateral process (*c.*). The strongly-marked ridge for muscular attachment situated posteriorly to the obturator foramen is, however, well preserved. Posteriorly (IIa), one side of the bar bounding the outlet of the pelvis has been fractured and somewhat displaced, so as to render this aspect of the specimen somewhat unsymmetrical.

In all respects the fossil fragment agrees so closely with the corresponding portion of the figured pelvis as to indicate that it certainly belonged to one of the larger *Bovidae*, the most characteristic features being the elongated form of the obturator foramen (*ob.*), the contour of the muscular crest (*b.*), and the great development and convexity of the epiphysis (*a.*) on the ventral aspect of the symphysis. The specimen, indeed, comes nearer to the pelvis of the larger antelopes than to that of the oxen; and it is probable that it belonged to one of the large Siwalik antelopes which are allied to existing African forms. The muscular ridge (*b.*) is, indeed, placed higher relatively to the obturator foramen than in the eland or any antelope with which I have been able to compare the specimen; but this is not a character of much importance.

In finally referring this specimen to its true position, I may again repeat the warning it gives against attaching any importance whatever to the association of Siwalik specimens.

Recent Assays from the Sambhar Salt Lake in Rajputana, by
H. WARTH, PH.D.

In his paper on salt in Rajputana (Records, 1880, page 197), Mr. C. A. Hacket referred to the apparently unfailling supply of salt in this lake. It is now twenty years since the lake was taken over by the Salt Revenue Department under the Government of India; and from the year 1869 to 1888 no less than 52,400,000 maunds of salt were extracted and removed, which is equal to about two million tons. Mr. Hacket quoted in his paper the analysis which I made at the lake in 1869 with somewhat primitive appliances. The water in the lake (lake brine A) contained 21.9% dry residue, which was composed as follows:—

Sodium chloride	90.9
„ sulphate	7.3
Balance, chiefly sodium carbonate	1.8

Unless the lake would be inexhaustible, the removal of two million tons of salt (sodium chloride) must produce a change in the composition of the soluble residue. I have

now made a careful analysis of the residue of lake brine drawn in January 1889, and the result is as follows. There are 8·81 % of residue, and the composition is—

Sodium chloride	87·6
„ sulphate	7·5
„ carbonate	4·6
Balance	0·3

Only in the latter analysis was the carbon dioxide directly determined, therefore it is not safe to draw conclusions from the large increase of sodium carbonate, but the sulphate is also increased.

Calculation based upon the proportion of sulphate to chloride in both cases shows the lake ought to last another three hundred years at the past rate of consumption. On the other hand, the actual decrease in the percentage of chloride would predict an end of the salt stores in sixty-five years. It is desirable that analysis should be repeated in the following years, and for this purpose the samples of brine should be taken when the lake is not concentrated, so that natural separation of common salt at the edges of the lake causes no relative increase of foreign salts. Percolation brine is obtained all over the lake-bed by excavation. It contains more foreign salt than the brine of the lake itself. I analysed a sample which was obtained by mixing percolation brine from all along the sixty miles of lake edge.¹ This sample compares as follows with percolation brine (or subterranean brine C) of 1869:—

	Percolation brine. 1869.	1888.
Dry residue	20·1 %	12·3 %
Sodium chloride	86·1	85·3
„ sulphate	12·4	11·3
„ carbonate	} 1·5 {	3·0
Balance		0·4

An isolated sample of percolation brine obtained in 1888 was exceptionally pure: its residue contained only 6·9 % sodium sulphate. This proves that the percolation brine varies much in composition.

I also analysed some extract salt prepared out of residual liquor (mother liquor) from the salt manufacture. The result was—

Sodium chloride	62·0
„ sulphate	18·0
„ carbonate	17·7
Balance	2·3
	100·0

Dr. Bauer, of the Chemical Laboratory, Stuttgart, suggested my trying for boracic acid, and when I did so, I was surprised to find that the above balance consisted to a large extent of borate of sodium (borax). Subsequently I observed that the ordinary brine of the lake showed the reaction for boracic acid also, and by a rough method I proved a yield of something like a half per cent. of crystallised borax in the dry residue of the lake brine.

¹ I am obliged for this and other specimens to Mr. Carey, C. S., the Commissioner of the Northern India Salt Revenue Department.

During an annual production of 30 lakh maunds of salt at the lake, the waste liquor, which is thrown away, contains therefore boracic acid enough to yield 15,000 maunds of crystallised borax, or in round numbers 500 tons. One ton of refined borax costs in Europe about ₹1,000.

Considering also the value of the soda in the waste liquors and even of the sulphate, it ought some day to be possible to combine the separation of borax and other sodium salts with the production of the pure edible salt.

The 3rd August 1889.

The Manganiferous Iron and Manganese Ores of Jabalpur, by PRAMATHA NATH BOSE, B.Sc., F.G.S., Deputy Superintendent, Geological Survey of India. (With one plate.)

In Vol. XXI, No. 3, of the "Records," I gave a sketch of the economic results of the manganese exploration in the Jabalpur district. In the present paper I propose giving, first, a geological sketch of the ground in which the manganese iron and manganese ores occur, and then, a summary of the observations which I made on their origin. (For map see Rec., Vol. XXI, Pt. 4.)

I.—GEOLOGICAL SKETCH.

1. *The Bijawars.*

Mr. C. A. Hacket, who surveyed and reported upon the area under description in 1871, divides this series into four groups as follows (in descending order) :—

1. Chanderdip group.
2. Lora ,,
3. Bhitri ,,
4. Majhauri ,,

Mr. Hacket observes that the boundaries between these groups are "by no means well defined, as they pass almost imperceptibly into each other," and that this division is made for "convenience of description."¹

The Chanderdip group is not exposed in the manganese ground; and for our purpose it would be more convenient to unite the Majhauri and Bhitri groups under one denomination. We have thus to deal with two groups, which are (in ascending order)—(i) the Majhauri-Bhitri and (ii) the Lora.

This group consists of limestones, shales, and green-stone like rocks. They stretch in a north-east—south-west direction (the direction of the strike) from Sleemanabad and Salaia to Majhauri and Indrana. They also occur in the southern portion of the area near Chhatarpur.

¹ MS. Report, p. 3.

The limestones or dolomites are generally cherty, often chert-banded. The dip as indicated by this banding is usually very high, sometimes approaching verticality. The limestone is never continuous over any considerable area; indeed, it is seldom traceable for more than 4 or 5 miles along, or a mile across, the strike; often it forms inconsiderable patches, only a few square yards in extent. It is associated more or less obscurely with quartzite and quartzose rocks of various kinds, the commonest being a hard cherty rock (with nests and strings of white quartz), generally tinged red or yellow. The quartz nests give the rock a brecciated appearance, which is also emphasized at places by the presence of fragments of quartzite. The cherty rocks occur in huge, shapeless masses, without a trace of bedding, and look like fault rock. But no indication of faulting was observable anywhere. At places—as, for instance, west of Majhauri and in the vicinity of Chhatarpur—the cherty rocks are so intimately associated with the limestones that it is almost impossible to separate them on the map. In fact, they here represent what in other parts of the district is essentially a limestone group.

These cherty beds form ridges which run with the general Bijawar strike. One such ridge runs almost uninterruptedly for 10 miles from Salaia (3 miles south of Sleemanabad) to Gouruha Bhitoli. The limestone outcrops invariably occur on comparatively low ground and usually at the foot of these ridges.

Banded red jasper was met with, associated, like the cherty quartzites, with the limestones at diverse localities. The bands dip in the same manner as the chert bands do in the limestones that are chert-banded. When the two (the banded red jasper and the chert-banded limestones) are in close proximity, as they are at Salaia, the one passes almost imperceptibly into the other.

Jaspery bands.

The cherty and jaspery rocks are often found in intimate association with that puzzle of Indian geology, "Laterite," as in the neighbourhood of Chhapra (Bara, 3 miles south of Sleemanabad) and elsewhere.

Shales were found interbedded with the limestones at various places. At Gouruha the latter are replaced by the former laterally in a rather abrupt manner. The shales are distinctly bedded dipping 70° south-east, and are contorted at places. They form a nearly continuous band, extending as far as Ponri (5 miles south-west of Gouruha), beyond which they are lost under alluvium. Red slaty shales with chert bands are very largely developed about Majhauri.

The limestones were observed to be cleaved at places; but their cleavage is not apparent except on the weathered surface, which also sometimes shows crumpling.

A band of a peculiar-looking green-stone like rock runs from Dhinari Khamarea (4 miles north of Sihora) in a north-eastern direction (the direction of the strike) to Dhangaon, a village situated on the Mirzapur road, 7 miles north of Sihora. The rock also occurs north-east of this village. Here, as well as at Dhinari Khamarea, it appeared to pass into the shales; but the passage was not distinctly seen.

There are two important outcrops of the Lora group within the area explored last season. One of these extends from the north-eastern extremity of the Lora range east of Sihora to Murhasan and

The Lora group.

Chindamani, 6 miles south-west of Gosalpur, and includes the towns of Sihora and

Gosalpur. The other occurs east of Panagar and extends north-eastward through Chhatarpur and Agarja to Saroli. The connection between these two outcrops is not clear, as the intermediate ground is mostly obscured by alluvium. There is, I am strongly inclined to think, some faulting.

The first of these two outcrops, which may be called the Sihora-Gosalpur out-crop consists of a lenticular patch of shales and thin,—frequently micaceous,—hematite-banded quartzites, flanked as it were by massive quartzites not very unlike those described as occurring in the preceding group. The shales and micaceous hematite-banded quartzites form a distinct synclinal (which we shall call the Lora syncline) just west of Gosalpur, their dip at Gosalpur pointing north-north-west and at Ghugri in the opposite direction. In the south-western direction the syncline is traceable to Murhasan and Khorawul, the micaceous,—hematite-banded quartzites, or hematite quartzites, as they may be more conveniently called, forming two broken parallel ridges, and the shales superposed on them, the valley between. North of Gosalpur, the syncline is more or less distinctly traceable to the Lora range proper, where the rocks are greatly folded and contorted.

The hematitic quartzites and associated rocks may for the sake of convenience be called the Sihora beds, after Sihora, the only place of importance in the neighbourhood of the Lora range where they are typically developed; and the massive quartzites which have been mentioned above as nearly enclosing or flanking these beds may be named after Gosalpur, where they are fairly well seen, as Gosalpur quartzites.

The relation of the Sihora beds to the Gosalpur quartzites is generally very obscure, owing to the usual absence of dip-indications in the latter. The dip is, however, seen at places, as in the Mansukra-Silondi ridge close to Sihora, and at Pahrewa, 2 miles south of that town. From these dips, as well as from their mode of occurrence, the Gosalpur quartzites would appear to underlie the hematitic quartzites and associated rocks (the Sihora beds), and form the base of the Lora group.

There is considerable lithological similarity between these quartzites and the cherty and jaspery rocks of the Majhauri-Bhitri group. Hand specimens of the one would be almost undistinguishable from those of the other. But, except at one place,¹ they have nowhere been found associated with limestones. They are variously coloured,—white, blue, red, brown, and yellow, the blue colour indicating the presence of manganese ore. At places they have an appearance of brecciation, which is sometimes very coarse, owing to the presence of veins and nests of manganese or iron ores. As the pyrolusite occurs almost exclusively in the Gosalpur quartzites, it would, from an economic point of view, be important to describe its outcrops in some detail. It is possible that future search at places where no ore, or only traces of it, have been found by me will prove more successful.

About Khorawul, at the south-eastern extremity of the western side of the Lora syncline, there is an immense development of quartzites. They do not all appear to belong to the same horizon. The Sihora strata are present at Khorawul in a greatly attenuated condition, and the quartzites apparently underlie as well as overlie them. It is more than possible that they in part replace the Sihora strata.

¹ Near Karaia, south of Kaleri (Kulery).

But the stratigraphy here is very obscure. East of Khorawul, and separated from the quartzites just mentioned by a short interspace of alluvium, there is another patch of massive quartzites at Keilwas. Just north of this village these quartzites are overlaid by a thin band of micaceous,—hematite-banded quartzites, superposed by shales.

Further north from Chandnota and Dharampur, the Gosalpur quartzites are traceable, though more or less covered by alluvium, at the base of the Sihora strata (which form a ridge running north-east along the strike) to Naigain, thickening and thinning out at places. North of Naigain, the quartzites, as well as the superjacent Sihora strata, are concealed by alluvium. There is either some faulting here or a twist of the strike.

Proceeding northward on the same (the western) side of the Lora syncline, the quartzites re-appear in great force at Sihora. They are here greatly mixed up with laterite. North-east of the town, they form a ridge running with the strike, nearly as far as Murhie. They again appear south of Karaia (not marked on map) near Kaleri (Kulery), and run through Daimapur to Tola, beyond which they are covered up by alluvium. There are quartzites of a similar aspect at Umaria. They are probably identical. If so, a considerable twist in the strike must be supposed to have taken place in the intermediate ground.

A mile north of Sihora, and separated from the quartzites occurring there by an interspace of alluvium, there are at Raipur (Reipur) quartzites of a similar appearance, but more intimately associated with laterite. They run through Chhapra (Chhota) to Karaia, where they appear to unite with the quartzite band described above.

On the eastern side of the Lora syncline, at its southern extremity, there is an insignificant outcrop of the Gosalpur quartzites at Murhasan. Traced northward, they are lost in lateritic-looking rocks which form a nearly continuous ridge as far as Gosalpur. Within this lateritic ground, however, a few blocks of quartzites were found at Deonagar near Burhagar.

The quartzites re-appear at Gosalpur just west of the dâk bungalow. They are surrounded by laterite on all sides. Just north of the village, by the Mirzapur road, mottled quartzose rocks appear in an old well and in some pits excavated close to it. These rocks probably represent the Gosalpur quartzites. Further north, a well-defined ridge of laterite runs from Juhari (Joojharee) to Bandha. Within this lateritic ground, however, small fragmentary patches of massive unbedded quartzites occur, as close to the village of Bandha. North of Bandha all is alluvium as far as Khatola and Bhatadon, with the exception of a very small piece of ground just south of Rethowri, where quartzites in close association with laterite were encountered.

There is a good show of the quartzites at Khatola (E. I. Railway Station), where they are worked for railway ballast. Hence they run on through Hargar, Danwie and Mungala to Deori, at places concealed under alluvium or getting lost in laterite. Beyond Deori the laterite predominates. A few fragmentary patches of quartzites, however, were met with at Dharaisar and elsewhere. If the Dharaisar quartzites be identical with Gosalpur quartzites, there is a remarkable twist of the strike here corresponding to a similar twist mentioned above as occurring on the western side of the Lora syncline at Umaria (Oomuria).

A minor band of quartzites is obscurely traceable from a short distance south of Burhagar, through Keolari (a deserted village a mile south of Gosalpur) to Budhua (Boodooa). Its course is roughly parallel to that of the quartzites running through Gosalpur. If the Burhagar and Keolari quartzites be identical with these, as I am inclined to think they are, they have been brought into the position they occupy by a minor anticlinal flexure. There is evidence, though very obscure, of considerable disturbance in the entire Lora group at, and east of Gosalpur.

In the Lora outcrop east of Panagar the Gosalpur quartzites were well seen at Nurgaon, 4 miles north-east of Panagar, distinctly bedded, and passing with a south-eastern dip under shales and micaceous,—hematite-banded (or hematite) quartzites (the Sihora beds). The Gosalpur quartzites here form a ridge extending for about 2 miles north-eastward along the strike. At Agaria, 5 miles further north in the same direction, some quartzites were met with which probably belong to the same horizon.

Two miles south-east of Panagar, there is a strong band of apparently much-crushed Gosalpur quartzites which runs very nearly in an east—west direction parallel to the Lamehra range of hills.

The sequence of the Sihora beds is as follows (in ascending order):—

1. Slaty shales.
2. Thin laminated quartzites usually of a jaspery type, and often parted by layers of micaceous iron ore interstratified with shales.
3. Slaty shales, usually sheeny and tinted red.

This sequence is typically developed at Ghugri (west of Gosalpur) and a few other places; it is not observable everywhere. The beds (2) are best developed in the Lora range east of Sihora, and are the most striking in the entire Lora group. The micaceous iron layers, which are usually of very small thickness (less than a quarter of an inch or so), are sometimes entirely wanting, as at Murhasan; sometimes they are developed to such an extent that the rock may be called a micaceous hematite schist, which is the case at Dharampur, Gosalpur, &c.; and sometimes the quartzites pass laterally into shales, as north of Gosalpur. This lithological variability is highly characteristic of the Gosalpur quartzites also.

All the beds of the series, especially those just described, show signs of great disturbance. The dip is high—nowhere less than 45° . The beds are folded and crumpled. The folding is sometimes very sharp and is well seen throughout the Lora range. Cleavage was distinctly observed in the shaly strata at some places, the dip of cleavage planes being in the same direction as that of the bedding planes, but higher.

The course of the Sihora strata being roughly parallel to that of the Gosalpur quartzites, it need not be traced in detail.

2. The Lateritic rocks.

The mapping of these rocks has been a source of great anxiety to me. In the area examined last season they may be classed as follows:—

First.—Lateritised Bijawar rocks,—*i.e.* rocks which by the action of percolating water charged with iron manganese, &c., have been altered, and come to

assume an unbedded, massive, more or less cellular form. Such rocks occur just in front of the dāk bungalow at Gosālpur. Here the passage from micaceous iron slates, belonging undoubtedly to the Bijawar formation, to lateritic rocks without a trace of the slates left in them, is clear and gradual. Similarly lateritised ferruginous slates were met with at Keolari, Burhagar, Hirdenagar, &c., within the ground previously mapped as Laterite. All such ground has now been reclaimed from it, and coloured as Bijawar.

Secondly.—Lateritic rocks which have been mentioned before in connection with the Gosālpur quartzites, and the relation of which to these as well as to the other rocks of the Lora group is extremely obscure. They are well seen in the ridge just west of the dāk bungalow at Gosālpur. The ridge slopes gently eastward,—i.e. towards the bungalow,—and is scarped on the western side, the scarp being somewhat steep. On this, the western side, the Sihora strata crop out, rolling about considerably, but usually dipping rather high in a north-western direction. The lateritic rocks come in towards the summit of the ridge, looking as if they capped the Sihora strata. But at the junction at one place where the latter appeared to be overlaid by the former, a shaft was sunk to a depth of 25 feet; and the entire thickness was found to consist of the lateritic rocks—white, yellow, and red mottled, gritty, ferruginous clays, apparently without a trace of stratification. These rocks become more and more vesicular above; and at the summit of the ridge, they are full of irregular vermicular tubes formed evidently by percolating water. Their disintegration results in a large spread of gravel, which is found along the slope of the ridge mentioned above, as well as in the ground to the south of the dāk bungalow. The gravel, which looks much more highly ferruginous than the parent rock, is re-cemented at places by a ferruginous matrix, producing lateritic alluvium, which will be mentioned presently.

The relation of the lateritic rocks under discussion to the Gosālpur quartzites is very peculiar. The former curiously follow the course of the latter and *alternate* with them. The quartzite outcrops, however, are frequently few and far between, and quite insignificant,—sometimes not more than a few square yards in extent. In several pits, as at Keolari, large blocks of the quartzite were found *in situ* surrounded by laterite on all sides. They are highly ferruginous and much decomposed at the edges. It did not appear to me quite beyond the range of possibility that the lateritic rocks here might be the result of the decomposition and alteration of the quartzites, as the laterite in front of the Gosālpur dāk bungalow is the result of the alteration of the Sihora ferruginous slates *in situ*. The laterite overlying the quartzites at Gosālpur appeared to me to be possibly of a similar origin. This impression was created by the manner in which, in the numerous pits opened there, the decomposed yellowish and yellowish-white quartz rock with veins and nests of manganese or iron ore, or both, occurring at the bottom, gradually passed upward, first into a layer containing fragments of the quartzite and of the ore-bearing blocks with the quartzite matrix occupying drusy cavities, and then into a layer of grains and nodules of the ore, in which the original rock-matrix is barely discernible at places. Pumpelly expresses a similar view with regard to the origin of the manganese ores of Missouri and Michigan. They occur in a "black porphyry with very hard matrix,

abounding in grains of smoky quartz and crystals of triclinic felspar." They are "in narrow comby strings, which are in places isolated, in others united to form a reticulated net-work throughout the mass; in this form the rock resembles a conglomerate, the ore representing the cement." [This is exactly the manner in which the pyrolusite occurs in the Gosalpur quartzites.] "In other instances the manganese has wholly replaced the matrix, the crystals of felspar and grains of quartz alone remaining intact. Finally, in portions of the rock, the replacement has been complete; here no traces of the porphyry, either crystals or matrix, remain, while a more or less porous semi-crystalline mass of the manganese ore takes their place." ["Iron Ores of Missouri and Michigan," Part I, p. 25.] The "manganese, laterite", into which the pyrolusite-bearing quartzites of the Jabalpur area pass above, resembles this porous semi-crystalline mass. The nodules towards the surface are usually of a spongy texture; and this texture is more satisfactorily explained by regarding the cavernous spaces to have been originally occupied by the quartzose matrix as in the layer immediately underlying them, than on any other hypothesis. But even if the mode of origin here suggested be correct, it would possibly account for only a very small portion of the lateritic rocks. Over the great spread of these rocks south-west of the Gosalpur dāk bungalow, no such connection between them and the quartzites is discernible in the numerous pits opened in them. It is not impossible that they may represent the Gosalpur quartzites, the lithologic change from mottled gritty clays to quartzites not being inconceivable; and the manner in which the two kinds of rocks run into each other gives colour to such a supposition. This is, however, only a possible view, and nothing more. On the view of the lateritic rocks having been deposited on the Gosalpur quartzites in comparatively recent times, from the manner in which the latter crop out they must be supposed to have undergone considerable subaërial denudation, and then to have been depressed before the former were deposited. The adjoining Sihora shales, which now form the long and well-defined valley west of Gosalpur, must have been denuded and depressed at the same time. It is noticeable, however, that the lateritic or any corresponding rocks are entirely absent from this valley, as also from a similar valley south of Sihora formed by the denudation of the same shales.

