RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA

VOLUME XXVI.

Published by order of His Excellency the Governor General of India in Council.

CALCUTTA:
SOLD AT THE OFFICE OF THE GEOLOGICAL SURVEY
(AND BY ALL BOOKSELLERS).
LONDON: KEGAN, PAUL, TRENCH, TRÜBNER & CO.

MDCCCXCIII.

CALCUTTA:
GOVERNMENT OF INDIA CENTRAL PRINTING OFFICE,
8, HASTINGS STREET.

CONTENTS.

PART 1.

PAGE

ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA, AND OF THE GEOLOGICAL MUSEUM, CALCUTTA, FOR THE YEAR 1892 1

Notes *on the* Central Himalayas, *by* C. L. GRIESBACH, C.I.E., F.G.S., *Superintendent, Geological Survey of India* (with map and plate) 19

Note *on the occurrence of* Jadeite *in* Upper Burma, *by* DR. FRITZ NOETLING, *Palæontologist, Geological Survey of India* (with a map) 26

On *the* occurrence *of* Burmite, *a new* Fossil Resin *from* Upper Burma, *by* DR. FRITZ NOETLING, *Palæontologist, Geological Survey of India* 31

Report *on the* Prospecting Operations, Mergui District, 1891-92, *by* T. W. H. HUGHES, A.R.S.M., F.G.S., *Superintendent, Geological Survey of India* 40

Tri-monthly Notes 53

DONATIONS TO THE MUSEUM.

ADDITIONS TO THE LIBRARY.

PART 2.

Notes *on the* earthquake *in* Balúchistán *on the* 20th December 1892, *by* C. L. GRIESBACH, C.I.E., *Superintendent, Geological Survey of India* 57

Further Note *on* Burmite, *a new amber-like fossil resin from* Upper Burma, *by* DR. OTTO HELM of Danzig. (Translated from the German by PROFESSOR BRUHL, Civil Engineering College, Sibpur 61

Note *on the* Alluvial deposits *and* Subterranean water-supply *of* Rangoon, *by* R. D. OLDHAM, A.R.S.M., *Superintendent, Geological Survey of India.* (With a map) 64

Tri-monthly Notes 70

DONATIONS TO THE MUSEUM.

ADDITIONS TO THE LIBRARY.

PART 3.

Geology *of the* Sherani Hills, *by* TOM D. LA TOUCHE, B.A., *Officiating Superintendent, Geological Survey of India.* (With Maps and Plates) 77

Carboniferous Fossils *from* Tenasserim, *by* FRITZ NOETLING, PH. D., F.G.S., *Palæontologist, Geological Survey of India.* (With 1 plate) 96

On a deep Boring *at* Chandernagore, *by* R. D. OLDHAM, A.R.S.M., *Superintendent, Geological Survey of India* 100

Note *on* Granite *in the districts of* Tavoy *and* Mergui, *by* P. N. BOSE, B. Sc. (London), F.G.S., *Deputy Superintendent, Geological Survey of India.* (With a plate) 102

Tri-monthly Notes 104

DONATIONS TO THE MUSEUM.

ADDITIONS TO THE LIBRARY.

PART 4.

PAGE

On the Geology *of the country between the* Chappar Rift *and* Harnai *in* Balúchistán, *by* C. L. GRIESBACH, C.I.E., *Superintendent, Geological Survey of India.* (With map and three plates) 113

Notes *on the* Geology *of a part of the* Tenasserim Valley *with special reference to the* Tendau-Kamapying Coal-field, *by* P. N. BOSE, B.Sc., F.G.S., *Officiating Superintendent, Geological Survey of India* 148

On a Magnetite *from the* Madras Presidency containing Manganese *and* Alumina, *by* T. H. HOLLAND, A.R.C.S., F.G.S., *Geological Survey of India* 164

On Hislopite (Haughton), *by* T. H. HOLLAND, A.R.C.S., F.G.S., *Geological Survey of India.* (With a plate) 166

Tri-monthly Notes : 171

DONATIONS TO THE MUSEUM.

ADDITIONS TO THE LIBRARY.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1893. [Feb.

ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA AND OF THE GEOLOGICAL MUSEUM, CALCUTTA, FOR THE YEAR 1892.

The staff of the Survey was distributed as follows:—In Burma; Messrs. Hughes, Griesbach, Noetling, Bose, and Datta. On the North-West Frontier, about the Punjab and Hazara; Messrs. LaTouche, Middlemiss, Edwards, and Sub-Assistants Kishen Singh and Hira Lal. In the Madras Presidency; Mr. Holland, in connection with the collection of mineral products and reporting thereon for the Imperial Institute. Mr. Oldham has been occupied in Calcutta with the preparation of the new edition of the Manual of the Geology of India.

I myself have been in advisatory communication, by touring, with the Agent to the Governor General in Baluchistan, with the Punjab Government, and with the Central India Agency in connection with the Rewa and Punna States.

PENINSULAR INDIA.

Madras Presidency.—During the past year, geological surveying in Peninsular India has been left in comparative abeyance; our sole work in that direction having been carried on by Mr. T. H. Holland at such times as he could be spared from his proper research work in the laboratory. In this pursuit, however, very interesting and important progress has been made in the petrological study of certain ores and their associated rocks, conducing largely to an increased probability of the development of the vast stores of iron and corundum which have so long baffled attempts in that way.

At the same time, but in the capacity of Officiating Superintendent of the Madras Central Museum, and thus working for the Government of Madras,[1] Dr. Warth has contributed in a marked degree to some further extension of the mineral and geological knowledge of Southern India.

Mr. Holland visited all the districts south of 14° N. Lat., so that the area covered

[1] I merely notice this independent work as showing that neither the geology nor its economies have lacked progress, even though the Survey itself was only able to dispose of a single officer in that direction: while Dr. Warth's interesting discovery of what appear to be very extensive phosphatic deposits in the cretaceous rock area of the Trichinopoly district; and his co-operation, at the instance of the Madras Government, with Mr. Holland at the iron, corundum, and mica enquiries can lose none of their value by being mentioned here.

(mainly with regard to the iron-enquiry) was far too large for detailed work beyond the mere collection of specimens. The remarkable district of Salem naturally received a considerable share of attention, and the resources of iron-ore, accessory minerals and fuel have been discussed by him in a paper published in the last volume of the Records. As this paper has been reprinted and discussed in Indian, English and American metallurgical journals it will not be necessary here to do more than mention that the question of the successful development of the enormous iron-ore deposits of that district becomes essentially a forest problem, as there is no coal in the district and no immediate prospects of profitably using for this purpose, on account of heavy transit charges, the coal raised in the other provinces. Amongst some interesting points which have been brought to light by Mr. Holland's observations is the occurrence of the chromite of the "Chalk Hills" in an intrusive mass of *dunite* associated with other ultra-basic olivine-bearing igneous rocks, which have been decomposed, with the formation of magnesite as well as compact and fibrous serpentine in-filling cracks. The same class of igneous rocks have, it seems, disturbed the iron-beds on the north-west slope of the well-known Kanja-malai, and the same formations of magnesite and serpentine characterise that locality also. Mr. Holland applies a similar explanation to the remaining magnesite-bearing localities in Sálem, and reasonably expects that as the igneous rock which contains the chromite of the "Chalk Hills" is the same in character and association as in the other magnesite areas, it would not be surprising to find that chromite occurs in these places likewise. The present association of igneous rocks