Thirdly.—Lateritic alluvium.—It is distinctly of detrital origin. It graduates into ordinary alluvial clay or loam with pisolitic or oolitic concretions of iron or manganese ore.

II.—ORIGIN OF THE MANGANIFEROUS IRON AND MANGANESE ORES.

The manganese ores of Jabalpur occur in the transition formation, and chiefly in the Lora group. In other parts of India, Mr. Ball notes the occurrence of manganiferous ores mixed with vein quartz, south of Chaibassa, in the same formation; and Mr. Hackett found them at the base of the Arvali series in Bundi (Rajputana).³

There can be hardly any doubt that the original source of the manganese ores of the Jabalpur ground is to be sought for in the micaceous,—iron-banded quartzites

¹ Memoirs, G. S. I., Vol. XVIII, pt. II, p. 86.

² Records, G. S. I., Vol. X, p. 91.

of the Lora group. The hematite usually assumes the form of micaceous iron ore, and has manganese disseminated in it, though in very minute quantities. The manner in which the hematite layers follow the complicated flexures of the accompanying quartzites leaves little room for doubt that they are true beds contemporaneous with the latter. At places the hematite predominates, and the quartzite is quite subordinate or entirely wanting. If this latter condition be due to original deposition, it is conceivable that at these places the same forces which produced the folding and crumpling of the hard quartzites would result in the cleavage of the comparatively soft micaceous iron-ore strata; and that mineral re-arrangement along cleavage planes might produce a schistose hematite such as was exposed in the trenches at Gosalpur and elsewhere.

The manganiferous hematite is to be distinguished from the micaceous iron ore just mentioned by the fact that manganese is present in some quantity in the former and makes itself apparent in the form of veins and nests of *psilomelane*. Two kinds of the manganiferous hematite may be distinguished according to their origin: one produced by the local concentration of the manganese in the micaceous hematite, and the other by the impregnation of the shales and quartzites accompanying this hematite. Rich pocket-like deposits of manganiferous hematite have been produced in either of these ways. They are invariably richest towards the surface; beds which are but slightly impregnated with the manganese iron ores in the form of veins and nests, becoming at or near the outcrop so rich as to claim to be called ore beds. The manganese iron ore beds of the Mansukra Silondi ridge near Sihora are beds of this description.¹

The manganese in the manganiferous hematite, whether formed by the concentration of the manganese in the micaceous hematites or by the impregnation of other Sihora strata, is met rather in the form of veins and nests of *psilomelane*. These veins and nests increase in number and magnitude towards the surface, nearly pure masses of the mineral, with but a slight admixture of hematite, being thus produced at the surface.

Sometimes there occur surface deposits of *psilomelane* which cover the underlying strata in such a manner as to leave but little room for doubt that they are not the result of impregnation or concentration.

The usual mode of occurrence of such deposits is represented in fig. 2. It is possible to conceive that the ore-mass *c* has been formed by the replacement-alteration of the fragments of micaceous hematite schist visible in *b*. But there is no passage from the one to the other; and not unfrequently the ore-mass *c* covers the edges of the micaceous hematite schist *a* without the intervention of the ore-mass *b*. Under the circumstances the most eligible supposition appears to me to be that the ore-mass *c* has been precipitated from water above the outcrop of the strata *b*.

From the manner in which the manganese deposits occur at places,—as, for instance, the pyrolusite deposits at Gosalpur,—they appear as if they were formed by impregnation accompanied by replacement of the rock by ore. In the numerous pits which were sunk into the manganese deposits at Gosalpur and

¹ See Records, Vol. XXI, p. 85.

elsewhere, the rock at the bottom is decomposed, and has frequently a blotched appearance owing to the presence of specks and patches of what appears to be some form of manganese or iron ore. These ore particles are seen under the microscope not only to occupy the interstices between quartz grains, but also to invade and gradually replace these. A slice of the Gosalpur quartzite from Pahrewa containing veins and nests of manganese ore from a portion of the rock in which the ore was not discernible macroscopically, showed an abundance of curious needle-like brownish microlites (?), along with a few black patches evidently of manganese ore (see plate). The needles are so numerous that they form a felt-like mass, through which the quartzose rock matrix is discernible only with polarized light.

Overlying the blotched decomposed quartzite mentioned above, we have, proceeding upward, first, the decomposed quartzite traversed by a net-work of veins and nests of manganese or iron ores; then blocks and fragments of the quartzite, some of which are very rich in the ores; in which case the quartzite, much decomposed and crumbly, has the appearance of occupying cavities in the ore-mass; and, lastly, grains and nodules of the ores without any admixture of the rock. (See plate, fig. 1.) This mode of occurrence of the ores and certain features which they present—their spongy texture, for instance — I could not satisfactorily account for without supposing the replacement of the rock by the ore to a certain extent. The loose, crumbly, decomposed rock accompanying the ore being washed or dissolved away, its place may be gradually taken by the manganese iron ores either occurring along with the rock or freshly precipitated from percolating water. It is possibly owing to this sort of displacement of the rock by the ore that the loose ore-nodules covering hill slopes are, as a rule, much richer than the ore *in situ* from which they appear to have been derived — a fact which has been noticed before.¹ It is not unlikely, however, that they may be the remains of a rich surface-deposit of ores which has been denuded away.

However, the displacement of the rock by ore accounts for the origin of the ore-deposits only partially, and possibly to a subordinate extent. They must have been mainly formed by precipitation from percolating water in cracks and crevices of the rocks. These cracks and crevices would be largest and most abundant at the outcrops (where the rocks are broken up into blocks and fragments), and would diminish in number and magnitude with depth. We would thus have the ore-deposit richest at the crop; and the rock here would frequently present the appearance of a 'crushed' breccia or conglomerate, cemented, as it were, by the manganese iron ores, as it does at Gosalpur, Dharampur, and other places. (See fig. 2 *b*.)

The hypothesis of springs bringing up manganese in solution from the underlying strata may account for the formation of certain superficial ore-deposits,—as, for instance, the deposit *c* in fig. 2. The ascending waters on coming to the surface would deposit the manganese as oxide, the conditions for the escape of carbonic acid, and for the

¹ Dr. King noticed near Vizianagram, at the foot of a hill, large blocks and smaller masses of manganese ore which appeared to have rolled down from above. The ore *in situ*, however, occurs higher up the slope, as a thin and irregular coating of limestones (Records, Vol. XIX, p 155).

cooling and evaporation of water being very favourable here. The manner in which the Lora beds have been folded and crumpled plainly shows that they have suffered exceptional disturbance, which, in all probability, was accompanied by considerable fissuring; and this condition must have been favourable to the production of numerous springs.¹ The concentration of manganese in the micaceous hematite schist, and the impregnation of the associated strata, as well as of the Gosalpur quartzites, may also have been effected by the ascending waters of springs. Precipitation of manganese as oxide from such waters would be most effective at, or close to, the surface, owing, in the first place, to the atmospheric condition being most favourable for it there; and, in the second place, to the rocks there being much fissured by weathering action. Thus we should have the ore-deposits richest at the surface—which is actually the case.

The ore-impregnations may, however, be generally accounted for quite as satisfactorily on the supposition that they have been precipitated from infiltrating surface-waters which have leached out the manganese and iron from the hematite-banded quartzites or from the micaceous hematite schists. This is the view entertained by Mr. Mallet.² As facts favourable to it, I may mention that I saw the plaster-coating of a *baoli* at the foot of the Lora hill was encrusted over by manganese ore, which there can be hardly any doubt was derived from the manganiferous strata forming that hill; and that the soil at the foot of some hills containing manganese ores was found to be similarly coated by manganese, as at Ponri. Bischof mentions a case in which peroxide of manganese was found to be present in a deposit from mine-water which was still being formed.³

There can be hardly any doubt that manganese iron deposits are being formed at the present day by precipitation from surface-waters which have leached out the manganese and iron from the micaceous hematite of the Sihora strata; and similar deposits must have been forming ever since the elevation of the Bijawurs. Whether all of the deposits which we see at the present day have been formed in this way, it is difficult to say. It is possible that some of them, like the psilomelane deposits covering the edges of the Sihora strata at the outcrop, owe their origin to deep-seated springs. But as we have no certain evidence of the existence of such springs, it would, I think, be safest not to assume it, but account for all of the deposits by means of agencies which we see at work at the present day, if they can be so accounted for, and there does not appear to be any insuperable difficulty in the way of so explaining them.

At some places, as near Sihora and at Pararia (near Panagar), we have the ridges formed by the Gosalpur quartzites containing manganese ores at some distance from the ridges formed by the Sihora beds with interstratified micaceous hematite (which

¹ The manner of occurrence of the manganese deposits in the Department of Hautes Pyrénées, which is similar to that of the Jabalpur deposits, appears, according to Gruner (quoted by Bernhard von Cotta in his "Treatise on Ore Deposits") to indicate that the ores have been deposited by mineral springs, containing bicarbonate of manganese in solution, which have penetrated to the surface.

² Records, Vol. XVI, p. 117.

³ Bischof's "Chemical and Physical Geology," Vol. I, p. 161. (Translation, London 1859.)

has been assumed to be the source of the manganese ores), and separated by an interspace of alluvium or of rocks from which the ores are absent, except as mere traces. In these cases the manganese deposits must have been formed before the carving out of the valley between them and the ridges containing micaceous hematite.

In some cases boulder-like masses of the Gosalpur quartzites were observed to be coated with manganese ores at some height above the surface of the ground. The encrustation could not clearly have been effected by percolating waters in the same way as the coating of the soil or of masonry structures referred to above. It is possible to suppose that the quartzites in question had been impregnated with ore before denudation brought down the surface of the ground to its present level,—that is to say, while the manganese-charged waters flowed over the surface of the quartzites. But while I can find no serious objection to such a supposition, some observations which I made led me to think that the quartzites may have been impregnated with ore in the position they occupy at present. At the foot of a hill at Ponri (wherein manganese ores occur), I observed the mud walls of a dilapidated hut some twenty years old to be coated with manganese, half a foot above the surface of the ground. There was no indication here of the lowering of the surface. In this case, and in that of the manganese-coated upstanding masses of quartzites, the manganese-charged surface-waters appear to me to have risen up the quartzites and the mud walls owing to capillarity; and the manganese has then been precipitated much in the same way as it has been thrown down on the soil, and in the cracks and crevices of rocks.

EXPLANATION.

Fig. 1.—Section in Pit XXXI, Gosalpur—

- a. Blocks of pyrolusite, with a little quartzite,
- a¹. Nodules of pyrolusite.
- b. Ditto iron-ore.
- c. Blocks of quartzite, with a little manganese ore.

Fig. 2.—

- a. Micaceous hematite schist (manganiferous).
- b. Psilomelane, with bits of the schist.
- c. Psilomelane.

Fig. 3.—Slice of quartzite, impregnated with manganese ore. Pabrewa, near Sihora.

On some Palagonite-bearing traps of the Rájmahál hills, and Deccan, by C.S. MIDDLEMISS, B.A., Deputy Superintendent, Geological Survey of India. (With three plates.)

General McMahon, in describing some Rájmahál and Deccan traps (Records, G. S. I., Vol. XX, page 104), mentions a peculiar substance which appears sometimes

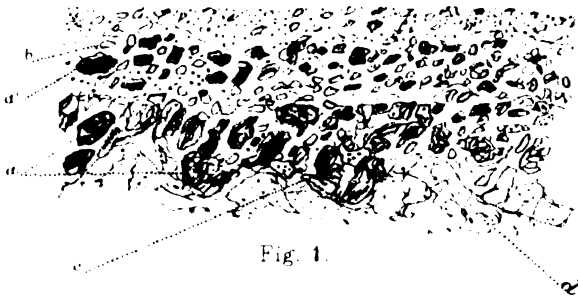


Fig. 1.



Fig. 2.

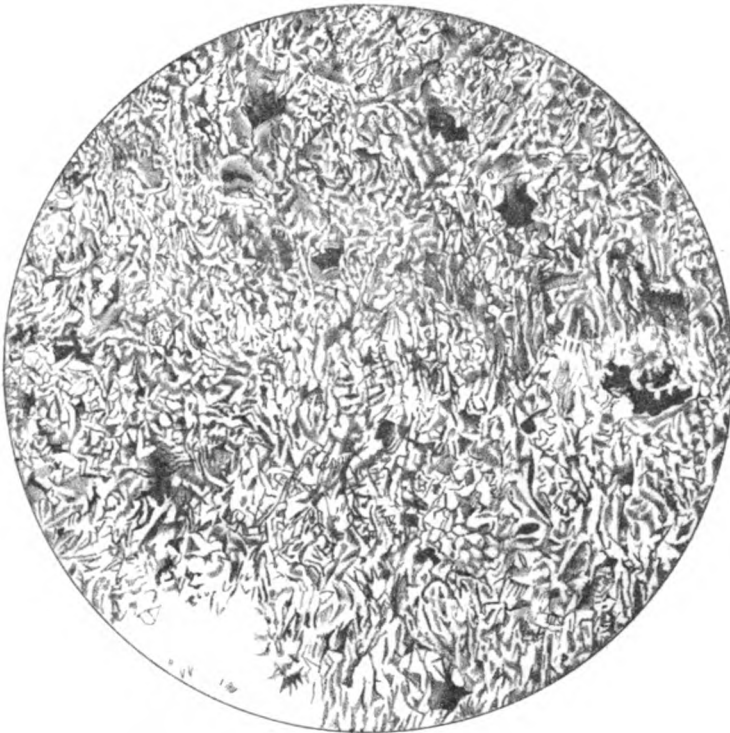


Fig. 3.

to fill up amygdules as a zeolite, and sometimes to play the part of a glassy base, in as much as it is perfectly isotrope under the microscope, with crossed nicols, and resists boiling with mineral acids.

With reference to specimen No. $\frac{1}{4}\frac{1}{11}$ (these and other similar numbers being those of the rock-register of the Geological Survey Museum), he writes—

“ A zeolite, varying from white to yellowish-red in colour, stops the amygdules, and invades the substance of the rock, forming very numerous *lacunæ*, with strongly marked marginal borders. The inner portions of many of the large felspars have also been replaced by this product of decomposition.”

Of specimen No. $\frac{1}{4}\frac{1}{8}$ he writes—

“ The products of decomposition are in No. $\frac{1}{4}\frac{1}{8}$ a greenish-brown; and in No. $\frac{1}{4}\frac{1}{5}$, a substance that is of greenish-brown colour in some places, and yellowish-red in others. This cannot be traced directly, or indirectly, to the alteration of the augite; on the contrary it fills the rôle of a glassy base, and possibly represents the uncrystallized residuum. Occasionally in No. $\frac{1}{4}\frac{1}{8}$ the greenish-brown matter appears in rounded forms, suggestive at first sight of pseudomorphs after olivine, but this appearance is, I think, delusive; and the hypothesis that might be based on it is refuted by the general behaviour of this greenish-brown matter and by other considerations. This greenish-brown material apparently forms the base in which the constituent minerals of the rock are imbedded. Moreover, these slices contain no serpentine, or serpentinous viridite, and no trace of *maschen structur* due to the deposition of opacite, or magnetite, round the edges or along the cracks in olivine crystals The conclusion at which I have arrived, after a careful study of the Rájmahál slices is that there is not a trace of olivine in any of them.”

With regard to some Deccan traps, besides mentioning amygdules stopped by chalcedony, quartz, and zeolites, he also describes No. 3 ball trap, with reference to the *lacunæ* :—

“ An orange-coloured substance is rather abundant, and forms a striking object in these slices, regarding which it is difficult to speak very positively. At first sight it looks like a mineral, but it plays the rôle of a glassy base; it is absolutely without external form or cleavage, and nearly all of it is inert between crossed nicols. Occasionally it polarizes feebly in its own natural colour. Closely allied to this is a dark-green substance, which in polarized light is perfectly isotropic. Soaking in hot hydrochloric acid sufficiently long to completely remove the hematite, and magnetite, makes scarcely any impression on the orange substance, and little on the green, that is to say, it removes the green colour, and converts the orange into a dull red but leaves a glass behind absolutely inert in polarized light.

“ On the whole, then, I have come to the conclusion that both the bright-orange and the dull-green substances, represent the original magma, or glassy base of the rock, and that they owe their mineral appearance to iron colouration.”

Of specimen No. 4, one Tree Hill quarries, Belgaum, he writes—

“ The remains of the original glassy base, in part green colour, and in part reddish-brown, is visible here and there. What I take to be the glassy base exhibits undulating marginal lines of colour that follow the borders of the bounding minerals. This appearance has been described by Zirkel in his “ Microscopical Petrography,” p. 234, and depicted in plate XI, fig. 1, of that work. Zirkel described this substance as the globulitic base of an altered basalt, metamorphosed into amygdaloidal nests. In the case of the Belgaum rock, however, the metamorphism can hardly have proceeded beyond the colouration of the glassy base, for boiling in hydrochloric acid makes little or no impression on it. It has no action on polarized light.”

From some sections that I have recently examined of the Rájmahál rocks I am inclined to put all these substances filling the *lacunæ*, and in many cases those of

the amygdules, into one category. They seem to belong to those amorphous bodies to which the name Palagonite has been given. In Fouqué and Levy's "Minéralogie Micrographique," plate XXVIII, there is an example of concretions of Palagonite which resemble these substances. MM. Fouqué and Levy define this Palagonite as follows:—"C'est-à-dire une matière amorphe, brunâtre, mamélonée, développée aux dépens du magma vitreux de la roche." It must be noticed, however, that the meaning assigned to the word Palagonite is somewhat different as applied by different authors. It would even seem to be used in another sense by the authors just cited; for in plate LII, fig. 2, they give an instance of olivine partly transformed into Palagonite.

Rosenbusch¹ describes minutely, under the head of Basalt tuffs, both Palagonite rock and Palagonite tuff; and he would seem to regard the substance as originally consisting of "lapilli of basalt glass, in which crystalline secretions have only a minor importance, and which are bound together by cement of various kinds resulting from the hydro-chemical metamorphism of the basalt glass itself."

Rutley² states that Palagonite rock "results from the action of heated water, or steam, upon flows of lava," without particularizing if it is the original magma of the flows either in the form of lapilli, or not, which is so metamorphosed.

Dana³ merely refers to Palagonite as an amorphous mineral belonging to, or near to, the Pinite group.

In spite of these differences of interpretation and definition, I prefer to make use of the word here, and to define these rocks as Palagonite-bearing traps. I am inclined, on the whole, to refer the substances to metamorphosed portions of the original magma; but, as will be seen in the following, some of these forms have a resemblance to olivine, which fact, taken into consideration with the general absence of that mineral from the basic traps of the Deccan and Rájmahál, and with the alleged transformation of olivine into Palagonite (Fouqué and Levy) may have some significance.

But, whatever be their ultimate nature, the following descriptions and drawings of the lacunæ and rock may be of some interest, as a further contribution to the microscopical study of Indian rocks, so ably begun by General McMahan.

A point of great importance, which I may indicate here, is that in some rocks from the Deccan and Rájmahál respectively, the Palagonite substances are almost identical (compare the drawings, figs. 3, 6, 8, and 9, Pl. I); a fresh link in the chain of proof as to the identity of these geographically separated volcanic outbursts.

The following sections were cut for me in the Geological Survey Laboratory, Calcutta: and I am much indebted to my friend Mr. E. J. Jones for the trouble he has taken in selecting and supervising the cutting, of these and other slices.

In none of them is there any indication of mechanical deformation of the minerals; a thing to be expected among gently undulating strata in non-mountainous country.

¹ Mikroskopische Physiographie der massigen Gesteine, p. 747.

² Study of Rocks, p. 272.

³ Text-book of Mineralogy, 4 edn., p. 331.

No. $\frac{1}{441}$.—This is described in the rock register of the Survey as “Amygdaloidal trap.” As referred to above, McMahan has described it microscopically, but he only mentions a zeolite of white and yellowish-red colour as stopping the amygdules.

Since the slices which I have had made of this rock differ in some respects from that description, I may be allowed to make mention of it again in this place. Passing over the general structure of the rock, which needs no further remarks, I will refer only to the amygdules and lacunæ present in it. The large amygdules, which are visible to the eye, are all of a different category from the very small lacunæ which I shall presently notice. One large oval amygdule in the second slice, sent me for micro-chemical testing, was $\frac{1}{4}$ inch across, and was undoubtedly chalcedony. It had a radiating fibrous structure and polarized in aggregate in pale blue-grey colours, displaying a black cross. It resisted scratching with a sharp knife, and was unaltered by acids, hot and cold.

The small lacunæ, which are noticeable in great numbers in other parts of the slice, seem to be entirely distinct from the above. They are more generally of a greenish-brown colour, though some are clear and colourless. The greenish-brown lacunæ have always a very distinct clear marginal, or sub-marginal, border of colourless material; whilst the colourless ones have a distinctly green marginal border. None in my slices of this rock were yellowish red. The shapes taken by these lacunæ are, if one may use the term, squarely amœbiform; that is to say, their main boundaries conform to the boundaries of the felspar crystals among which they lie, or to the cleavage of those crystals, though they have, as it were, put forth numerous blunt processes, very like in shape the pseudopodia of the amœba.

Fig. 1, Pl. I, is a characteristic example of the green kind. It has first a surrounding colourless envelope *a*; secondly, an amber-coloured thin zone *á*, dividing the envelope from the central portion *b*, which is dark greenish-brown coloured, and radially fibrous, the fibres being at right angles to the walls of the lacunæ. The surrounding envelope *a*, in polarized light, changes from light to dark, being dark when *x-y* is parallel or at right angles to one of the nicols. The central portion *b* gives aggregate polarization in its own colour.

In fig. 2, Pl. I, is seen an example of the clear colourless forms, with a border of green material. No structural peculiarities are noticeable in the central portion, such as the radiating structure in the green forms. Under crossed nicols a very faint blue-grey aggregate polarization can be made out in the central portion, resembling that of a fine-grained petrosiliceous rock. The green border polarizes in aggregate, in its own colour, like the central portion of fig. 1. As mentioned by McMahan, these substances invade the crystals of felspar, and sometimes even seem to be included in them, as well as lying between the crystalline contents of the rock.

On testing a portion of the cleaned slice by heating to redness on platinum foil, the results favoured the theory of the zeolitic nature of the substances. All the colourless lacunæ, and many of the felspars, lost their translucent aspect, and became clouded and opaque; whilst the green marginal borders of the former became rusty brown. The green lacunæ also became rusty brown and nearly black, as to their central portion, and clouded and opaque as to their marginal borders.

On the other hand, portions of the fresh slice, tested with acids, showed at first no change in the lacunæ. Subsequent boiling with strong hydrochloric acid removed the magnetite from the rock, and began to affect the augite; but, except for absorbing the green colour of the lacunæ there was no other effect on them. A colourless, amorphous substance was left, showing a marginal border, as before.

It seems probable, therefore, that this undissolved substance, inert under polarized light, represents the original glassy magma, among which, however, zeolitic secretions had begun to form, as in the felspars.

No. ¹/₄₃₉, "Columnar trap, near Agga, Rájmahál" (*Register*).—A fine-grained, black rock. This rock has not been described microscopically before, so far as I know. The mineral composition of the rock, as revealed by the microscope, is as follows (plate II):—There is a considerable amount of dark-brownish grey confusedly smudged glassy base, the smudging being caused by the great amount of minute specks of magnetite. A prominent feature of the slice is the occurrence of long rods, or rectilinear strings, of magnetite, as though a pen had been tried in all directions across the slice. They are doubtless attempts at crystallization on a large scale. Among this magnetite-saturated base come star-shaped, cruciform, and sometimes fan-shaped, groups of microlites and micro-crystals of triclinic felspar and augite. The augite is generally present as irregularly bounded grains. Here and there (especially noticed in the second slice sent me) basal sections of larger augites were seen with characteristic cleavages. The colour of this mineral is pale yellowish brown. Of frequent occurrence are groups of augite grains and micro-crystals of plagioclase, bound together into inextricably mixed clusters suggestive of having crystallized together. The drawings, figs. 1 and 2, plate I, accompanying McMahon's paper "on the altered basalts of the Dalhousie region"¹ represent this structure so faithfully that they might be taken for drawings of the same rock; especially the one showing the "shooting" of felspar prisms through crystals of augite. Finally, there are larger groups of porphyritic triclinic felspars; all of very clear microcline habit. They have very marked inclusions of magnetite, and a few of augite. In sections at right-angles to the composition planes of the common albite twins, these inclusions appear as slender elongations parallel to the prisms; but in sections coinciding with those planes the inclusions are more irregular, numerous, and expanded. They throng the more central portions of the crystals. The grains of augite are often accumulated round the porphyritic crystals of felspar. The porphyritic felspars also show zonal growth bands, which, near the edge of the crystals, besides being poorer in inclusions of the ground-mass, have different polarizing powers to the rest of the crystal. Occasionally, the outer edges of these large crystals are irregular, as if they had been corroded away and had then grown out again irregularly, and simultaneously with the augite. In one crystal I noticed inclusions of micro-crystals of the same mineral. The twinning of the plagioclases is very marked and beautiful, generally in fairly broad lamellæ. From the extinction angles of the microlites, and from those of hemitrope twins, the species is anorthite. The broad lamellæ also indicate a very basic felspar. Twins on the albite pattern are most common; pericline twins very rare, and the combination of the two rare, and on a minute scale.

Records, G. S. I., vol. XVI, p. 186.

There are very many interesting examples of skeleton crystals of plagioclase. As indicated by the drawings, figs. 10 to 16. Pl. I, a straight rod is first formed, the extremities of which then grow out at right angles, and their extremities again at right angles, until a square in outline is formed. To this, which is untwinned, are added apparently buttresses, and a diagonal growth (figs. 14, 15), when twinning becomes apparent. Here again, exactly similar skeleton growths have been described by McMahon in the Dalhousie basalts ¹, plate II, figs. 1, 3—7, 10, 12. Enclosures of the base are also common in them.

The larger grains of augite show twinning rarely, and frequently inclusions.

Coming now to the Palagonite lacunæ, they are of a brighter yellow than those of the last slice. One, depicted, fig. 3, is of a roughly hexagonal shape; and generally in this slice they are all more compact in outline, and without the "pseudopodia" noticed in $\frac{1}{4}\frac{1}{4}\text{T}$. The border in this case appears like the centre of $\frac{1}{4}\frac{1}{4}\text{T}$; that is to say, it is fibrous, the fibrils radiating at right angles to the walls of the lacuna. Here and there, however, the inner edge of the border is seen to be distinctly mammillated, in which case the fibrils are at right angles to the curved edge. Sometimes, little spherical portions are all but detached from the inner edge of the border; and when that is so, the fibrils radiate from the centre of those spherules. This is distinctly seen in fig. 3. Within the border there is a perfectly hyaline material of the same colour as, but of lighter tint than, the border. Irregular cracks traverse it. Under crossed nicols, whereas the border polarizes in aggregate, the central part gives no effect whatever, except complete darkness faintly tinged with the colour of the substance. It has all the appearance of a structureless glass.

Treating the section with hydrochloric acid removed some of the colour of the Palagonite, but not all.

No. $\frac{1}{4}\frac{1}{4}$, "Basaltic trap: Hills, Dhumni, Rájmahál Hills" (*Register*).—A fine-grained, dark-green, porphyritic rock. The general appearance of this rock is very like that of $\frac{1}{4}\frac{1}{4}$. There is no amorphous base, or very little, the ground-mass being finely crystalline. The magnetite is in irregular aggregates, sometimes slightly linear. The felspar appears in micro-crystals, and porphyritic crystals, and the augite in grains without crystallographic form.

The porphyritic plagioclases are similar to those of $\frac{1}{4}\frac{1}{4}$; they are of microtine habit, with inclusions and growth lines. The augite and plagioclase show also an intermingling, as in $\frac{1}{4}\frac{1}{4}$.

The Palagonite lacunæ (fig. 4, plate I) are more irregular than in $\frac{1}{4}\frac{1}{4}$. They penetrate among the crystalline constituents of the rock, moulding them more completely than in the case of $\frac{1}{4}\frac{1}{4}$. Their outlines are sometimes indistinct on one or more sides. In other words their shape does not so much resemble filled-in amygdules, but they seem structurally to occupy the positions where we should naturally expect to find remnants of an amorphous base. There do not seem to be any colourless substances. The coloured ones are greenish or yellowish brown. The radiating fibrous structure almost completely fills the lacunæ, and their marginal border is paler tinted, but not absolutely clear. There is faint aggregate polarization as before, among the fibrous material, and in its own colour.

No. $\frac{1}{4}\frac{1}{4}$, "Trap from a bed of concretionary boulders, Wardah" (*Register*).—A

¹ Records, G. S. I., Vol. XVI, p. 186.

fine-grained, greenish-black rock. This is finer-grained, when seen under the microscope, than the last described, and than $\frac{1}{4}$ inch. Essentially, however, it seems to be much the same. The ground-mass is made up of irregular grains, of pale augite matted together, among which small micro-crystals of plagioclase, somewhat ragged in appearance, are scattered about. The porphyritic plagioclases contain inclusions of the augitic ground-mass, and sometimes of the Palagonite substance. The plagioclase is of the same species as before, judging by measurements of the extinction angles of very good symmetrically twinned lamellæ. The cleavage of the porphyritic crystals is very fine and good.

A few large augite crystals are also developed.

The lacunæ are filled with a brighter, more grass-coloured Palagonite; which does not show any fibrous, or radiating structure, but a very distinct, many-times-repeated zonal structure (see fig. 5, Pl. I).

No. $\frac{1}{4}$, "Basaltic trap (compact): Motighamia Falls, Rájmahál hills" (*Register*)—A fine-grained, compact, dark-grey rock. Under the microscope it is seen to be finer-grained than even the last. It is built up of a mass of very small granules of augite, magnetite, and micro-crystals of triclinic felspar, with a few large porphyritic ones, the same as in previous slices.

The lacunæ are filled by a pale grass-green substance, without any fibrous structure visible. It appears quite amorphous, save for irregular cracks, and only sometimes possesses a zonal arrangement, as in the last specimen. Most of the lacunæ have lost their substance, leaving holes in the slice.

No. $\frac{1}{8}$, "Dense basalt: N. of Abhund, Malwa, Deccan" (*Register*).—A dirty black, finely crystalline rock. This trap from the Deccan very much resembles those described above from the Rájmahál hills. Its mineral constitution is almost exactly the same (see plate III). There is no uncrystallized magma. It is made up of a set of rather small micro-crystals of triclinic felspar, and grains of augite. The latter is of the same pale colour as in the Rájmahál rocks; but there are some larger crystals of it, some with definite crystalline form, and showing characteristic extinction angles. The magnetite is largely developed, filling up the intervals between the micro-crystals and grains of augite. The porphyritic plagioclases contain inclusions of the ground-mass, and magnetite, these lying, as before parallel to the composition planes of the largely developed albite twins. They belong to the anorthite species, and completely resemble those mentioned above in the nature and appearance of the twin lamellæ.

The lacunæ of Palagonite, fig. 6, Pl. I, are very large and distinct, some in the rock chip being spherical and $\frac{1}{4}$ inch across, and of pale yellowish orange, or golden yellow colour, with clean-cut margins and dark-brownish orange borders. Their shapes are squarely amœbiform, as in $\frac{1}{4}$ inch and $\frac{1}{4}$ inch. The borders show numerous dark and light bands, which, seen with high powers, display a fine cross striation (see fig. 7). The central portion of the lacunæ has a mottled or granular appearance and is split up by irregular cracks. Under crossed nicols the dark border evinces a granular aggregate polarization, altogether irregular. The central portion polarizes differently in different lacunæ. In some the outer edge of the central portion remains faintly illuminated, and of a deep green colour, whilst the very central portion is dark. In others the central portion appears split up into dark, and faintly

illuminated patches, which, on revolving the stage, resolve themselves into a set of conflicting dark and light crosses, which travel with the revolving stage, but at twice the rate, completing a revolution of 360° whilst the stage has only gone through 180° . Some lacunæ contained a dark dusty-looking, colourless substance, others contained the latter in combination with the yellow and orange substance, sometimes in stripes. Under polarized light they gave uncertain changes from light to dark.

On treating the uncovered slice with cold, strong hydrochloric acid, the colour of the Palagonite substances began to be absorbed in a few moments. Repeated treatment in this way soon dissolved away all the colour, and, with it, all structural differences between the margins and the central portions. At the edges of the slices, where the acid had barely spread, the change from the bright orange substance with its marginal border, zonal lines, and fine cross striation, to the structureless and colourless substance acted on by the acid could be well seen.

Heating a portion of the slice to redness on platinum foil changed the orange colour to a dark red; subsequent boiling of the slice in acid gave no result owing to the slice going to pieces, and to the marking of the effects by other changes in the magnetite and augite.

On the other hand, it was very simple to isolate fragments of the Palagonite from the rock chip from which the slice was taken, and treat them chemically. Several of these, individually transferred to a glass slide, were drawn, and then treated with acid and heated. After the colour had been removed, and all the structure gone, except the irregular cracks, they were heated to ebullition with fresh acid, ten or twelve times, and steeped all night in cold acid. The outlines, when drawn again, were the same as before the test. A clear, colourless, unaffected glass remained, without structure (except cracks), and which, very carefully tried with polarized light, remained completely inert.

It would seem, therefore, that there was originally, both in the central and marginal portions, a zeolitic substance, developed in or from the glass of the Palagonite substance, and which became absorbed by the acid, leaving the glass behind.

No. $\frac{1}{3}$, "Basaltic trap, with zeolites: hills S. of Dhumni, Rájmahál Hills" (*Register*).—A fine-grained, dark-green rock, with amygdules. This appears to be from the same locality as $\frac{1}{3}$. It resembles the latter closely, but in the Palagonite lacunæ there are some differences.

Under the microscope it is seen to be a fine-grained rock, with very contrastingly large porphyritic plagioclase feldspars. The feldspars are anorthite, as before, the angle between two hemitrope extinctions of albite twins measuring in one case 72° . There is no uncrystallized base, the ground mass being made up of very minute irregular grains of augite of pale colour, mixed with microlites of anorthite and magnetite. This crystalline ground-mass is finer in the vicinity of the larger porphyritic feldspars.

The slice possesses a larger number of lacunæ than any above described. The rock chip sent with the slice, as in the previous case, contained (plainly visible to the eye) spherical aggregates of Palagonite, $\frac{1}{8}$ th of an inch across, besides the smaller ones just visible as specks.

Under the microscope they show very little structure individually, and are of various shapes, generally irregular, and without pseudopodial processes (figs. 8, 9, Pl. I).

Their colouration varies from an exceedingly brilliant orange to pale grass green. Patches of the slide have all the lacunæ tinted one colour, and other patches tinted another, between which there is a set of lacunæ showing intermediate colours. From this it is abundantly evident that the colouration is a superinduced phenomenon, affecting different portions of the rock differently in groups or bands.

As a rule, the marginal border is only faintly seen by ordinary light in the case of the orange Palagonite lacunæ, whereas some of the green ones have a very marked zonal structure throughout. The orange-coloured substance, like the golden yellow substance of $\frac{1}{15}$, is roughly marked with an irregular granular structure, and traversed by irregular cracks. Under crossed nicols the margins come out a lighter colour, polarizing in aggregate, whilst the central portion remains almost completely dark: sometimes a faint change appearing in some of the lacunæ. In one (fig. 8) there is a finely dotted, sub-central portion, which is lighter under crossed nicols and with fine aggregate polarization, like the margins. The shapes and cracks of some of these lacunæ, at first sight, suggest a resemblance to olivine grains. There is no trace, however, here, as elsewhere, in these rocks, of normal unaltered or serpentinized olivine.

The large porphyritic crystals of plagioclase contain small Palagonite lacunæ, as well as inclusions of magnetite; and they are streaked along their cleavages by a yellow-colouring matter, which runs continuously into connection with certain of the Palagonite lacunæ.

These substances resemble most nearly those described by McMahon under the head of "No. 3, Ball trap."

Heating on platinum foil, and boiling a portion of the slice in acid, gave no good results, as in the case of $\frac{1}{15}$; but I was able again to isolate portions from the chip and treat them as in the last case. The only difference noticeable was that the whole of the colour was not absorbed, the grain of Palagonite remaining at the end a pale brownish yellow. It acted as a simple glass under polarized light. The general resemblance between the Palagonite substance of this rock from the Rájmaháls, and of the last from the Deccan, is very noteworthy, both microscopically and macroscopically.

No $\frac{1}{4}$, "Basaltic trap, with zeolites: Burhait valley, Rájmahál hills" (*Register*).—Light, dirty green, fairly fine-grained rock. This rock had fallen to pieces in the grinding. As it resembles $\frac{1}{15}$, almost completely, it needs no separate description. There is the same, blurred, glassy base, the same lines of magnetite, granular augite, and plagioclase crystals, showing all stages of growth from skeleton crystals. Lastly, the Palagonite lacunæ were the same in colour, shape, and structure.

In conclusion, I would state that, though I consider these substances described in this paper as undoubtedly belonging to what has been called Palagonite, I would not absolutely bind myself to the view either that they are metamorphosed, or zeolitized, portions of the original glassy magma (though I lean to this view), or that they are pseudomorphs after olivine. It may be remarked, however, that in the Manual of the Geology of India,¹ some of the Rájmahál traps are said to contain olivine in large quantities.

¹ Pt. I, p. 170.



Fig. 1.



Fig. 2.

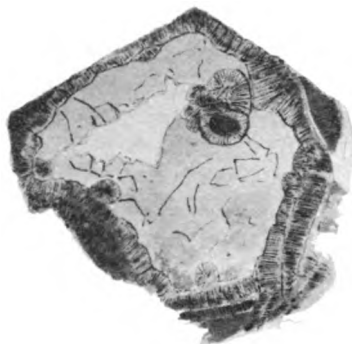


Fig. 3.



Fig. 4.

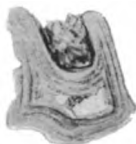


Fig. 5.



Fig. 7.



Fig. 6.

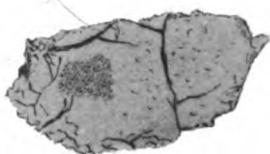


Fig. 8.



Fig. 10.



Fig. 9.



Fig. 11.



Fig. 13.



Fig. 15.



Fig. 12.



Fig. 14.

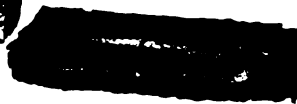


Fig. 16.

Plate I.

GEOLOGICAL SURVEY OF INDIA.

C. S. Middlemiss.

Records, Vol. XXII.



Plate II.

Photo-colotype, Survey of India Offices, Calcutta, November 1889.

GEOLOGICAL SURVEY OF INDIA.

C. S. Middlemiss.

Records, Vol. XXII.



Plate III.

Photo-Collotype, Survey of India Offices, Calcutta, December 1889.

REFERENCES TO PLATES.

Plate I, figs. 1 to 6, 8 and 9, lacunæ of Palagonite, as seen under the microscope by ordinary light; fig. 7, enlarged border of fig. 6, showing cross striation; figs. 10 to 16, skeleton crystals of plagioclase.

Plate II, Slice of a Rájmahál trap, No. 417, seen under the microscope by ordinary light.

Plate III, slice of a Deccan trap, No. 617, seen under the microscope by ordinary light.

Notes on Tin Smelting in the Malay Peninsula, by T. W. HUGHES HUGHES, C.E., A.R.S.M., F.G.S., Superintendent, Geological Survey of India.

The native method of tin smelting in vogue in the Malay Peninsula and the Tenassarim Province of Burma, has been described by various writers who have touched on the subject of the mineral resources of those parts of the world.

There are two varieties of furnaces for the reduction of ore;—one in which a natural draught is depended on, and the other where the blast is artificially applied. The latter is the only furnace that I have seen in operation; but Mr. Treacher, Secretary to Government, Perak, tells me that the other was in common use in the back parts of the State to the end of 1888, when legislation prohibited its continuance, on the ground that to feed it charcoal, made from the hardest and most valuable timber in the forests, had to be employed.

The blast furnace known as the Tonka type is the prevalent one in all the large smelting yards, and there is a general belief amongst the Chinese owners and their admirers that it cannot be improved upon for economy in working. This view is in some measure supported by the fact that at Taiping an attempt to introduce the ordinary European system of treating ore has not been a triumph. The cause of failure, however, did not, in my opinion, lie in the system, but rather in some defect of management or of measures; for, while at Singapore, passing on my way to Australia, I had the pleasure of visiting a successfully conducted enterprise, worked entirely, on the lines of an English undertaking, thus showing that, with proficient direction the expedients of western metallurgical skill could throw into shade the modest operations of native effort.

Under the title of the Straits Trading Company, Limited; large smelting works, consisting of a burning house, two reducing and refining furnaces, and necessary appliances, have been erected on Pulo Brani, which faces the New Harbour, and is separated by a narrow strait of about half a mile in width from the Island of Singapore. The Manager, Mr. John McKillop, explained to me the whole process as carried out by him, from the calcining of the raw ores to the tapping of the metal; and showed me the laboratory where assays of ore and tin were constantly being made.

I am not at liberty to enter into the details of all I observed, the Works being still "private" and strangers not ordinarily admitted, but I have permission to publish the few particulars that follow.

The raw tin stone is obtained chiefly from the Malay States of Perak, Salangore, and in less quantity from Negri Sembilan and Singapore.

Ore. Lower class ore can be accepted by the Company than the native smelter will deal in, and, as their financial transactions are ready money ones, they obtain an important advantage in purchasing.

The principal impurities are mundic, arsenical pyrites, and wolfram—the latter being a very unwelcome associate. The fuel used is Welsh anthracite and Australian Bulli coal, a bright bituminous variety. I advised a trial of such of our Assam and Bengal coals as contained a fairly high percentage of fixed carbon, as, if found suitable, of which I had no misgiving, it would then be a question of relative effect and cost, whether they obtained a footing so far south.

The charge was $1\frac{1}{2}$ of coal to 1 of ore, and the resulting slag contained 20 to 25% of tin. This slag is treated separately, and, Mr. McKillop says, is resmelted with scrap iron and coral limestone, yielding tin and a slag carrying 25 to 50 per cent. of tin, which is thrown away.

Analysis of tin. The analysis of their purest commercial tin is—

Sn.	99'97%
Fe.	'03%
	<hr/>
TOTAL	. 100'00
	<hr/>

This is a much higher quality than that of Perak tin, the analysis of which by Karsten is—

Sn.	95'66
Fe.	'07
Pb.	1'93
Bi.	2'34
	<hr/>
TOTAL	. 100'00
	<hr/>

Mr. McKillop has promised to send samples of ores and metal to our Geological Museum, and also the results of his long series of assays. These will be very interesting, and must add further repute to the inauguration of progressive science.

CALCUTTA ;

14th October 1889.

Provisional Index of the Local Distribution of Important Minerals, Miscellaneous Minerals, Gem Stones, and Quarry Stones in the Indian Empire
By W. King, B.A., D. Sc., Director of the Geological Survey of India.

An urgent demand having been made for an Annual Statement, showing the quantities and value of mineral products in British India, for publication in the *Mining and Mineral Statistics of the United Kingdom of Great Britain and Ireland*; it is thought that a considerable amount of help may be afforded to the local authorities, in their compilation of returns for the formation of the statistics required, by issuing an Index such as this professes to be. It must necessarily be a provisional issue, because the information in hand up to date is, to a very large extent, except in the matters of coal, salt and gold, very isolated, fragmentary, and, in many cases, only that of hear-say. There is also as yet considerable hesitation as to the class "Important Minerals" in India as compared with "Important Minerals" in Great Britain, many of the latter being still only known in India by traces, or as—owing to absence of fuel—of really little or no immediate importance.

The system of classification of useful minerals adopted in this Index is thus open to considerable modification or improvement; or the whole plan of the Index itself may ultimately require re-arranging; but, such as it is now, it is put forward and will be continued in issues of the Records until the whole is sufficiently complete and satisfactory to be published in a volume by itself. I would ask, however, as these issues appear, that all who are in any way interested in the completion of the Index, would obligingly send in to the Survey corrections of errors of omission or commission; and at the same time supply such information as may be within their own observation or ken.

In this Index the following arrangement of Presidencies, Provinces, Agencies, or Native States has been adopted, each being taken in its alphabetical order:—(1) Assam, (2) Bengal, (3) Bombay (including Sind, &c.), (4) Burma, (5) Central Provinces, (6) Madras (including Travancore, Cochin, Vizianagram, &c.), (7) North-West Provinces and Oudh, and (8) Punjab. *Native States.* (I) Afghanistan, (II) Baluchistan, (III) Central India and Rajputana, (IV) Kashmir, (V) Mysore and Coorg, (VI) Nizam's Dominions, (VII) Nepal, Sikkhim and Thibet.

The Mineral Products are taken under the following headings:—*Important Minerals*, including:—Coal, Iron ores, Gold, Petroleum, and Salt; *Miscellaneous Minerals* including:—Alum, Antimony Ores, Arsenical Minerals, Asbestos, Bismuth and Cobalt Ores, Borax, Chrome Ores, Copper Ores, Corundum, Gypsum, Lead Ores, Magnesia Minerals, Manganese Ores, Mica, Natron, Nitre, Ochres, Phosphates, Platinum, Plumbago, Soapstone, Soda Salts, Sulphur, Tin Ores, Zinc Ores; *Gem Stones*, including:—Amber, Beryl, Diamond, Garnet, Jade and Jadeite, Quartz, &c., Rubellite, Ruby, Sapphire, Spinel; and *Quarry Stones*, including:—Clays, Granite (Gneiss, &c.), Laterite, Limestone (Marbles, Kunkar, &c.), Slate, and Trap.

The following contractions have been adopted:—

Man. = Manual of the Geology of India.

Mem. = Memoirs of the Geological Survey of India.

Rec. = Records of the Geological Survey of India.

Mus. = Museum of the Geological Survey of India.

ASSAM.

IMPORTANT MINERALS.

Coal, C. Iron Ores, I. Gold, G. Petroleum, Oil. Salt, Sal.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.	
COAL, <i>Symbol C.</i>	CACHAR.				
	DARRANG— Barnadi R. . . .	Stat. Acct. I. 137 .	G. COR.		
	GARO HILLS—				
	Darrang-giri Garegittam, (a place in the Darrang-giri field). . . .	Man. III. 106 Mus.	. . .	...	Cretaceous; promis- ing; area of field, 20 sq. miles, 76,000,000 tons.
	Harigaon	Man. III. 106 .	. . .	...	} Not of much value.
	Rongrengiri . . . .	" " " .	. . .	...
	Somesari R. . . .	Rec. XX. 41 .	. . .	...
	Siju . . . .	" " " .	. . .	...
	KHASI AND JAINTIA HILLS—				
	Amwi	Man. III. 109 .	. . .	...	Nummulitic.
	Borsora	Rec. XVI. 164 .	. . .	...	Cretaceous.
	Byrang	Man. III. 108 .	. . .	...	Nummulitic.
	Cherra Punji	" 109 .	. . .	I. GRT. LIM. SND.	Ditto, approxi- mate quantity, 1,184,369 tons.
	Jarain	Rec. XVI. 199 .	. . .	...	Cretaceous.
	Langrin	Rec. XVII. 143 .	. . .	SND.	Ditto 30 sq. miles. Very pro- mising.
	Lairungao	Man. III. 108.	. . .	...	Nummulitic, 1,500,000 tons.
	Lakadong	" 109 .	. . .	...
	Maodon	} " 108.	. . .	...	63,000 tons.
	Maolong				
	Maonaichora				
	Maostoh				
	Maosynram				
	Maobelarkar . . . .	...	TRP.	Cretaceous; small field, 52,000 tons.	
	Narpur	Man. III. 109 .	. . .	...	Nummulitic.
	Shatyngah . . . .	. . .	. . .	...	Ditto.
	Shella	Man. III. 108.	. . .	...
	Shermang	" 109.	. . .	...
Thanjinath	" 108.	. . .	...
SINGPHO HILLS—					
Upper Dehing R. . . .	Rec. XIX. 111.	. . .	...

ASSAM—continued.
IMPORTANT MINERALS—continued.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.	
COAL— <i>contd.</i>	NAGA HILLS—				
	Dikhu . . .	Mem. XII. 354 .	ALM.		
	Dirak Nadi . . .	" 311 .	...	Makum field.
	Disai field . . .	" 355 .	G. OIL .	Poor, badly situated.	
	Disang . . .	" 353 .	OIL SND. .	Good, but out of the way.	
	Jaipur field . . .	" " .	I. OIL PLT.	Better.	
	Janji field . . .	" 355 .	G. . .	Small, comparatively unimportant.	
	Makum field . . .	" 304 .	...	Worked.
	Nazira field . . .	" 328.	...		
	Rangring . . .	" 309, 348	...	Makum field.	
	Saffrai R. . . .	" 332, 346, 348.	OIL . . .	Nazira field.	
	Tel Pung . . .	" 293, 337, 348.	I. OIL LIM. SND.	Ditto.	
	Tirap . . .	" 305, 348	...	Makum field.	
	Tiru Nadi . . .	" 332, 348	OIL . . .	Nazira field.	
	Wakang Jan . . .	" 336, 348	...	Ditto.	
	NOWGONG—				
	Dhaneswari R. . .	Stat. Acct. I. 176 .	LIM.		
	Jamuna R. . . .	" " "	LIM.		
	SIBSAGAR—				
Doigrung R. . .	Rec. XVIII. 31 .	LIM.			
IRON ORES, I.	GARO HILLS—				
	Lakkiduar Range . . .	Mus.			
	GOALPARA—				
	Dhubri . . .	Mus.			
	KAMRUP . . .	Stat. Acct. I. 21 .	LIM.		
	KHASI AND JAINTIA HILLS—	Mus. . . .	C. G. COR. GRT. LIM. SND. TRP. C. GRT. LIM.		
	Cherra Punji . . .	Mus. . . .	...	
	Lailangkot . . .	} Mem. I. 202 .	SND. . . .	Washed iron sand.	
	Molim . . .		...
	Nonkrim . . .		...
	Noyandri . . .	Stat. Acct. II. 235 .	...	Industry died out. In 1858, export 45,000 maunds.
	NAGA HILLS—				
	Dholbagan . . .	Mus. Mem. XII, 296, 360			
	Jaipur . . .	" 273 .	C. OIL PLT.		
	Tel Pung . . .	" 290, 359	OIL LIM. SND.		
	Tirugaon . . .	" 359, 360	OIL . . .	Saffrai valley, hill east of, clay-iron stones. Once worked a good deal by the Assamese.	
	SIBSAGAR—				
	Giliki Guard . . .	Mem. XII. 297 .	...	} Partly in Naga Hills.
	Golaghat . . .	Mus. . . .	...	
Naphuk . . .	Mem. XII. 297, 360	...			

ASSAM—continued.

IMPORTANT MINERALS—continued.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GOLD, G.	DARRANG—			Mostly auriferous sands.
	Bargang R. . . .	Man. III. 223.		
	Bhairavi R. . . .	" "		
	Bharoli R. . . .	" 222.		
	Burigang R. . . .	" "		
	KHASI AND JAINTIA HILLS—			
	Bogapani Nadi, Mofang.	Man. III. 227.		
	LAKHIMPUR—			
	Borpani R. . . .	Man. III. 225.		
	Dibong R. . . .	" 226.		
	Digaro R. . . .	" "		
	Dihong R. . . .	" 225.		
	Dikrang	" "		
	Joglo R. . . .	" 226.		
	Noa Dihing R. . . .	" 227.		
	Parghat	" 224 .	PLT.	
	Sadiya	" "		
	Sirsi R. . . .	" 225.		
	Subansiri R. . . .	{ " 225 and Rec. XVII. 192.		
	Tengpani Mukh	Man. III. 224.		
SIBSAGAR—				
Bari Dihing R. . . .	Man. III. 224.			
Dhaneswari R. . . .	" 223 .	C. LIM.		
Disai R. . . .	" "	C. OIL.		
Jangi R. . . .	" 224 .	C.		
Pakerguri R. . . .	" "			
P E T R O - LEUM, Oil.	CACHAR—			
	Barak R. . . .	Man. III. 138.		
	Sarung R. . . .	Stat. Acct. II. 370.		
	Siltee	" " 137.		
	SIBSAGAR AND NAGA HILLS—			
	Bari Dihing R. . . .			
	Disai Valley	Man. III. 137	C. G.	
	Disang R. . . .	" 136	C. SND.	
	Hil Jan. N. . . .	" 137.		
	Jaipur	" 136	C. I. PLT.	
	Makum N. . . .	" 134.		
	Namchick Pathar	" 133.		
	Saffrai R. . . .	" 137	C.	
	Sarang R. . . .	" 138.		
	Supkong	" 133.		
	Tel Pung, Dikhu R. . . .	" 137	C. LIM. SND.	
	Tiru Nadi	" "	C.	
	SINGPHO HILLS—			
	Tirugaon, Upper Dehing.	" "	I.	

ASSAM—continued.

IMPORTANT MINERALS—concluded.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SALT, <i>Sal.</i>	CACHAR . . .	Stat. Acct., II. 370	LIM. . .	Salt.
	LAKHIMPUR— Borhat . . .	Man. III. 491.	...	Springs; yielded in 1809, 100,000 maunds of salt.
	Sadiya . . .	" "		
	NOWGONG— Jungthang, Mikir hills	Stat. Acct. I. 176.	...	? Salt Mine.
	SIBSAGAR— Jaipur . . .	Mem. XII. 356 .	...	Saline springs, formerly utilized by the Assamese.

MISCELLANEOUS MINERALS.

Alum, *Alm.* Antimony Ores, *Ant.* Arsenical Minerals, *Ars.* Asbestos, *Asb.* Bismuth and Cobalt Ores, *B.C.* Borax, *Bx.* Chrome Ores, *Chr.* Copper Ores, *Cop.* Corundum, *Cor.* Gypsum, *Gyp.* Lead Ores, *Ld.* Magnesia Minerals, *Mag.* Manganese Ores, *Man.* Mica, *Mi.* Natron, *Nat.* Nitre, *Nit.* Ochres, *Och.* Phosphates, *Pho.* Platinum, *Plt.* Plumbago, *Ptm.* Soapstone, *Sop.* Soda Salts, *Sod.* Sulphur, *Sul.* Tin Ores, *Tn.* Zinc Ores, *Znc.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
ALUM, <i>Alm.</i>	SIBSAGAR— Dikhu Valley . . .	Mem. XII. 361; Mus.	C. . .	From pyritous shales of coal measures, might be manufactured profitably.
COPPER ORES, <i>Cop.</i>	MUNIPUR— Kubo Valley . . .	Man. III. 278.		
CORUNDUM, <i>Cor.</i>	DARRANG . . .	Stat. Acct. I. 139 .	...	Small quantity.
	KHASI AND JAINTIA HILLS— Nongrynieu . . .	Man. III. 426 .	...	Worth attention.
MAGNESIA, MINERALS, <i>Mag.</i>	MUNIPUR— Kasom.			
PLATINUM, <i>Plt.</i>	SIBSAGAR— Jaipur . . . Noa Dihing, R. . .	Mus. . . Man. III. 168 .	C. I. OIL. G.	
SULPHUR, <i>Sul.</i>	NOWGONG— Mikir and Rengmah Hills.	Mus.		

ASSAM—continued.

GEM-STONES.

Amber, *Amb.* Beryl, *Brl.* Diamond, *D.* Garnet, *Gar.* Jade, and Jadeite, *Yd.* Quartz, *Q*
 Rubellite, *Rbl.* Ruby, *R.* Sapphire, *S.* Spinel, *Spl.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
QUARTZ, <i>Q.</i> (Includes rock-crystal and the various forms of quartz, as Agate, Amethyst, Blood-stone, Chalcedony, Chert, Flint, Jasper, Onyx, Opal, &c.)	KHASIA AND JAINTIA HILLS— Maram . . .	.....	...	Amethystine quartz.

No further reliable information.

QUARRY STONES.

Clays, *Cly.* Granite, Gneiss, &c., *Grt.* Laterite, *Lte.* Limestone, Marbles, Kunkar, &c., *Lim.*
 Slate, *Slt.* Trap, Basalt, &c., *Trp.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
CLAYS, <i>Cly.</i>	LAKHIMPUR— Brahmakhund . . .	Man. III. 567 . . .	...	Kaolin. Very out of the way.
	Bora . . .	" "		
	GARO HILLS— Tura . . .	Rec. XX. 42 . . .	GRT.	White shaly indurated clay; thick deposit. Fine white clay, base of cretaceous rocks.
	Western end of range	Man. III. 567 . . .	...
	GOALPARA— Goalpara . . .	Mus.		
	NAGA HILLS— Ledo Coal Mine . . .	Mus. . . .	C.	

ASSAM—continued.

QUARRY STONES—continued.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GRANITE, &c., <i>Grt.</i> (Includes all fairly compact crystalline rocks; as gneisses of all kinds, generally of grey greenish or flesh colors. Not compact massive black or dark-green rocks such as Basalt, Trap, &c.)	CACHAR— Kopili R. . . .	Mus. . . .	LIM.	
	DARRANG— Tezpur	Mus.		
	GARO HILLS—	Man. III. 535.		
	KAMRUP— Kamaikia	Mus.		
	KHASIA AND JAINTIA HILLS— Cherra Punji	Mus. . . .	C. I. LIM.	
	Lailangkot	"	SND.	
	Molim	"		
	Nongepang	"		
	Nonglang	"	TRP.	
	Surarim	"		
NAGA HILLS— Nambar Falls	Mus. . . .	C. LIM.		
LIME- STONE, &c., <i>Lim.</i> (Includes most marbles of different kinds, calcareous, flag-stones, Kunkar or G h u t i n , Travertine. Also, for convenience, serpentines and alabaster.)	CACHAR.			
	Gunjung	Rec. XVI, 243.		Travertine, or kunkar.
	Quilong	" 203 . . . .	...
	DARRANG— Mangaldai Sub-Divn.	Mus.		
	GARO HILLS— Arnok	Rec. XX. 41	GRT.	Cretaceous limestone, vertical beds.
	Damalgiri	Mus." 42.		
	Khalupara	"		
	Rongkon Stream	"		
	Siju	Rec. XV. 178	C.	
	KAMRUP— Foot of Bhutan Hills.	Stat. Acct. 121	I. . . .	Apparently travertine: good quarry.
KHASI AND JAINTIA HILLS— Bhawal	Stat. Acct. II. 234		Large quarries. Inglis & Co.	
Borsora	Rec. XVI. 164	C. . . .		

ASSAM—continued.

QUARRY STONES—continued.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LIMESTONE —contd.	KHASI AND JAINTIA HILLS—contd.			
	Borpungi	Stat. Acct. II. 234	...	Supply inexhaustible: goes by the name of Sylhet Lime. Export in 1876-77; 1,600,000 maunds. Revenue R67,626. Khasi Chiefs' Revenue more than £2,000.
	Borsyrmai			
	Byrang			
	Chunchhora			
	Chunjura			
	Dholai			
	Dwara			
	Ichhamati			
	Lamapushi			
	Langrin			
	Lithang			
	Longlong			
	Lumdihlong			
	Maoni			
	Maodon			
	Maokartilla			
	Maolong			
	Moheshkali			
	Myrlipungi			
	Nongtha-long			
	Nokria			
	Patharia			
	Ramsengraiskeh			
	Rowai			
	Rupnath			
	Shella			
Silai				
Sohlai				
Tharia Ghat				
	Nowgong—			
	Panimur	Stat. Acct. I. 176.		
	Sibsagar—			
	Doigrung	Rec. XVIII, 32	C.	
	Nambar R.	Mem. IV. 412	C. GRT.	
	Tel Pung. Valley	" XII.		
	Sylhet—			
	Bagoli	Rec. XVII. 114	Foot of Langrin Coal-field. Worked by Inglis & Co. Burnt at Sonamganj. Output 1888-89, 1,223,570 maunds.
	Lokma	" 145.		
SAND-STONES, Snd.	DARRANG	COR.	
(Includes any sandy rock used for building,	GARO HILLS—			
	Ganchi.			
	Puthimari.			
	Rongphagiri.			

ASSAM—concluded.

QUARRY STONES—concluded.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SAND-STONES —concluded. (even calcareous sandstones, flags. Also quartzites, which are only indurated sandstones, pebbly rocks.)	GARO HILLS— <i>contd.</i>			
	Rongphar stream. Sumesari. Do. R.			
	KHASI AND JAINTIA HILLS— Cherra Punji Liam. Shillong. Umblay R.	.....	C. I. GRt. LIM.	
SLATE, <i>Slt.</i> . (Includes flags, though these are cleaved like slates.)	KHASI AND JAINTIA HILLS— Moflung Umiam	Mus. "		
TRAP, &c., <i>Trp.</i> (Includes basalt, whinstone, and other compact massive dark colored rocks.)	KHASI AND JAINTIA HILLS— Lime Glen Maomlu Maubelarkar Nonglang Soktia Tharia R. . . . Tharia Ghat. . . .	Mus. " " " " " "	C. GRt. LIM.	

BENGAL.

IMPORTANT MINERALS.

Coal, C. Iron Ores, I. Gold, G. Petroleum, Oil. Salt, Sal.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
COAL, C. .	BHAGULPUR— Bramini R. . . . Chapurbita Hura Mhowagarhi Pachwara	} Man. III. 78; Mem. XIII. Part 1.	TRP. SND. "	Being tried by boring.
	BURDWAN— Barakar Jainti Kundit Karalah . . . .				See Raniganj Man. III. 78; Rec. VII. 247. Man. III. 78.	I. LIM. SND. Pits.

BENGAL—continued.

IMPORTANT MINERALS—continued.

Mineral or Stones.	Locality.	Reference.	Other Minerals.	REMARKS.
COAL— contd.	BURDWAN—contd. Laikdih . . .	.....	SND. . .	Open quarry, with seam of coal over 70 feet thick, worked by Bengal Coal Company.
	Raniganj . . .	Man. III. 81; Mem. III, Part 1.	LIM. SND. . .	500 square miles. Estimated quantity, 14,000 million tons. 44 collieries. Raniganj is the general name for the field. Messrs. Apcar and Company, working Churanpore Colliery, expect to put out for 1889-90 2,000 tons. The output of the Bengal Coal Company for the year ended April 1889, was 213,119 tons. The New Beerbhoom Coal Company's output for the half-year ending April 1889, was 3,207,849 maunds. The Raniganj Coal Association for the year ending March 1889 raised 1,391,591 maunds.
	Sahajori . . .	Man. III. 78.		
	Sanktoria . . .	" 78; Mem. III, Part 1.	SND. . .	Pits.
	CHOTA NAGPUR— Aurunga . . .	Man. III. 85; Mem. XV. 55.	I. LIM. SND.	97 square miles. 20 million tons.
	Bisrampur . . .	Man. III. 88; Rec. VI. 81.	...	400 square miles.
	Bokaro . . .	Man. III. 83; Mem. VI. 39.	...	220 square miles, 1,500 million tons.
	Chopé . . .	Man. III. 85; Mem. VIII. 347.	...	1 square mile.
	Daltongunj . . .	Man. III. 87; Mem. VIII.	COP. . .	200 square miles. 11 million tons.
	Giridih . . .	.....	...	Pits. East Indian Ry. Co. Bengal Coal Company.

BENGAL—*continued.*IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
COAL— <i>contd.</i>	CHOTA NAGPUR— <i>contd.</i>			
	Hutar	Man. III. 86; Mem. XV. 91.	SND.	78 square miles.
	Irea	Man. III. 87; Mem. XVII.		
	Itkuri	Man. III. 85	...	Half a square mile.
	Jhilmilli	" 88; Mem. XXI. 205.	...	35 square miles.
	Jharia	Man. III. 83; Mem. V.	...	200 square miles.
	Karanpura N. & S.	Man. III. 85; Mem. VI.	...	465 million tons. 472 and 72 square miles. 8,750 million tons, and 75 million tons.
	Karharbari	Man. III. 78	SND.	8½ square miles, estimate, 136 million tons. Output of Bengal Coal Company, ending April 1889, 100,160 tons, E. I. R. Company, for half-year ending June 1889, 260,924 tons, Raniganj Coal Association, for year ending March 1889, 2,675,743 maunds.
	Lakhanpur	Man. III. 80.		
	Morne	" 87; Mem. XVII.		
	Ramgarh	Man. III. 84; Mem. VI. 109.	...	40 square miles.
	Ramkola.	Man. III. 89.		
	Rampur	" 87; Mem. XV. 21.		
	Tattapani	Man. III. 89	G. SND.	
	ORISSA—			
Patrapara	} Man. III. 75; Mem. I. 33.	G. SND.	700 square miles. Inferior.	
Talchir				
RAJSHAYE—				
Daling	} Mem. XI,	COP. TN.		
Jainti R.				
Pankabari				
Tindaria				.....	...	Tried, but found to be too much crushed; might make briquettes.

BENGAL—*continued.*
IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
IRON ORES, <i>I.</i>	BHAGULPUR— Kharakpur Hills . . .	Man. III. 367 . . .	SLT. SND.	Lateritic ores.
	BURDWAN— Ballia	Man. III. 364.	C. LIM. }	Clay ironstone, Bengal Iron Works. Lateritic ore largely.
	Barakar	Man. III. 362.		
	Deocha	" "		
	Dumra	" "		
	Goanpur	" "		
	Narainpur	" "		
	CHOTA NAGPUR— Balunagar	Man. III. 378; Mem. XV. Part 1.	LIM.	To the north of; 4 square miles, man- ganiferous.
	Chaibassa	Man. III. 375.	C. G. }	Lateritic ore. Bedded magnetite. Remarkable abund- ance of ores. Ferruginous shales.
	Gangpur	" 381		
	Jashpur	" "		
	Kasai R.	" 374		
	Palamow	" 376		
	Rajbar	" 377; Mem. XV. 112.	Ferruginous shales.
	Tiludih	Man. III. 374	Magnetic iron.
	DACCA— ? Madapur Jungle	? Lateritic ore.
	ORISSA— Talchir State	Man. III. 361; Mem. I. 11.	C. G. SND.	Ironstone, shales, or lateritic ore.
Ungul State	Man. III. 361; Mem. I. 11.			
GOLD, G.	BURDWAN— Dalkissar (Bankura)	Man. III. 189	Sands. And tributaries. 21 gold washers.
	Kasai R. (Midnapur)	" "	
	CHOTA NAGPUR— Asantaria (Singh- bhum).	Rec. II. 11. Man. III. 194.	} COP. SLTR. SND. } LD.	Sands.
	Bajragi (Udaipur)	" 197.		
	Bakaruma	" 199.		
	Bamni R. (Manbhum)	" 192.		
	Bhagmundi (")	" 190.		
	Bonai (Trib. States)	" 195.		
	Chaibassa	" 192		
	Dalma Hills (Man- bhum).	" 192.		
	Dhipa	" 193.		
	Hisatu . . . . .	.....	
	Ichagarh	Man. III. 193.		
Jamargi	" 199.			

BENGAL—*continued.*IMPORTANT MINERALS—*concluded.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.	
GOLD, G.— <i>contd.</i>	CHOTA NAGPUR— <i>contd.</i>				
	Jashpur (Trib. States)	Man. III. 196	I. . . .	Nugget in Museum.	
	Kamerara (Singbhum)	" 193.			
	Kamhar (Udaipur)	" 199.			
	Kappargadi Ghat	" "			
	Karkari R. (Manbhum)	" 192.			
	Kasai R. (")	" "			
	Khandrajah (Udaipur)	" 199.			
	Koweri R. (")	" 192.			
	Landu . . .	" 194.			
	Namra . . .	" 192.			
	Pharsabahal . . .	" 197.			
	Porahat . . .	" 193.			
	Rabkob . . .	" 194.			
	Salka . . .	" 199.			
	Saranda . . .	" 195.			
	Sonapet . . .	" 194			
	Subhanarekha R. . .	" 192.			
	Supur (Manbhum) . .	" "			
	Tutko R. (Manbhum)	" "			
	Udaipur . . .	" 194.			
		DACCA—			
		Tipperah? . . .	Man. III. 228	...	On authority of Tavernier.
		ORISSA—			
		Brahmani R. . . .	" 180	...	Sands.
		Dhenkanal . . .	" 188.		
		Keonjhar . . .	" "		
	Ouli R. . . .	" 189.			
	Pal Lahara . . .	" 189; Mem. 188.	...	Sand, said to be worked considerably.	
	Tikaria R. . . .	Man. III, 189.			
P E T R O - LEUM, <i>Oil.</i>	CHITTAGONG?				
SALT, <i>Sal.</i>	CHITTAGONG—				
	Bangamura . . .	Man. III. 491	...	Salt lick.	
	Mawdangklang . . .	" "	...	Ditto.	
	Lungshem range . . .	" 492	...	Two salt springs.	
	Sorphuel Hill . . .	" "	...	Salt spring.	
	ORISSA—				
	Balasore . . .	Man. III. 477	...	Artificial.	
	Puri . . .	.....	...	Artificial. ; Chilka Lake.
	PATNA—				
	Behar . . .	Man. III. 477	...	Indirectly, from the Saltpetre factories.	

BENGAL—continued.

MISCELLANEOUS MINERALS.

Alum, *Alm.* Antimony Ores, *Ant.* Arsenical Minerals, *Ars.* Asbestos, *Asb.* Bismuth and Cobalt Ores, *B.C.* Borax, *Bx.* Chrome Ores, *Chr.* Copper Ores, *Cop.* Corundum, *Cor.* Gypsum, *Gyp.* Lead Ores, *Ld.* Magnesia Minerals, *Mag.* Manganese Ores, *Man.* Mica, *Mi.* Natron, *Nat.* Nitre, *Nit.* Ochres, *Ochr.* Phosphates, *Pho.* Platinum, *Plt.* Plumbago, *Plm.* Soapstone, *Sop.* Soda Salts, *Sod.* Sulphur, *Sul.* Tin Ores, *Tn.* Zinc Ores, *Znc.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
ANTIMONY ORES, <i>Ant.</i>	CHOTA NAGPUR— Dhadka (Manbhum) .	Man. III. 164 .	Ld.	Associated with lead ores.
	Hisatu (Hazaribagh) .	" "	G. Ld.	
ASBESTUS, <i>Asb.</i>	CHOTA NAGPUR— Manbhum Dist. .	Man. III. 519 .	...	No abundant source known.
BISMUTH & COBALT ORES, <i>B.C.</i>	CHOTA NAGPUR— Singbhum Dist. .	Man. III. 163; Rec. III. 97.	Cop.	Traces of bismuth from copper ores.
COPPER ORES, <i>Cop.</i>	BHAGULPUR— Bairuki . .	Man. III. 244; IV. 25.	...	Deogarh Copper Mines Company.
	Deogarh . .	Man. III. 244; IV. 25.	Ld.	
	BURDWAN— Bodh Bandh . .	Man. III. 244 .		
	CHOTA NAGPUR— Baragunda . .	Man. III. 254 .	Ld.	The Bengal Baragunda Copper Company, for the year ending December 1888, turned out 218 tons of refined copper.
	Chaibassa . .		G. Stt. SND.	
	Daltonganj . .	Man. III. 256 .	C.	
	Kalianpur (Manbhum) . .	" 247.		
	Kasianuan . .	" 256.		
	Landu (Singbhum) . .	" 249; IV. 5; Rec. III. 89.	...	Traces of native metallic copper.
	Purda (Manbhum) . .	Man. III. 246 .	...	Ancient copper mine.
Singbhum . .	" 247 .	...	Numerous localities for a distance of 76 miles, between Lopsa on the frontiers of Lohardaga, and Kamerara on those of Midnapur.	

BENGAL—*continued.*MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
COPPER ORES, <i>Cop.</i> — <i>contd.</i>	RAJSHAYE— Buxa (Chel R.).	Man. III. 276; Mem. XI. 79.	...	Worked 1871-72.
	Kalimpung . . .	Man. III. 275; Mem. XI. 76.		
	Mahanadi . . .	Man. III. 275; Mem. XI. 78.		
	Mangphu . . .	Man. III. 275; Mem. XI. 76.	...	Said to be the only mine worked at present in Darjeeling territory.
	Pashok . . .	Man. III. 275; Mem. XI. 75.		
	Rangbong . . .	Man. III. 275; Mem. XI. 75.		
	Rani Hat . . .	Man. III. 274; Mem. XI. 72.	...	Traces. One set of mines worked in 1873.
	Re Ung . . .	Man. III. 275; Mem. XI. 76.		
CORUNDUM, <i>Cor.</i>	BHAGULPUR— Jamui Hills? (Monghyr)	Stat. Acct. XV. 31	Mi.	
	LEAD ORES, <i>Ld.</i>	BHAGULPUR— Bairuki . . .	Man. III. 287 . . .	COP.	Deogarh Copper Mines. Rumours of lead ores. } Silver lead ores.
Chakai Hills . . .		" 290 . . .	Mi.	
Dudijor . . .		" 289 . . .		
Gonora . . .		" " . . .		
Gouripur or Phaga . . .		" 288 . . .		
Karabank . . .		" 289 . . .		
Karda . . .		" " . . .		
Kajurea . . .		" " . . .		
Kharakpur Hills? . . .		" 290 . . .	I. SLT. SND.	
Khurikhar . . .		" 289 . . .		
Panch Pahar or Akasi . . .		" 287 . . .	...
Sankera Hills . . .		" 286 . . .		
Turee Pahar or Tiur . . .		" 287 . . .		
CHOTA NAGPUR—	Baragunda . . .	Man. III. 292 . . .	COP.	Baragunda Cop- per Mines.
	Barikhap (Lohardaga) . . .	" 294 . . .		
	Barhamasia . . .	" 292 . . .	...	No silver reported.
	Bhelounda (Sirguja State) . . .	" 294 . . .		
	Chiraikhund (Sirguja State.) . . .	" 295 . . .	...	Abandoned lead mine.

BENGAL—continued.

MISCELLANEOUS MINERALS—continued.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.	
LEAD ORES —contd.	CHOTA NAGPUR—contd.				
	Dhadkha (Manbhum)	Man. III. 290	ANT.	Fine argentiferous ore.	
	Hisatu	" 293	G., ANT.		
	Khasmi	" 292			
	Mahabagh	" 291			
	Mahandadi	" 29	COP., LIM., ZNC,		Argentiferous galena; good.
	Mukundganj	" "			
	Nawada	" "			
Parseya	" 293				
	Sili (Lohardaga)	" 294			
MANGANESE ORES, Man.	CHOTA NAGPUR— Chaibassa	Man. III. 328; Mem. XVIII. Pt. 2. 87.	G. COP. SLTE. SND.	Manganiferous limonite; abundant.	
MICA, <i>Mi.</i> (Erroneously called Talc: Mica is an elastic mineral; Talc is only flexible and seldom in plates.)	BHAGULPUR— Chakai Hills	Man. III . . .	LD. COR.		
	Jamui	...			
	Jamtara	Man. III. 527.			
	CHOTA NAGPUR— Bhooria.				
	Dhanwi	Man. III. 525	...	1863; 10,000 maunds were exported, value Rs. 30,000.	
	Dhab or Dhub	" 526; Rec. VII. 41.			
	Dhobapat.				
	Dumchash.				
	Gawan.				
	Gumji	Man. IV. 96; Rec. VII. 41			
Kakariar.					
Kuderma	Man. III. 526		In 1843, 9 Mica mines; annual rent Rs. 113-10.		
	Quadrumma	" 525.			
	Ghingho.				
	PATNA— Chutkari	...	GRT. . .	Usually called Gya mines.	
	Dabour				
	Rajaoli	Man. III. 527.			
OCHRES, <i>Och.</i>	BHAGULPUR— Kharakpur Hills	Man. III. 417.			
	Rajmahal	" "			
PHOSPHATES, <i>Pho.</i>	CHOTA NAGPUR— Smiratari	Man. III. 455; Rec. VII. 43.	...	Apatite, crystals, rare.	

BENGAL—*continued.*
MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
PHOS- PHATES; <i>Pho.—contd.</i>	CHOTA NAGPUR— <i>contd.</i> Tendwa Nadi.			
	ORISSA— Ramidi	Rec. VII. 43. Man. IV. 131; Mem. I. 37.	...	Apatite, crystals, rare.
PLATINUM, <i>Ptt.</i>	CHOTA NAGPUR— Guram R. (Dhadka, Manbhum).	Man. IV. 3; Rec. XV. 55.	...	Traces.
	Landu (Chaibassa)	Man. IV. 3; Rec. XV. 55.		
	ORISSA— Brahmini R.	Man. IV. 3; Rec. XV. 55.		
PLUMBAGO, <i>Pimb.</i>	CHOTA NAGPUR— Hutar (Koel R.) Lo- hardaga.	Man. III. 53	C.	Trace in gneiss.
SOAP- STONE, <i>Sop.</i> (Includes Steatite, Pot- stone, Talc. (not Mica), Bulpum).	CHOTA NAGPUR— Aranga	} Man. III. 442; Mem. XVIII. 111—148.	...	All these are rather potstones, a coarse form of soapstone or steatite.
	Bandgaom			
	Barahatu			
	Bogra			
	Chaibassa			
	Ellora			
	Gendra			
	Gopalpur			
	Jabla			
	Jogidih			
	Khurbunni			
	Moisara			
	Mutgoda			
	Pardih			
	Pokarhattu			
	Punsa			
	Sarusbad			
Semna				
ORISSA— Nilgiri Hill	Man. III. 441.			
PATNA— Pathalkoti	Man. III. 441; Stat. Acct. XIII. 26.	...	Dark blue or black.	
SODA SALTS, <i>Sod.</i>	RAJSHYBE DIV.— Darjiling Terai	Man. III. 495; Mem. XI. 90.	Sodium sulphate from salt licks along out-crop of Damuda rocks, foot of Darjiling Hills.

BENGAL—continued.

MISCELLANEOUS MINERALS—concluded.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SODA SALTS, <i>Sod.—contd.</i>	PATNA DIVISION— Behar			Patna <i>Khari</i> ; sodium carbonate, produced artificially from soil efflorescence of sodium sulphate, a form of <i>reh</i> ,
TIN ORES. <i>Tn.</i>	CHOTA NAGPUR— Nurgo or Nurunga . . . Phira . . . Simratari . . .	Man. III. 314; Rec. VII. 35. Man. III. 315; Rec. VII. 35. Man. III. 315; Rec. VII. 35.	I . . .	Grains of tinstone in gneiss. Traces
ZINC ORES <i>Znc.</i>	BHAGULPUR— Bairuki (Santhal Parg.)	Man. IV. 18, 25 .	COP. LD. .	Deogarh Copper Mines.

GEM, STONES.

Amber, *Amb.* Beryl, *Brl.* Diamond, *D.* Garnet, *Gar.* Jade, *Jadeite*, *Jd.* Quartz, *Q.*
Rubellite, *Rbl.* Ruby, *R.* Sapphire, *S.* Spinel, *Spl.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
BERYL, <i>Brl.</i>	CHOTA NAGPUR— Tendwaha R. (S. of Mahabar Hill, Hazaribagh). ORISSA— Ramidi . . . Ungul . . .	Man. III. 521; Rec. VII. 43. } Mem. I. 36; Man. IV. 87.	... ...	Small crystals, yellow. Also Chrysoberyl.
DIAMOND, <i>D.</i>	CHOTA NAGPUR— Koel R. ? . . . Sunk R. ?	Man. III. 24 .	...	Apparently fabulous.
QUARTZ, &c., <i>Q.</i>	BHAGULPUR— Barhait (Panch Pahar)	Man. III. 505 .	TRP. . .	Agates, quartz crystals, smoky quartz, also carnelian.
(Includes Rock crystal and the various forms of Quartz: as Agate, Amethyst, Bloodstone, Chalcedony, Chert, Flint, Jasper, Onyx, Opal. &c.)	BURDWAN— Bankura . . . CHOTA NAGPUR— Hazaribagh . . . Palamow . . . Singhbhum . . .	Man. IV. 68 . Man. IV. 68 . Man. III. 505 . " " .	... ... ... ...	Rose quartz. Rose quartz. Agates. Banded jaspers.

BENGAL—*continued.*

QUARRY STONES.

Clays, *Cly.* Granite, gneiss, &c., *Grt.* Laterite, *Lte.* Limestone, Marbles, Kunkar, *Lim.* Sandstone, *Snd.* Slate, *Slt.* Trap, Basalt, &c., *Trp.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
CLAYS, <i>Cly.</i>	BHAGULPUR— Colgong	} Man. III. 565 .	...	Pottery clays.
	Lohandia			
	Monghyr			
	Patharghata			
	Rajmahal Hills			
	BURDWAN— Bankura	Man. III. 566 .	...	White lithomarge from lateritic deposits, 12 miles N. E.
	Monad . . . . .	.. 564 .	...	Tenacious loam, used as glaze or varnish.
	Raniganj . . . . .	.. 565 .	C.	Coal-measure clays; also fire clays. Messrs. Burn & Co.'s Pottery Works.
	CHOTA NAGPUR— Karharbari	Man. III. 569 .	C.	Fire clays in coal measures.
	PRESIDENCY— Akra	Man. III. 569 .	...	Brick factory. Alluvial clays.
Kulna . . . . .	.. 564 .	...	Siliceous and ochreous earth, used for glaze or varnish.	
GRANITE, &c., <i>Grt.</i> (Includes all fairly compact crystalline rocks; as gneisses of all kinds, generally of grey greenish or flesh colors. Not compact massive black or dark green rocks such as Basalt, Trap, &c.)	BHAGALPUR— Colgong	Man. III. 536 .	...	Small hills of piled masses of compact grey granite quarried in old times.
	CHUTIA NAGPUR . . . . .	.....	...	Gneisses and granites common; but have not been much used.
	ORISSA— Niltigarh Hill (Ultee Pargana).	Man. III. 536 .	...	Garnetiferous gneiss.

BENGAL—continued.

QUARRY STONES—continued.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LATERITE, <i>Lto.</i>	BHAGULPUR— Kharakpur Hills Rajmahal . . .	Man. III. 550 " "	I. SLT. TRP.	
	BURDWAN— Bankura, Mahommed Bazar Midnapur . . .	..... Man. III. 550.	I.	
	DACCA— Madapur Jungle ?			
	ORISSA . . .	Man. III. 550 .	...	Largely used in connection with irrigation works.
LIMESTONE, &c., <i>Lim.</i> (Includes: Marbles of different kinds, cal- careous flag- stones, Tra- vertine, 'Kunkar,' or 'Ghuti n.' And, for con- venience, serpentines and alabas- ter.)	...	.....	...	Kunkar is generally distributed, even in the alluvium: mostly used for lime or road material, very seldom as a building material.
	BURDWAN— Barakar . . . Jamwan . . . Ramlallpur . . .	..... Man. III. 458 . " "	C. I.	Kunkar. Limestone, Dolomitic lime- stone. Kunkar.
	Raniganj . . .	.....	C. . .	Kunkar.
	CHOTA NAGPUR— Deredag (Lohardaga)	Man. III. 458; Mem. XV. 32. 125	...	Very considerable deposit, in calcareous gneisses.
	Hansapathar . . .	Man. III. 458 .	...	Crystalline lime- stone.
	Mahabagh . . .	" 459; Rec. VII. 34.	LD. . .	Ditto. .
	Pachit Hill . . .	Man. III. 458. .	SND. .	Limestone associat- ed with sand- stones. N.-W. corner of hill.
	Purda Satbarwah . . .	" " " 459 .	COP.	Crystalline dolomite. Limestone, abund- ant, but not very pure.
	Singbhum . . .	" 447; Mem. XVIII. Part 2.	...	Serpentines have been found.
	SAND- STONE, <i>Snd.</i>	BHAGULPUR— Kharakpur Hills . . .	.....	...	Massive beds of quartzite or alter- ed sandstone.
Rajmahal Hills . . .		Man. III. 547 .	...	Sandstones and flags.

BENGAL—concluded.

QUARRY STONES—concluded.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SAND-STONE, <i>Snd.—contd.</i> (Includes any sandy rock used for building, even calcareous sandstones. Flags; also quartzites which are only indurated sandstones. Pebble rocks.)	BHAGULPUR— <i>contd.</i> BURDWAN— Barakar . . .	Man. III. 546	Numerous sandstones of every degree of durability and consistence. Numerous quarries. Sandstones of all kinds. Quartzite, altered sandstone. Burdwan Paving Stone Co.
	CHOTA NAGPUR— Giridih . . .	.....	...
	Hazaribagh . . . Karharbari . . . Ranchi . . . Susunia Hill . . .	} Man. III. 547. " 549 . . .	...
	ORISSA— Cuttack . . .	} Man. III. 547; Jour. As. Soc., Bengal, XI. 836; Rec. V. 59.	...	
	Kundagiri . . .		...
	BHAGULPUR— Kharakpur Hills . . .	Man. III. 552 . . .	...
	CHOTA NAGPUR— Chaibassa . . .	Man. III. 553 . . .	...
SLATE, <i>Slt.</i> (Includes flags, though these are cleaved like slates.)	Manbhum . . .	" "	...	Coarsely cleaved, coarse clay slates; not proper slates, but an approach to the material of English commerce. Some of these coarse clay slates are finer and better than those of Kharakpur. Generally distributed; but poor, and have never been utilized.
	Singbhum . . .	" "	...	
	BHAGULPUR— Rajmahal Hills . . .	Man. III. 538, 539 . . .	...
	BURDWAN— Raniganj Coal-field . . .	Man. III. 538, 539 . . .	...
TRAP, <i>Trp.</i> (Includes Basalt, whinstone, and other compact massive dark colored rocks).	CHOTA NAGPUR— Dalma Hill . . . Kuchung . . . Mainpat . . .	Man. III. 538, 539 . . . " " " "	Basaltic trap flows and sheets. Dykes of greenstone. Dykes. Basalt, Deccan Trap Series.
	Pubbia . . . Rajabasa Hill . . .	" " " "	... ...
	ORISSA—			

BOMBAY.

IMPORTANT MINERALS.

Coal, C. Iron Ores, I. Gold, G. Petroleum, Oil. Salt, Sal.

Mineral or Stone.	Locality.	Reference.	Other Minerals,	REMARKS.
COAL, C.	SIND DIVISION— Lainyan . . .	Man. III. 96; Mem. VI. 13; XVII. 192.	I. . . .	No true coal, but only lignite, according to Mr. Blanford. Not without promise.
IRON ORES, I.	NORTHERN DIVISION— <i>Ahmedabad Collectorate—</i> Gogha <i>Kaira Collectorate—</i> Kapadvanj <i>Panch Mehals Collectorate—</i> Godra Village (Palanpur). Jambughora Surajpur <i>Rewa Kantha—</i> Bhelod Jambughora Sunodra Tadkesar <i>Surat Collectorate—</i> Balsar Bodham Pardi <i>Katch Agency—</i> Bhachan Dudhai Kaura Lunva <i>Kattywar Agency—</i> Ranawao Ranpur CENTRAL DIVISION— <i>Sattara Collectorate.</i>	Bomb. Gazetteer, VI. 11. Bomb. Gazetteer, III. 15. Bomb. Gazetteer, III. 197. Sel. from Rec., Bomb. Govt., XXIII. 109; Mem. VI. 378; Bomb. Gazetteer, VI. 11. Man. III. 399; Bomb. Gazetteer, II, 38. Trans. Geol. Soc., Lond., V. 2nd Series, 293; Mem. IX. 87; Bomb. Gazetteer, V. 19; Sel. from Rec., Bomb. Govt., XV. 72. Sel. from Rec., Bomb. Govt., XXXVII. 465. Man. III. 398; Madras Jour. Lit. and Sci., VI. 364.	LTE.	

BOMBAY—*continued.*
IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.	
IRON ORES, <i>I.—contd.</i>	SOUTHERN DIVISION— <i>Ratnagiri Collectorate</i>		LTR.		
		Man. III. 398; Jour. Bomb. Branch, Roy. As. Soc., I. 139 and 436.			
	<i>Kholapore Agency—</i>		LTR.		
	Cunala . . .	{ Sel. from Rec., Bomb. Govt., VIII. 34.			
	Kohlapur . . .				
	Vishalgarh . . .				
	<i>Sawantwari Agency .</i>		Sel. from Rec., Bomb. Govt., X. 44.		
	SIND DIVISION—		Mem., XVII. 193.		
	Bandh Vera (east of Jhirak (W. and S. W. of).				
	Kotri (N.W. of) . . .				
Lainyan					
Laki Range (base of).					
GOLD, G.	NORTHERN DIVISION— <i>Kattywar Agency—</i>		{ Sel. from Rec., Bomb. Govt., XXXVIII. 36.		
	Aji				
	Sourekha				
	SOUTHERN DIVISION— <i>Belgaum Collectorate—</i>		Man. III. 207.	Q.	
	Belowuddi				
	Byh Hongul				
	Chikota				
	Murkombi				
	<i>Kaladgi—</i>		Man. III. 207.		
	Galudegud				
	<i>Dharwar Collectorate—</i>		{ Madras Jour., Lit. and Sci., XI. 44; Jour. Roy. As. Soc. VII. 205; Jour. As. Soc., Beng., XIV. 291; Trans. Bomb. Geog. Soc., XI. 1; Rec., VIII. 133; Mem., XII. 259; Balfour's Cyclo-pædia, Art. Gold.	...	
	Chik Mulgund				
Dambal (or Damul)					
Dhoi					
Harti (Hurtee)					
Surtur					
				Quartz reefs.	

BOMBAY—continued.

IMPORTANT MINERALS—concluded.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
PETROLEUM, <i>Oil.</i>	NORTHERN DIVISION— <i>Cutch Agency</i> . .	Mem. IX. 89 .	...	No real oil, but only bituminous lumps.
SALT, <i>Sal.</i>	.....	No reliable information as yet.		

MISCELLANEOUS MINERALS.

Alum, *Alm.* Antimony Ores, *Ant.* Arsenical Minerals, *Ars.* Asbestos, *Asb.* Bismuth and Cobalt Ores, *B.C.* Borax, *Bx.* Chrome Ores, *Chr.* Copper Ores, *Cop.* Corundum, *Cor.* Gypsum, *Gyp.* Lead Ores, *Ld.* Magnesia Minerals, *Mag.* Manganese Ores, *Man.* Mica, *Mi.* Natros, *Nat.* Nitre, *Nit.* Ochres, *Ochr.* Phosphates, *Phs.* Platinum, *Plt.* Plumbago, *Plm.* Soapstone, *Sop.* Soda Salts, *Sod.* Sulphur, *Sul.* Tin Ores, *Tn.* Zinc Ores, *Znc.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
ALUM, <i>Alm.</i>	NORTHERN DIVISION— <i>Cutch Agency—</i> Mhurr or Madh . .	Man. III. 432; Mem. XI 88.		
	SIND DIVISION— Suleman range, flanks of.	Mem. XVII. 195; Man. III. 434.	...	Probable.
BORAX, <i>Bx.</i>	NORTHERN DIVISION— <i>Kattywar Agency</i> . .	Man. III. 498.		
COPPER ORES, <i>Cop.</i>	SOUTHERN DIVISION— <i>Dharwar Collectorate</i> Kappatgode range . .	{ Jour. R. As. Soc. VII. 150; Madras Jour. Lit. and Sci., XI. 42. Rec. VII. 140.		
GYPSUM, <i>Gyp.</i>	NORTHERN DIVISION— <i>Bombay Collectorate</i> . .	Man. III. 451 .	...	As selenite; small production.
	<i>Cutch Agency—</i> Chitrore (near) . . Lukput . . Mhurr (W. of) Oomirsir (E. & N.-E of). On the Runn, east of Adeysur. <i>Kattywar Agency</i> . .	{ Mem. IX. 90 . Man. III. 451; Mem. XXI. 62	...	Occurs in large quantities.
			...	As selenite; small production.

BOMBAY—*continued.*MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals	REMARKS.
GYPSUM, <i>Gyp.—contd.</i>	SIND DIVISION— Kirthar range . . .	Mem. XVII. 195; Trans. Bom. Geol. Soc. X. 229.		
LEAD ORES, <i>Ld.</i>	NORTHERN DIVISION— <i>Panch Mehals Collec- torate.</i> Jubhan and Khan- delao Lake.	Bomb. Gazetteer, III. 197.		
MANGA- NESE ORES, <i>Man.</i>	SOUTHERN DIVISION— <i>Dharwar Collectorate.</i> Bhimgarh . . . Wodoorti (in the K a p p a t g o d e range).	Mem. XII. 259. Jour. R. As. Soc. VII. 212; Madras Jour. Lit. & Sci. XI. 44.		
MICA, <i>Mi.</i> (Erroneously called Talc; Mica is an elastic mine- ral; Talc is only flexible, and seldom in plates.)	NORTHERN DIVISION— <i>Rewakartha Agency— Jambughora . . .</i>	Sel. from Rec., Bomb. Govt. XXIII. 101.		
NITRE, <i>Nit.</i>	NORTHERN DIVISION— <i>Ahmedabad Collec- torate.</i>	Man. III. 501 . . .	...	Manufacture now almost extinct.
SOAP- STONE, <i>Sop.</i> (Includes Stea- tite, Potstone, Talc (not mica), Bul- pum).	SOUTHERN DIVISION— <i>Dharwar Collectorate</i> <i>Ratnagiri Collectorate</i>	Madras Jour. Lit. & Sci. IV. 462; Jour. As. Soc. Beng., XIV. 291; Mem. XII. 258. Jour. Bomb. Branch R. As. Soc. I. 144.		
SULPHUR, <i>Sul.</i>	SIND DIVISION— <i>Karachi Collectorate— Ghizri Bandar . . .</i>	Jour. As. Soc. Beng. XII. 835.		
TIN ORES, <i>Tn.</i>	SOUTHERN DIVISION— <i>Dharwar Collectorate— Dambal Hills . . . Gujrat . . . Jambughora . . .</i>	Rec. VII. 140 . . . Man. III. 315.	G. GRT. . .	Trace.

BOMBAY—continued.

GEM STONES, &c.

Amber, *Amb.* Beryl, *Brl.* Diamond, *D.* Garnet, *Gar.* Jade and Jadeite, *Yd.* Quartz, *Q.*
 Rubellite, *Rbl.* Ruby, *R.* Sapphire, *S.* Spinel, *Spl.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
QUARTZ, <i>Q.</i> (Includes Rock Crystal and the various forms of Quartz: as Agate, Amethyst, Bloodstone, Chalcedony, Chert, Flint, Jasper, Onyx, Opal, &c.)	NORTHERN DIVISION— <i>Ahmedabad Collectorate</i> — Ranpur . . .	J. M. Campbell; Bomb. Gazetteer; Man. III. 508.	...	Cambay Stones, carnelians, agates, &c.
	<i>Kaira Collectorate</i> — Kapadvanj. The Manjam.	} Do. do.		
	<i>Cutch Agency</i> — Dhokavada . . .		Do. do.	
	<i>Guzerat</i> . . .	Bomb. Govt. Sel. XVI. 49.		
	<i>Kattywar Agency</i> — Nr. Mahmedpur . . .	} J. M. Campbell; Bomb. Gazetteer; Man. III. 508.		
	Bud Kotra.			
	Tankara . . .	J. M. Campbell; Bomb. Gazetteer; Man. III. 509.		
	Bhag Hill . . .	Do. do.		
	<i>Rewa Kantha Agency</i> — Ratanpur . . .	Mem. VI. 381; Bomb. Gazetteer, VI. 205.		
	Malwa State— Ujein . . .	Man. III. 514.		

QUARRY STONES.

Clays, *Cly.* Granite, Gneiss, &c., *Grt.* Laterite, *Lte.* Limestone, Marble, Kunkar, &c., *Lim.*
 Sandstone, *Snd.* Slate, *Slt.* Trap, Basalt, &c., *Trp.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
CLAYS, <i>Cly.</i>	SIND DIVISION— Fatta . . .	} Man. III. 566; Birdwood: Industrial Arts of India.	}	For production of glazed pottery.
	Hala . . .			
	Hyderabad.			
	Jerruck.			
Bulri . . .	} Do. do. . . .	}	Production of encaustic tiles.	
Saidpur . . .				

BOMBAY—*continued.*
 QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GRANITE, <i>Grt.</i> (Includes all fairly compact crystalline rocks; as gneisses of all kinds, generally of grey greenish or flesh colors. Not compact massive black or dark green rocks such as Basalt, Trap, &c.)	DIVISION ?— Goomlee . . .	Professional Papers on Indian Engineering, VI. 137, 1869, Roorkee.	...	Syenite obtainable here.
	CENTRAL DIVISION— <i>Ahmednagar Collectorate</i> <i>Khandesh Collectorate</i> <i>Poona Collectorate</i> <i>Shalapur Collectorate</i>	} Mem. VI. 362, 363	...	Distributed.
LATERITE, <i>Lts.</i>	SOUTHERN DIVISION— <i>Belgaum Collectorate</i> — Dharwar . . . Kaunia . . . Ratnagiri . . .	} Mem. XII. 267; Rec. IV. 44.	...	Distributed; Konkani laterite.
LIMESTONE <i>Lim.</i> (Includes most marbles of different kinds, calcareous flagstones, kunkar, or ghutina, travertine: also, for convenience, serpentines and alabaster.)	NORTHERN DIVISION— Western extremity of Narbada Valley. <i>Panch Mehals Collectorate</i> — Dohad . . . Jambughora . . .	Mem. VI. 216 . . . Man. III. 465. " "	...	Limestones, cretaceous and nummulitic.
	Pali Station . . .	Bomb. Gazetteer, III. 197.	...	Kunkar.
	<i>Surat Collectorate</i> — Turkesar . . .	Man. III. 465.		
	<i>Cutch Agency</i> — Nr. Hybbye on the Juria Hills. Kala Mountains (in the Putchum). The Lodge and Jarun Range. Raimulru (Nr. Kaora).	} Mem. IX. 90; Man. III. 466.		
	SOUTHERN DIVISION— <i>Dharwar Collectorate</i> — Dhoni (N. & N. W.) of).	Rec. VII. 134; Mem. XII. 262—264.	...	Would also yield lime.
	SIND DIVISION— Jhirak Karachi.	} Mem. XVII. 194.	{ C. I. Gvp. ALM.	

BOMBAY—concluded.

QUARRY STONES—concluded.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LIMESTONE <i>Lim.—contd.</i>	SIND DIVISION— <i>contd.</i> <i>Guserat</i> — Gir Hills. Forebunder.	} Man. III. 465.		
	? DIVISION— Lakaree Gooneaser		} Prof. Papers on Indian En- gineering, VI. 1869, Roorkee.	
S A N D - STONES, <i>Snd.</i> (Includes any sandy rock used for building, even calca- reous sand- stones. Flags. Also quartzites which are only indur- ated sand- stones. Peb- bly rocks.)	NORTHERN DIVISION— Cutch Agency .	Mem. IX. 93.		
	Kattiwār Agency .	Mem. XXI. 62.		
	Western Sind .	Mem. XVII. 194.		
SLATE, <i>Sl.</i> (Includes flags; though these are cleaved like slates.)	SOUTHERN DIVISION— Belgaum .	Mem. XII. 262.		
	? NORTHERN DIVISION - N. E. of Baroda (between Surajpur and Jambughora).	Mem. VI. 217.		
TRAP, &c. <i>Trp.</i> (Includes ba- salt, whin- stone, and other com- pact massive dark colored rocks.)	Bombay Island .	Mem. V. 14.	LIM. LTK.	Basaltic. } Universal over the Deccan. Always good building stones.
	Bhuj (Cutch) .	Prof. Papers on Indian Engineer- ing (Roorkee), VI, 1869, 134.		
	Ballacherry	} <i>Katty- wāl.</i> Do. do. 135		
	Behree Bunder			
	Nowa Nugger			
	Additiana .	Do. do. 137.		
	Chumardee Hills .	Do. do. 140.		
	Bhownugger .	Do. do. 141.		
	Bhugwarra .	} Do. do. 142.		
	Damaun .			
	Doongree .			
	Kookranee .	Do. do. 143.		
Neela Doongree .	Do. do. 143.			
Daravee .	Do. do. 143.			
Bandora .	Do. do. 144.			

BURMA.

IMPORTANT MINERALS.

Coal, C. Iron Ores, I. Gold, G. Petroleum, Oil. Salt, Sal.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.	
COAL, C.	ARAKAN DIVISION— <i>Kyaukpyu District</i> — Ramri . . . } Cheduba, &c. . . }	Rec. XI. 209	OIL, LIM.		
	IRRAWADDY DIVISION— <i>Hensada District</i> — Mokhoung . . . } Poosoogyee . . . } Kywaising . . . }	Rec. XV. 178	OIL.		
	PEGU DIVISION— <i>Thayetmyo District</i> — Thayetmyo . . .	Sel. Rec. Gov. Ind., X. 99; Mem. X. 295; Rec. XVIII. 150.	LIM. OIL .	No good. Has been unsuccessful- fully worked.	
	TENASSERIM DIVISION— Great Tenasserim . . } Little " . . . } Lensa R. " . . . }	Sel. Rec. Gov. Ind., X. 31.			
	MERGUI— Nr. Thuggoo . . .	Sel. Rec. Gov. Ind., X. 852; J. A. S. B., XVI. 1, 369.	I. LIM. .	Impure graphite.	
	UPPER BURMA.				
	NORTHERN DIVISION— Thingadaw . . .	Geol. Papers on Bur., 318; Dr. Anderson's W. Yunnan, 198-9; Bredemeyer, M. S. Report; Ind. Econ., V. 14.			
	Shwaygoo, below Bhamo.	Ind. Econ. V. 14.			
	SOUTHERN DIVISION— <i>Yaw District</i> — Yaignaw E. of Nat- taik.	Ind. Econ., V. 14.			
	EASTERN DIVISION— <i>Mieiktila and Shan Hills</i> — Panlaung . . .	Rec. XX. 177; Ind. Econ., V. 14.	...	Probably not work- able.	
	Legaung Nr. Singule- byin.	Rec. XX. 188 .	...	No prospect of successful working.
	Ngw, nr. Puehla . . .	" 189 .		Ditto ditto.	

BURMA—continued.

IMPORTANT MINERALS—continued.

Mineral or Stone.	Locality,	Reference.	Other Minerals.	REMARKS.
COAL, C— contd.	CENTRAL DIVISION— Chindwin— Kalewa, and north- wards beyond Yu R.	Rec. XX. 170 .	...	Fairly promising.
IRON ORES, I.	PEGU DIVISION— Eastern Prome District	Mem. X. 65, 343	...	Hydrated peroxide, in fossil wood group; magnetic ore in the meta- morphics and specular in the schists.
	TENASSERIM DIVISION— Tavoy . . .	Helper. Rep. on ye Tavoy, &c., 29; Rec. VI. 91; (Geol. Papers, 407); J. R. A. S., III. 49; J. A. S. B., XIII. 236, 238	LIM., TN., G., COP., PLT.	Magnetic ore in many places.
	Mergui . . .	J. A. S. B., XIII, 237, 239; Geol. Papers Bur. 456.	LIM. C. TN.	Brown hematite.
	UPPER BURMA— Poppadoug . . .	Geol. Papers Bur. 335; J. A. S. B., XXXI, 219; (Geol. Papers, Bur. 342.)	TRP.	Peroxide of iron in fossil wood group.
	Shwebo . . .	Geol. Papers, 335.	NIT.	Occurs at Macdoo some way north of Shwebo.
	Shan States . . .	Do. do. 335; Ind. Econ. V. 14.	COP.	Large quantities of hematite.
	Sagaing . . .	Ind. Econ. V. 14.		
GOLD, G.	PEGU DIVISION— Shwegyeng . . . } Prome . . . }	Mem. X. 343 . . .	OIL.	
	TENASSERIM DIVISION— Shwegyeng (Sittang)	Mem. I. 94; Adm. Rep. B. B., 1863- 64, 56; Adm. Rep. B. B., 1866-67, 96; Adm. Rep. B. B., 1868-69, 107; B. B. Gazette, II. (1879). 649; Geol. Papers, Bur. 463.		
	Henzai R. . . .	Man. III. 229.	C.	
	Tavoy	" "	TN. LIM. MAN., PLT. COP.	
	Tenasserim . . .	Helper's 2nd Rep. Ye, &c., 34.	TN.	

BURMA—*continued.*
 IMPORTANT MINERALS—*concluded.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
G O L D— <i>contd.</i>	UPPER BURMA— Hunkong Valley . . . Chindwin (Kani) . . . Upper Irrawaddy . . .	J. A. S. B., VI. 270 J. A. S. B., I. 16. Geol. Papers, Bur., 332; J. A. S. B., I. 17.	SAL. AMB. PLT. PLT.	Bhamo. Bhamo and Thin- gadaw.
	Upper Irrawaddy . . .	Anders., Yunnan, 200, 201.	...	
	Mogaung . . .	Anders., Yunnan, 63.		
	Meza Valley . . .	Rec. XIX. 268 (Chem. News, LIV. 278).		
	Shan States (N. E. of Mandalay)	Ind. Econ. V. 14.		
	S. E. of Mandalay at Thayetpein-yua.	" "		
	Yaw country. Taunglebyin . . .	Rec. "XX. 194."		
PETRO- LEUM, <i>Oil.</i>	ARAKAN DIVISION— Ramri } Cheduba } &c. . . Baronga }	Rec. XI. 207.	C. LIM.	
	IRRAWADDY DIVISION— <i>Hensada District—</i> Yaynantoung . . .	Rec. XV. 180	C.	
	PEGU DIVISION— Thayetmyo . . .	Mem. X. 346; Rec. III. 72, V. 120; Rec. XVIII. 149.	LIM.	
	Prome . . .	Ind. Econ. III. 191; Rec. V. 120.	G.	
	UPPER BURMA— Pagan . . .	Geol. Paper, Bur., 302.		
	Yenangchoung (Ye- nangyoung) = Tesing- oung and Beme of Dr. Noetling.	As. Res. VI. 127; Geol. Paper, Bur., 296; R. Romanis' Report, 1884; Rec. XIX. 203; XXII. 75.	...	Present yield es- timated at 2½ million gallons <i>per annum.</i>
	SALT, <i>Sol.</i>	Pegu . . .	Rec. VI. 67.	
UPPER BURMA— Shimpagah (above Mandalay on W. bank of Irrawaddy).		Ind. Econ., V. 14.	...	Doubtful.

BURMA—continued.

MISCELLANEOUS MINERALS.

Alum, *Alm.* Antimony Ores, *Ant.* Arsenical Minerals, *Ars.* Asbestos, *Asb.* Bismuth and Cobalt Ores, *B.C.* Borax, *Bx.* Chrome Ores, *Chr.* Copper Ores, *Cop.* Corundum, *Cor.* Gypsum, *Gyp.* Lead Ores, *Ld.* Magnesia Minerals, *Mag.* Manganese Ores, *Man.* Mica, *Mi.* Natron, *Nat.* Nitre, *Nit.* Ochres, *Ochr.* Phosphates, *Pho.* Platinum, *Plt.* Plumbago, *Plm.* Soapstone, *Sop.* Soda Salts, *Sod.* Sulphur, *Sul.* Tin Ores, *Tn.* Zinc Ores, *Znc.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
ALUM, <i>Alm.</i>	TENASSERIM DIVISION— <i>Amherst District</i> — Yonzalin . . .	Adm. Rep. B. B., 1861, 39.	LD.	
	Tenasserim . . .	Mason's Burma, 33.		
ANTIMONY, <i>Ant.</i>	TENASSERIM DIVISION— Martaban . . .	Rec. VI. 94; B. B. Gazetteer, I. (1880), 65; J. A. S. B., V. 272.		
	<i>Moulmein District</i> .— Toungweyn range . . .	Man. III. 167; Man. IV. 13, 62. Rec. XVIII, 151.		
	Tenasserim . . .	Mason's Burma, 33.	...	About 40 miles below Mahtah at the forks.
	UPPER BURMA— Shan Country, East of Ava.	J. A. S. B. III. 194.		
ARSENICAL MINERALS, <i>Ars.</i>	TENASSERIM DIVISION— <i>Amherst District</i> — Yonzalin R. . . .	Proc. A. S. B., 1870, 279; Man. IV, 14.		
	Upper Burma . . .	Man. III. 162 . . .	...	Said to occur here.
BISMUTH, AND COBALT ORES, <i>B.C.</i>	TENASSERIM DIVISION— Between Attaran and Moulmein Rivers.	Jour. of the Ind. Archip. III. 733; Man. IV. 13. Man. III. 163.	Cop. . . .	Bismuth. Said to occur in Burma with Antimony and Galena.
	Henjai . . .	J. A. S. B., XXXIII, 524.	G. . . .	Cobalt.

BURMA—*continued.*MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
COPPER, <i>Cop.</i>	TENASSERIM DIVISION— Yonzalin R. . . .	Proc. A. S. B., 1870, 279; Man. IV. 14.	LIM., TN., G., I., PLT.	
	Moulmein and Tavoy	Sel. Rec. Gov. Beng., VI, 27, 33.		
	Megathat R. . . .	Geol. Pap., Bur., 454.		
	UPPER BURMA— Shan States . . .	Geol. Pap., Bur., 335; Ind. Econ. V. 14. Rec. XX. 194.		
	Sagaing	Ind. Econ. V. 14 . I.		
CORUN- DUM, <i>Cor.</i>	Ruby Mines	See Ruby	• ...	Occurs with the ruby.
GYPSUM, <i>Gyp.</i>	Tenasserim R. (lat. 13° 14'N.)	Man. III. 454.		
LEAD ORES, <i>Ld.</i>	TENASSERIM DIVISION— Martaban	Rec. VI. 93.	CLV. ALM.	
	Teetalay and Teeta- meelay Hills, &c.	Geol. Pap. Bur., 446, <i>et seq.</i>		
	Moulmein	Rec. XVI. 203 .		
	Maingay's Island . .	Geol. Pap., Bur., 421, 438.		
	Onkarcan	Geol. Pap. Bur., 457.		
	Tha-pe-do near Yon- zalin R.	Geol. Pap. Bur., 470.		
	Taw-de-lo near Pen- ni-pecco.	Geol. Pap. Bur., 472.		
	Tavoy district . . .	Adm. Rep. B. B., 1861-62, 39.		
	Houndraw R. . . .	Jour. Ind. Archip., III. 736.		
	UPPER BURMA— Shan States	Ind. Econ., V. 14 ; Rec. XX, 191. Sel. Rec. Gov. Ind., XLIX. 39. Geol. Pap. Bur., 334; J. A. S. B., I. 15.		

BURMA—*continued.*
MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
PLATINUM, <i>Plt.—contd.</i>	UPPER BURMA-- Mandalay District near Ava.	Glean. in Sc., III. 39; As. Res. XVIII. 279; Rec. VI. 95.	..	Doubtful.
	Chindwin . . .	J. A. S. B., I. 16 |	G.	
	Bhamo . . .	Rec. "XIX," 17.		
	Meza Valley . . .	Rec. XIX, 268.		
	Shan States . . .	Ind. Econ., V. 14.		
PLUMBAGO, <i>Plm.</i>	TENASSERIM DIVI- SION— <i>Mergui District.</i> — Nr. Thuggoo . . .	J. A. S. B., X. 852; XVI. 1, 369.		
	UPPER BURMA— E. of Nattaik, near Myoketoke. Sagyin Hills . . .	Ind. Econ., V. 14. Letter from Fin. Com., Burma, 9-11-88.	SPL., R, LIM.	
SOAP- STONE, <i>Sop.</i> (Includes stea- tite, pot- stone, talc (not mica) Bulpum).	ARAKAN— Minbu . . .	Rec. IV. 43; Mem. X. 336-352.		
	Upper Burma . . .	Man. III. 445.		
SULPHUR, <i>Sul.</i>	UPPER BURMA— Mooda Myo N. . .	) Ind. Econ., V. 14.	COP., LD.	
	Tsein Goon E. S. E. . .			
	Kyaukhoo, S. E. . .	) Rec. XX. 194; Ind. Econ., V. 14.		
	Bawzin, Shan States, S. E. (Bawzaing). . .			
	Dybagen Myo, N. W. . .	) Ind. Econ., V. 14.		
	Pagan Myo, west bank of Irrawaddy. Toogthoo] Einlay, E. S. E., Bhamo District.			" "
TIN ORES, <i>Tn.</i>	TENASSERIM DIVISION— Amherst and Tavoy Districts.	Rec. VI, Helfer, 2nd Rep. on Ye Tavoy, &c., 29; Sel. Rec. Gov., Beng., VI. 21; J. R. A. S., III. 47.	MAN., G., PLT., COP.	

BURMA—continued.

MISCELLANEOUS MINERALS—concluded.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
TIN ORES, <i>Tin—contd.</i>	TENASSERIM DIVISION —contd. Mergui District . . .	Geol. Pap., Bur., 413, <i>et seq</i> ; Glean. in Sc., I. 143; Helfer, 2nd Rep., Ye Tavoy, &c., 31; J. A. S. B., XI. 841; J. A. S. B., X. 846; Sel. Rec. Gov. Ind., X. 57 (Geol. Pap. Bur., 396); Adm. Rep., Bur., 1874-75; Adm. Rep., Bur. 1877-78; Rec. XXII, 188.	..	Being exploited.
	UPPER BURMA— Shan States . . .	Ind. Econ., V. 14.		

GEM-STONES, &c.

Amber, *Amb.* Beryl, *Brl.* Diamond *D.* Garnet, *Gar.* Jade and Jadeite, *Jd.* Quartz, *Q.* Rubellite,
Rbl. Ruby, *R.* Sapphire, *S.* Spinel, *Spl.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
AMBER, <i>Amb.</i>	UPPER BURMA— Payentoung (Mein- khun).	J. A. S. B., VI. 270; Griffith's Priv. Jour. 77; Anders. Yunnan, 65.		
JADE, JADEITE, <i>Jd.</i>	Mogaung . . .	Anders. Yunnan, 66.		
RUBY, <i>R.</i>	Ruby Mines . . .	J. A. S. B., II. 75 (Geol. Pap. Bur., 285; Geol. Pap. Bur., 336).	SPL.	
	Sagyin Hills . . .	Bredemeyer, M. S., Ind. Econ., V. 14.	SPL. PLM.	

BURMA—continued.

GEM-STONES, &c.—concluded.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
RUBELLITE, <i>Rbl.</i>	Upper Burma . .	Mason's Bur., 2nd ed., 14; Man. IV. 108.		
SPINEL, <i>Sp.</i>	Tenasserim . .	Sel. Rec. Gov. Beng., VI. 38.		
	Ruby Mines . .	See Ruby . .	R.	
	Sagyin Hills . .	Rep. by Dr. Nötling.	R., LIM., PLM.	

QUARRY STONES.

Clays, *Cly.* Granite, Gneiss, &c., *Grt.* Laterite, *Lte.* Limestone Marbles, Kunkar, *Lim.* Sandstone, *Snd.* Slate, *Slt.* Trap, Basalt, &c., *Trp.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
CLAYS, <i>Cly.</i>	Alluvial portions of the country especially Tenasserim.	Mem. X. 341; Brit. Bur. Gazette, I (1880), 65.		
	Maulmain . .	Cal. Jour. Nat. Hist., II. 596.	LD. . .	Fire clay.
GRANITE, &c., <i>Grt.</i> (Includes all fairly compact crystalline rocks; as gneisses of all kinds, generally of grey, greenish or flesh color, not compact massive black or dark green rocks, such as Basalt, Trap, &c.)				
LATERITE, <i>Lte.</i>	Pegu . . Sittang . .	Mem. X. 56. Mem. X. 56; Adm. Rep. 63-65, 56; Brit. Bur. Gazetteer, II (1879), 646.		
LIME-STONE, &c., <i>Lim.</i>	ARAKAN— Ramri, &c. . . S. of Sandoway . .	Rec. XI. 221. Mem X. 345.		

BURMA—concluded.

QUARRY STONES—concluded.

Mineral or Stone.	● Locality.	Reference.	Other Minerals.	REMARKS.
LIMESTONE, &c., <i>Lim.</i> — <i>contd.</i> (Includes most marbles of different kinds, calcareous flagstones, kan-kar or ghuin, traver-tine; also, for convenience, serpentines, and alabaster).	PEGOU—			
	Along Arakan Range W. of Irrawaddy.	Mem. X. 344		
	Bassein . . .	" "		
	Thyetmyo . . .	"	C., OIL.	
	TENASSERIM DIVN.—			
	Maulmain . . .	Mason's Burma, 29.		
	Taungyin Valley . . .	Romanis' Rep. on Minerals. in Tenasserim, 4.		
	Tavoy . . .	{ J. A. S. B., XII.	TN., MAN., PLT., I., C., COP.	Elephant Island, Mergui Archi- pelago.
	Mergui . . .	{ 238-9; Rec. XXI. 29.		
	UPPER BURMA—			
Sagyin Hills . . .	Geol. Pap. Bur., 308.	SPL. R.		
Bhamo . . .	Anderson's Yunnan. 59. 213.			
SAND-STONES. <i>Snd.</i> (Includes any sandy rock used for building, even calcareous sandstones, flags; also quartzites which are only indurated sandstones. Pebbly rocks).	ARAKAN COAST—			
	Koranji Island nr. Nga-Tha-Mu.	Mem. X. 152.		
SLATE, <i>Sl.</i> (Includes flags, though these are cleaved, like slates.)	No information.			
TRAP, &c., <i>Trp.</i> (Includes basalt, whinstone, and other compact massive dark colored rocks. All volcanic rocks.)	East of Sittang and in Tenasserim.	Mason's Burma, 2nd ed., p. 4.	...	Not largely developed.

CENTRAL PROVINCES.
IMPORTANT MINERALS.

Coal, C. Iron Ores, I. Gold, G. Petroleum, Oil. Salt, Sal.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
COAL, C.	CHHATTISGARH DIVISION— <i>Bilaspur District—</i> Ghordewa . . .	Rec. XX. 199 .	SND. .	Borings, 5' of good coal.
	Korba . . .	Rec. III. 54; X, 198.	SND. .	In great seam, 69, of shale and coal; 38' of favourable part of seam assayed, poor.
	<i>Sambalpur District—</i> Hingir . . .	Rec. IV. 101—107; Rec. VIII. 102—121.	I., SND. .	Poor.
	Raigarh . . .	Rec. IV. 101—107; Rec. VIII. 102—121.	I., SND.	
	Tumidih (Raigarh) .	Rec. XX. 194 .	...	Poor.
	NAGPUR DIVISION— Chanda District Akapur . . .	Man. III. 92. Mem. XIII. 23 .	I., SND.	
	Akarjun . . .	" " "	...	Borings, 3 seams; like Warora.
	Bandar . . .	Mem. XIII. 145—154; Man. III. 92; Man. I. 226.	...	
	Ghugus . . .	Mem. XIII. 32, 34.	...	45 million tons available.
	Kanji . . .	" 23.		
	Telwasa . . .	" 30.		
	Warora . . .	" 23 .	SND. .	14 million tons available. Collieries, output for half-year ending June 1889, 136, 795 tons, from three pits.
	NARBADA DIVISION .	Man. III. 90; Mem. II. 97, 267; Mem. X. 133, 188.		
	<i>Beitul—</i> Shahpur or Beitul field.	Man. III. 92; Rec. VIII. 65, 74.	...	Promising.
	Tawa . . .	Rec. I. 8; Rec. VIII. 69, 75; Mem. XXIV. 40.	...	70 square miles.
	<i>Chhindwara—</i> Barkoi field . . .	Mem. XXIV. 23 .	...	7 square miles; old pit fallen in.
	Gajundoh field . . .	" 34 .	...	Very small.
	Harai field . . .	" 33 .	...	Small and unimportant.

CENTRAL PROVINCES—*continued.*IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
COAL, C.— <i>contd.</i>	NARBADA DIVISION— <i>contd.</i> Hingladevi field . . .	Mem. XXIV. 35 .	...	Nearly 3 square miles.
	Kanhan field . . .	Man. III. 92 .	...	12 square miles.
	Pench (Chhindwara field.)	...	...	Many seams of coal, some of fair quality.
	Sirgora field . . .	Mem. XXIV. 20 .	SND. . .	Very small.
	Narsingpur— Mohpani . . .	Man. III. 91; Mem. II. 2; X. Rec. III; IV, 66; V, 109; VIII; XII. 95.	...	Narbada Coal and Iron Co.'s collieries. Output for 1888, 23,442 tons.
UMARIA COAL FIELD . (S. Rewah). See CENTRAL INDIA AGENCY.	Rec. XV. 169; XVI. 118; XVII. 146; Mem. XXI. Part 3.	...	Worked by C. P. Government. Output for half year ending June 1889 52,059 tons. Belongs properly to Cl. I. Agency.	
IRON ORES, I.	CHHATTISGARH— Bilaspur District Raipur District Daundi Lohara . . .	C. P. Gazetteer. Man. III. 383.	...	Hematite; rich and abundant.
	Gundai . . .	} Rec. XX. 168.	SND. . .	Red hematite.
	Khairagarh . . .		SLT. . .	Hematite, and lateritic ores.
	Nandgaon . . .		LIM. . .	Lateritic ores.
	Thakurtola . . .		CLY. . .	Ditto.
	Worarbund . . .	...	...	Ditto.
	Sambalpur District— Kodaloi . . .	Man. III. 382 .	...	Raigarh and Hingir Coal-fields.
	Kudderbuga . . .	Man. III. Rec. X. 182.	...	Weathered magnetite.
	Rehrakol . . .	Man. III. 381; C. P. Gazetteer, 224—249.	...	
	JABALPUR DIVISION— Damoh . . .	Man. III. 387 .	...	Unimportant; Bijawar formation.
	Jabalpur Agaria . . .	} C. P. Gazetteer; Rec. XVI. 96; Rec. XXI. 71.	...	Ores abundant in this district, most important mines being at Ghogra and Jaoli.
	Bolia . . .		...
	Dalrora . . .		...
Dubwara . . .	...		
Ghogra . . .	Man. III. 384.	...	Manganiferous	
Gosalpur . . .	Rec. XXI. 71 .	...	Hematites, lateritic ores.	
Jaoli . . .	Man. III. 384.	...		
Lameta . . .	Ditto.	...		

CENTRAL PROVINCES—*continued.*IMPORTANT MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.	
IRON ORES, <i>I.—contd.</i>	JABALPUR DIVISION— <i>contd.</i>				
	Mungela . . .	Man. III. 384; Rec. XVI. 96.			
	Palle (Pullee) . . .	Man. III. 384; Rec. XXI. 71.			
	Panagarh . . .	Man. III. 384.			
	Simra . . .	" "			
	Mandla—				
	Umerwani . . .	} Rep. on the Mandla Dist. by Capt. Pear- son, 1860, 21.	TRP.		
	Ramgar . . .				
	Mowai . . .				
	Saugor . . .	Man. III. 387 . . .	...	Bijawar formation.
	NAGPUR DIVISION—				
	Balaghat . . .	Man. III. 383.			
	Bhandara . . .	Man. III. 383.	...	Lateritic ores in good part.	
	Chandpur . . .	" "			
	Tirora . . .	" "			
	Pratapgarh . . .	" "			
	Chanda—	} Q. J. Geol. Soc., XI. Pt. II, p. 345. Cent. Prov. Ad- minist. Rep., 1861-79. Supplement to Gazette of India, 1871, 1341. Do. do. 1874, 1854 and 1847. Do. do. 1875, 288. David Forbes, "Colliery" Guardian, 13th Sept. 1873. Mining Journal, 25th Dec. 1875. Public Works Dept. Proceed- ings for May 1876.	...	Chanda district richest in iron ore, in the Wardha valley.	
	Bhanapur . . .				
	Ogulpet . . .				
	Dewalgaon . . .				
	Gunjwahi . . .				
	Lohara	Largest deposit at Lohara; cryst. hematite, with magnetic oxide.
	Menda . . .				
	Metapur . . .				
	Pipalgaon	Cryst. hematite, with magnetic oxide.
	Ratnapur	Brown iron ore.
	NARBADA DIVISION—				
Hoshangabad . . .	Mem. XXI. 64.				
Nimar—					
Chandgar . . .	} Man. III. 397.				
Punassa . . .					
Narsingpur—					
Omarpani or Tendukhera . . .	} Man. III. 385 . . .	L.I.M. SND. . .	Hæmatites in the Bijawar forma- tion; deposit pro- bably about dant.		

CENTRAL PROVINCES—*continued.*IMPORTANT MINERALS—*concluded.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
GOLD, G.	CHHATTISGARH—			
	Bilaspur—			
	Sonakhan . . .	Calc. Jour. Nat. Hist., III. 292.	...	♀ Sands.
	Raipur—			
	Rajim (Rajoo) . . .	Calc. Jour. Nat. Hist., III. 292.	...	♀ Sands.
	Sambalpur—			
	Jhunan . . .	Man. III. 200 . . .	...	Sands; colony of gold-washers.
	Sambalpur (Mahanadi R.).	Man. III. 200; Jour. As. Soc., Beng., VIII. 1058. Rec. X. 190.	...	
	Sonpur (and Tributaries of Mahanadi)			
	Tahud (Ebe R.) . . .	Man. III. 200; Rec. X, 191.	...	Sands; gold-washers.
	JABALPUR DIVISION—			
	Damoh . . .	Man. III. 203.		
	Jabalpur . . .	" "		
	Sangor . . .	" "		
	Seoni . . .	Balfour's Cyclopædia.		
	NAGPUR DIVISION—			
	Balaghat—			
	Lanji . . .	Man. III. 202; Cent. Prov. Gazetteer; As. Res., XVIII. 213; Calc. Jour. Nat. Hist. III. 292.	...	Auriferous sands.
	Mau . . .	Qr. Jour. Geol. Soc., XI. 380.		
	Panchera.	Cent. Prov. Gazetteer.		
Bhandara—				
Ambagarh . . .	Man. III. 201 . . .	...	Three professional gold-washers; auriferous sands.	
Thirora . . .	" "			
Chanda . . .	" 202 . . .	...	Six professional gold-washers; auriferous sands eastern part of district.	
Nagpur . . .	" 203 . . .	...	One hundred and three gold-washers.	
Wardha . . .	" 203 . . .	...	Twenty-six gold-washers.	
UPPER GODAVERI DISTRICT—				
Bhadrachellum . . .	Man. III. 203; Cent. Prov. Gazetteer, 506. Do. do. . .	...	Seldom washed for.	
Marigudem . . .	Do. do. . .	...	
Bastar (Native State)	Man. III, 204.			
Bharamgarh . . .	Cent. Prov. Gazetteer.			
Pratappur (Partabpur).				

CENTRAL PROVINCES—*continued.*

MISCELLANEOUS MINERALS.

Alum, *Alm.* Antimony Ores, *Ant.* Arsenical Minerals, *Ars.* Asbestos, *Asb.* Bismuth and Cobalt Ores, *B. C.* Borax, *Bx.* Chrome Ores, *Chr.* Copper Ores, *Cop.* Corundum, *Cor.* Gypsum, *Gyp.* Lead Ores, *Ld.* Magnesia Minerals, *Mag.* Manganese Ores, *Man.* Mica, *Mi.* Natron, *Nat.* Nitre, *Nit.* Ochres, *Ochr.* Phosphates, *Pho.* Platinum, *Plt.* Plumbago, *Plm.* Soapstone, *Sop.* Soda Salts, *Sod.* Sulphur, *Sul.* Tin Ores, *Tn.* Zinc Ores, *Znc.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.	
COPPER ORES, <i>Cop.</i>	CHHATTISGARH— Bilaspur— Lurmi . . .	...	...	North of : traces observed by P. N. Bose.
	Ratanpur . . .	Rec. XVIII. 176 .	...	Trace.
	Raipur— Chicoli . . .	Man. III. 256; Rec. X. 185.	Ld. . .	Traces.	
	Wararbund . . .	Man. III. 256; Rec. X. 185.			
	JABALPUR— Jabalpur District— Sleemanabad . . .	Man. III. 257; Rec. III. 70.	Ld. . .	Trace.	
	NAGPUR DIVISION— Balaghat— Malanj Khandi . . .	Rec. XIX. 165 .	SND. . .	Old mines; worked out.	
	Chanda— . Thana Wasa . . .	Man. III. 257; C. P. Gazetteer, 135.	...	Old mine, tradition-ary.	
	NARBADA DIVISION— Narsingpur— Birmanghat . . .	Man. III. 257; Rec. VII. 62.	...	Narbada Coal and Iron Company's property. Experimental mining in 1873.	
	CORUNDUM <i>Cor.</i>	NAGPUR DIVISION— Pohora . . .	Man. III. 424; Jour. As. Soc. Beng., XIX. 489.	..	Doubtful.
		UPPER GODAVERI DISTRICT— Bhadrachellum . . .	Man. III. 424	Doubtful
LEAD ORES, <i>Ld.</i>	CHHATTISGARH DIVISION— Raipur— Chicoli (Ranitalao)	Man. III. 296; Rec. I. 37; Rec. II. 101.	COP. . .	Well marked vein.	
	Sambalpur— Jhunani . . .	Man. III. 295; Rec. X. 191.	ANT., COP.	Silver lead ore. Zinc lode.	

CENTRAL PROVINCES—*continued.*
MISCELLANEOUS MINERALS—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
LEAD ORES, <i>Ld.—contd.</i>	CHATTISGARH DIVISION — <i>contd.</i>			
	Sambalpur— <i>contd.</i>			
	Padampur . . .	Man. III. 295; Rec. X. 192.	LIM. . .	Traces in Vindhyan limestone.
	Talpuchia . . .	Man. III. 295; Rec. X. 192.	...	Rolled pebbles; original site unknown, but may be this place.
	JABALPUR DIVISION— Jabalpur—			
	Sleemanabad . . .	Man. III. 297; Rec. III. 70.	COP.	
NAGPUR— Nagpur—				
	Nimbha (or Nima)	Man. III. 298; As. Res. XVIII. 198.	...	Loose boulders; source unknown.
	NARBADA DIVISION— Hoshangabad—			
	Joga . . .	Man. III. 297; Rec. XII. 174.	...	Old mines.
MAN- GANESE ORES, <i>Man.</i>	JABALPUR— Jabalpur—			
	Bhatadon . . .	Man. III. 328; Rec. XII. 99; XXI. 84.	I. . .	Pyrolusite, 76,000 tons available in this region; between Gosalpur and Sihora.
	Chindamani . . .	Man. III. 328; Rec. XII. 99; XXI. 86.	I.	
	Darsani . . .	} Man. III. 328; Rec. XII. XXI. 73-79.	} I.	} Associated with manganese ferrous hematites and laterite. Generally called the Gosalpur manganese ore field.
	Dhangaon . . .			
	Dhanwai . . .			
	Dharampur . . .			
	Gosalpur . . .			
	Khatola . . .			
	Mungeli . . .			
	Mangela . . .			
	Murhasan . . .			
	Naigain . . .			
	Pararia . . .			
	Ponri . . .			
Sihora . . .				
NAGPUR— Balaghat—				
Burha . . .				
Bhandara— Ambagarh.				
Nagpur— Kodaigowan . . .	Man. III. 330.			
Ramtek . . .	" 329; Rec. XII. 73.			

CENTRAL PROVINCES—*continued.*
MISCELLANEOUS MINERALS—*concluded.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.	
MICA, <i>Mi.</i> (Erroneously called Talc; Mica is an elastic mineral, Talc is only flexible, and seldom in plates.)	NAGPUR— Balaghat— Bamni . . . } Chitadongri . . . }	Man. III. 528; C. P. Gazetteer, 18.	...	So far, plates too small in size to be of any value.	
	CHHATTISGARH— Raipur— Gandai Zemindari		I. SND. . Red ochre; carried great distances.
	Mandanpur . . . } Thakurtola . . . }		C. P. Admn. Rep., 1861-62, 123.		...	Red ochre.
OCHRES <i>Ochr.</i>	JABALPUR— Jabalpur— Jauli . . .	Man. III. 417.			
	NAGPUR— Balaghat— Salitekri Hills . . . Seukeindan (Lari- hee Hills). . . Chanda . . .	C. P. Gazetteer, 18. Cal. Jour. Nat. Hist., III. 290. Man. III. 418.			
	CHHATTISGARH— Sambalpur— Daramgarh . . . } Domaipali . . . } Lanjigaon (Kalahandi State).	Man. III. 53 .	...	Impure.
S O A P S T O N E, <i>Sop.</i> (Includes steatite, potstone, talc (not mica) 'bul-pum').	JABALPUR . . .	Man. III. 443; Mem. II. 137.			
	Jabalpur . . .	Calc. Jour. Nat. Hist., III. 291.			
	Marble Rocks . . .	Rec. XXII. 64 .	...	Supply said to be abundant and excellent.
TIN ORES, <i>Tn.</i>	NAGPUR DIVISION— Bhandara— Biroli, Nr. Tharora . . .	Man. III, 443;	...	Pale colored; potstone.	
	Kanheri Village . . .	Ditto Rec. XXII. 64	...	Lte., Steatite.	
	Chanda— Jambal Ghat . . .	Man. III. 443; Q. J. G. S. XI. Pt. Iii, 380.	...	Potstone.	
	UPPER GODAVERI DISTRICT— Native Principality— Bastar— Patargudiem . . .	Man. III. 315.			

CENTRAL PROVINCES—*continued.*

GEM-STONES, &c.

Amber, *Amb.* Beryl, *Brl.* Diamond, *D.* Garnet, *Gar.* Jade, and Jadeite, *Yd.* Quartz.
Q. Rubellite, *Rbl.* Ruby, *R.* Sapphire, *S.* Spinel, *Spl.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
DIAMOND, <i>D.</i>	CHHATTISGARH— Sambalpur—			
	Sambalpur, near .	Man. III. 30; Asiæ X Tab. "Geographiæ Libri Octo, Gr. et Lat. Opera P. Bertii, Lugduni;" Bat. 1618. Fol.	Amethyst, carnelian, clear quartz.	Sand washings in the Mahanadi above the town of Sambalpur, near an island called Hira Khund.
	Native States— Gangpur . . .	Tab. X. "Cosmographiæ," Libri VIII., Lat., Justide Albano, Ulmæ;) 1486, Fol.		
	Jashpur . . .	"Asiatic Annual Register," London, 1799.		
	Raigarh . . .	Jour. As. Soc., Beng., XIII. 1844, 859; "Medical Topography of the districts of Ramgarh, Chotanagpur, Sirgōja, and Sambalpur," 1825, by P. Breton; Transactions of the Medical and Physical Society of Calcutta, Vol. II, 1826; Jour. As. Soc., Beng., VIII, 1839, 375; Sel. from Rec. Beng. Govt., No. XXIII, 1852; Sel. from Rec. Mad. Govt., No. XIV, 1855; Karl Ritter's Erd. Kunde Asien, Vol. VI, 343; Rec. X, 186.		
	NAGPUR— Chanda— Wairagarh . . .	Man. III. 37; "Ain i-Akbari," Gladwin's Translation, London, 1800, Vol. II, 58;	...	Old mines, in lateritic deposit.

CENTRAL PROVINCES—*continued.*GEM-STONES, &c.—*concluded.*

Mineral or Stone.	Locality.	Reference.	Other Minerals	REMARKS.
DIAMOND, <i>D.—contd.</i>	NAGPUR— <i>contd.</i> Chanda— <i>contd.</i> Wairagarh— <i>contd.</i> The Sath River .	Ferishta's History, Ed. by J. Briggs, London, 1819, Vol. II, 416. R. Jenkins' Report on the territories of the Raja of Nagpur. Calcutta, 1827, 14; Cal. Jour. Nat. Hist., III, 290; Q. J. G. Soc., Lond., XI, 355; Jour. Bomb. Br. Roy. As. Soc., I, 520; Rep. on the Archæological Survey of India, VII, 129.		
GARNET, <i>Gar.</i>	UPPER GODAVERI DISTRICT— Bhadrachellum .	Man. III. 523.		
QUARTZ . Includes rock crystal and the various forms of quartz, as agate, amethyst, bloodstone, chalc edony, chert, flint, jasper, onyx, opal, &c.)	CHHATTISGARH— Sambalpur— Bijkomar . . . JABALPUR Mandla . . . NAGPUR DIVISION— Chanda— Ballapur . . .	Man. IV. 63 . . . Man. III. 806; IV. 72. Man. III. 860; IV. 72. Ain-i-Akbari (Gladwin's Edition) Vol. II, 58.	... ... ... ...	Rock crystal. Agates, chalc edony, &c., from the Deccan trap formation. Also crystalline quartz, or rock crystal, moss agate, Mocha stones, onyx. Mostly pebbles from the bed of the Narbada; sometimes Carnelian. Agates.
RUBY, R. .	CHHATTISGARH— Sambalpur— Sambalpur . . .	Jour. As. Soc., Beng. VIII, 372.	... ...	Doubtful.

CENTRAL PROVINCES—*continued.*

QUARRY STONES.

Clays, *Cly.* Granite, Gneiss &c., *Grt.* Laterite, *Lte.* Limestone, Marbles, Kunkar, &c., *Lim.*
Sandstones, *Snd.* Slate, *Sl.* Trap, Basalt, &c., *Trp.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
CLAYS, <i>Cly.</i>	JABALPUR DIVISION—			
	Jabalpur -	} Rec. XXII. 140	} C.	Pottery clays. Very promising.
	Amdari (Umaria) .			
	Chota Simla Hill .			
	Lameta			
	Mahanadi R.			
Marjadlia Valley .				
Umaria Coal-field .			C.	Fire clay.
GRANITE, &c., <i>Grt.</i> (Includes all fairly compact crystalline rocks; as gneisses of all kinds, generally of grey greenish or flesh colors. Not compact massive black or dark green rocks, such as basalt, trap, &c.)	Common in eastern portion of Nagpur Division, and northern parts of the Bilaspur District; also in the neighbourhood of Jabalpur; and along the southern edge of the Mandla, Seoni, and Chhindwara basaltic plateau. Likewise in the Chanda District about the Waingunga.			
	LATERITE, <i>Lte.</i>	Only very locally distributed over, and bordering on the basaltic plateaux: in the divisions of Chhattisgarh (Raipur), Jabalpur, and Nagpur.		
LIME-STONE, &c., <i>Lim.</i> (Includes most marbles of different kinds, calcareous flagstones, kunkar or ghut-in, travertine: also, for convenience, serpentines and alabaster.	CHHATTISGARH—			
	Raipur	Man. III. 460	LTE., SND.	Vindhyan limestone. Abundant rock, thick beds, flags, &c., over Chhattisgarh plains. Also kunkar.
	Sambalpur.—	} Rec. X. 178, 182, 183.	SND.	Also kunkar. Vindhyan limestone.
	Bolangir			
Kujerma				
Padampur on the Mahanadi and southwards.				
JABALPUR—				
Damoh	Man. III. 462.			

CENTRAL PROVINCES—*continued.*QUARRY STONES—*continued.*

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.	
LIME-STONE, &c., <i>Lim.—contd.</i>	JABALPUR— Kutni . . . . .	.....	...	Lime-burning largely. Dolomite marble. Lime-burning.
	Marble Rocks . . . . .	.....	Sop.	
	Marwara Sleemanabad	Man. III. 460.			
	NAGPUR DIVISION—				
	Chanda— Kandara, 6 miles north of Warora.	} Mem. XIII. 113 .	}	...	Kunkar, abundant.
	Karamgohan				
	Mardha				
	Nilja, 2 miles south of Warora.				
	Nagpur— Chicholi Kelod Korhadi	} Mem. IX. 302, 330.	}	...	Crystalline limestone.
	Mahadula				
Wardha					
NARBADA DIVISION—					
Chhindwara— Bakur. Enkawari. Hoshangabad (western portion).					
Narsingpur— Bambari. Bichna. Khariri.					
CHHATTISGARH DIVISION—					
Raipur— Raipur Sambalpur	Man. III. 546 . . . . . " " . . . . .		... ...	} Limestone beds.
JABALPUR DIVISION—					
Jabalpur— Jabalpur	Rec. V. 77 . . . . .		...
NAGPUR DIVISION—					
Nagpur— South of Nagpur	Man. III. 546 . . . . .		...
NARBADA DIVISION—					
Hoshangabad— Chirakhan	Mem. XXI, 70 . . . . .		...
SAND-STONES, <i>Snd.</i> (Includes any sandy rock used for building, even calcareous sandstones, flags; also quartzites, which are only indurated sandstones, Pebble rocks.)					

CENTRAL PROVINCES—concluded.

QUARRY STONES—concluded.

Mineral or Stone.	Locality.	Reference.	Other Minerals.	REMARKS.
SLATE, <i>Slt.</i> (Includes flags, though these are cleaved like slates.)	NAGPUR DIVISION— Chanda NARBADA DIVISION— Chhindwara	} Adm. Rep., Cent. Prov., 1866-67, 80.		
TRAP, <i>Trp.</i> (Includes basalt, whinstone and other compact massive dark colored rocks.)	A large portion of Central Provinces.		Man. III. 538.		Forming a considerable portion of the great Deccan Trap plateau. Trap and basalts of all kinds.

GEOLOGICAL SURVEY OF INDIA DEPARTMENT.

TRI-MONTHLY NOTES.

I. ENDING NOVEMBER 1ST, 1889.

Director's Office, Calcutta, November 1889.

The staff of the Survey is at present disposed in the following parties :—

Madras Party.—R. B. FOOTE, F.G.S., Senior Superintendent, Bellary District.

Burma Party.—THEO. W. HUGHES HUGHES, A.R.S.M., Superintendent.

TOM D. LATOUCHE, B.A., Deputy Superintendent.

Mr. Hughes returned from privilege leave on the 4th October; and is engaged in tin exploitation in Tenasserim. Mr. LaTouche is at present engaged on a survey of the Lakadong coal-field in Assam, but is under orders to accompany the Chittagong Column of the Chin-Lushai Expedition, sailing with troops from Calcutta about 20th November.

Baluchistan Party.—R. D. OLDHAM, A.R.S.M., 1st Grade Deputy Superintendent.

PHILIP LAKE, B.A., Assistant Superintendent.

(Not filled yet).

Sub-Assistant Kishen Singh.

Sub-Assistant Hira Lal.

This party is formed for full exploration of coal and oil: under immediate orders of the Agent to the Governor-General in Baluchistan. Assembled at Quetta early in October.

Salt Range Party.—C. S. MIDDLEMISS, B.A., Deputy Superintendent.
P. N. DATTA, B.Sc., Assistant Superintendent.

Darjiling and Sikkim.—P. N. BOSE, B.Sc., Deputy Superintendent.

Mr. Bose left for Sikkim early in September, and joined Mr. White the Political Officer; returning to Darjiling in the beginning of November, whence he takes up further search for coal in the Western Dooars.

Head Quarters, Calcutta.—The Director; Palæontologist; and Officer in charge of Museum and Laboratory.

The Director has to record with deep regret the untimely death of Mr. E. J. Jones, A.R.S.M., Deputy Superintendent and Officiating Curator, at Darjiling, on the 15th October. Mr. Jones was a very promising and reliable officer, especially in Mineralogy and Chemistry, and his loss to the Survey is great. As Vice-President of the Microscopical Society of Calcutta, he was also doing valuable work outside the Department.

List of Reports or Papers sent in to Office for publication or record during August, September and October.

Author.	Subject.	Disposal.
C. L. GRIESBACH, C.I.E.	Geological Notes, Spiti	Published in the Records of the Geological Survey of India, Vol. XXII, part 3.
TOM D. LA TOUCHE	Report on the Cherra Poonjee Coal-field.	Ditto ditto.
E. J. JONES	Note on a Cobaltiferous Matt from Nepal.	Ditto ditto.
R. LYDEKKER, Harpenden, Herts.	Land-Tortoises of the Siwaliks	To appear in the Records of the Geological Survey of India, Vol. XXII, part 4.
Ditto	Pelvis of Ruminant from the Siwaliks.	Ditto ditto.
DR. H. WARTH, Forest Department.	Sambhar Salt Lake Assays	Ditto ditto.
P. N. BOSE	Manganiferous Iron and Manganese Ores of Jabalpur.	Ditto ditto.
C. S. MIDDLEMISS	Palagonite Traps from Rajmahal Hills and the Deccan.	Ditto ditto.
THEO. W. H. HUGHES	Tin Smelting in the Malay Peninsula.	Ditto ditto.
DR. W. KING	Provisional Index of Minerals in Indian Empire, 1st part.	Ditto ditto.
R. D. OLDHAM	Memorandum on Protective Works, Naini Tal.	Record.
H. B. MEDLICOTT, F.R.S., CLIFTON.	Index to his papers in the 2nd ten volumes of the Records.	For Index to the 1st twenty volumes of the Records.
V. BALL, F.R.S., DUBLIN.	Ditto ditto	Ditto ditto.
A. B. WYNNE, H.M.'s Geological Survey of Ireland.	Ditto ditto	Ditto ditto.
DR. OTTOKAR FEISTMANTEL, PRAGUE.	Ditto ditto	Ditto ditto.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of August, September and October 1889.

Substance.	For whom.	Result.
Decomposing pyritous shale, from Corriari Valley.	W. MACCLAGAN REID, Rohtasgarh.	Contains SO ₂ , FeO ⁿ ; some SO ₂ , BaO ⁿ ; and free SO ₂ , HO ₂ .
Carbonate of copper from Belbathan, Santal Parganas.	J. REGINALD HAND, Sub-Divisional Officer, Godda.	Contains 48·83 per cent. of copper.
7 samples of coal, from the Chindwin and Irrawaddi coal-fields, Upper Burma.	F. NOERTLING, Geological Survey of India.	<p>Pelusa Pelusa Pelusa Pelusa Pelusa Pelusa Pelusa Pelusa Pelusa Pelusa Chindwin, Chindwin, Chindwin, Chindwin, Chindwin, Chindwin, Chindwin, Chindwin, Chindwin, Chindwin, 3' seam. 2' seam. 3' seam. 4' seam. 4' seam. 4' seam. 4' seam. 4' seam. 4' seam. 12' seam. (highest.)</p> <p>Moisture 9·40 9·38 9·42 11·24 9·20 10·10 10·60 Volatile matter 28·34 34·02 37·60 39·94 33·56 36·16 33·96 Fixed carbon 40·36 50·38 49·54 45·00 34·08 46·38 47·24 Ash 21·90 6·22 3·44 3·76 23·16 7·36 8·20</p> <p>TOTAL 100·00 100·00 100·00 100·00 100·00 100·00 100·00</p> <p>Color of ash Pale buff. Pale buff. Buff. Buff. Light buff. Dirty buff. Dirty buff.</p> <p>None of the coals cake, but they all sinter slightly.</p>
Metallic lead from near Maymio, Upper Burma.	F. NOERTLING, Geological Survey of India.	Contains 8 oz. silver to the ton of lead, and an appreciable quantity of arsenic, and a trace of Fe.
Coal from the Sarakula Valley, 8½ miles from Quetta.	D. MORRIS, Engineer in charge Coal Mines, N. W. Railway, Sukkur.	<p>Moisture 7·04 Volatile matter 37·04 Fixed carbon 51·86 Ash 4·06</p> <p>TOTAL 100·00</p> <p>Cakes, but not strongly. Ash, dark red.</p>

Notifications by the Government of India during the months of August, September and October 1889, published in the "Gazette of India," Part I.—Appointment, Confirmation, Promotion and Retirement.

Department.	Number of order and date.	Name of Officer.	From	To	Nature of Appointment, &c.	With effect from	REMARKS.
Foreign Department.	1177F., dated 25th July 1889.	C. L. GRIESBACH.	Deputation.	1st Grade Deputy Superintendent.	Rejoining	23rd July 1889.	Return from deputation to Afghanistan.
Revenue and Agricultural Department.	³⁴⁴ ₁₇₋₈ S., dated 6th August 1889.	E. J. JONES .	...	...	Officiating Curator.	22nd June 1889.	
Revenue and Agricultural Department.	⁵⁰⁷ ₁₇₋₁₅ S., dated 9th October 1889.	C. L. GRIESBACH.	1st Grade Deputy Supdt.	Superintendent.	Promotion	22nd June 1889.	
Revenue and Agricultural Department.	⁵⁰⁷ ₁₇₋₁₅ S., dated 9th October 1889.	R. D. OLDHAM.	Officiating 1st Grade Deputy Supdt.	1st Grade Deputy Supdt.	Do.	22nd June 1889.	

Notifications by the Government of India during the months of August, September and October 1889, published in the "Gazette of India," Part I.—Leave.

Department.	Number of order and date.	Name of Officer.	Nature of Leave.	With effect from	Date of Return.	REMARKS.
Revenue and Agricultural Department.	³⁵² ₁₇₋₁₀ S., dated 8th August 1889.	THEO. W. H. HUGHES	Privilege leave.	15th July 1889.	4th October 1889.	For 2 months and 23 days.

Annual Increments to graded Officers, sanctioned by the Government of India during August, September and October 1889.

Name of Officer.	From	To	With effect from	Number and date of sanction.	REMARKS.
E. J. JONES . . .	Rs. 500	Rs. 540	1st July 1889.	³³⁸ ₁₃₋₇ S., dated 2nd Aug. 1889.	
P. LAKE	380	410	1st Aug. 1889	³⁶⁸ ₁₃₋₉ S., dated 15th Aug. 1889.	
Tom D. LA TOUCHE.	540	580	1st Oct. 1889	⁵⁸⁵ ₁₃₋₁₁ S., dated 30th Oct. 1889.	

Postal and Telegraphic Addresses of Officers.

Name of Officer.	Postal Address.	Nearest Telegraph Office.
R. BRUCE FOOTE . . .	Bellary (Madras) . . .	Bellary.
T. W. H. HUGHES . . .	Mergui (Burma) . . .	Tavoy.
C. L. GRIESBACH . . .	Calcutta . . .	Park Street, Calcutta.
R. D. OLDHAM . . .	Quetta (Baluchistan) . . .	Quetta.
P. N. BOSE . . .	Kalimpong (Darjeeling) . . .	Kalimpong.
T. H. D. LA TOUCHE . . .	Shillong (Assam) . . .	Shillong.
C. S. MIDDLEMISS . . .	Khewra (Jhelum) . . .	Khewra.
P. LAKE . . .	Quetta (Baluchistan) . . .	Quetta.
P. N. DATTA . . .	Lahore . . .	Lahore.
F. NOETLING . . .	Calcutta . . .	Park Street, Calcutta.
KISHEN SING . . .	Quetta (Baluchistan) . . .	Quetta.
HIRA LAL . . .	Do. do. . .	Do.

ADDITIONS TO THE MUSEUM.

FROM 1ST OCTOBER TO 31ST DECEMBER 1888.

Inspissated petroleum, petroleum, and fireclay, from South Lakimpur; portion of a fossil elephant's tooth, from Debrugarh, and some sulphuric acid, from the Shoran Sulphur Mine. PRESENTED BY R. A. TOWNSEND.

Matrix of the diamond (known locally as 'blue'), from Griqualand, South Africa. PRESENTED BY R. BATEMAN-SMYTHE.

Model of the Indian Diamond "Gor-do-Norr," before and after cutting, found near Vujra Karur, Bellary District, Madras. PRESENTED BY MESSRS. P. ORR & SONS, MADRAS.

Copper smelted at Chunabatti, Alipore sub-division, Jalpaiguri. PRESENTED BY THE GOVERNMENT OF BENGAL.

Samples illustrating the smelting of lead from argentiferous galena, and extraction of silver from the lead, from the mines of the Myelat, Bawzaing, Ngwe-gunhmu, (Shan States, Burma). PRESENTED BY THE FINANCIAL COMMISSIONER, BURMA.

A cake of cobaltiferous matt, from Kachipatar, Argah Zillah, Sowrobhar, about 8 miles north of Doolha. PRESENTED BY THE RESIDENT IN NEPAL.

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FROM 1ST OCTOBER TO 31ST DECEMBER 1888.

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January 19th, 1889.

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Five specimens of Indianite, from Southern India; and three of Tscheffkinite, from Kantamala, Coromandel.

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Six specimens of fossil plants, from the coal-measures, Raniganj.

PRESENTED BY J. L. REUSS.

Nodule, from north of Port Blair, consisting of sand grains, cemented by carbonate.

PRESENTED BY COMMANDER A. CARPENTER, R.N.

Specimens of the Tabor, Alfanello, and Ogi meteorites.

PRESENTED BY THE TRUSTEES OF THE BRITISH MUSEUM, LONDON.

Specimens of fuller's earth, red granite, sand, limestone, and conglomerate, from Sind and Rajputana.

PRESENTED BY HORACE BELL.

Igneous rock (?) from 'neck' at Wajra Karur, Bellary District.

PRESENTED BY MESSRS. P. ORR AND SONS, MADRAS.

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PRESENTED BY H. B. W. GARRICK, ARCHÆOLOGICAL SURVEY OF BENGAL.

Specimens of *Parkeria compressa*, Carter; *Parkeria sphaerica*, Carter, from the Upper Greensand, Cambridge; and *Loftusia persica*, Brady, from the Lowest Tertiaries, Bakhtiyari Mountains, Persia. PRESENTED BY PROFR. H. B. BRADY, F.R.S.

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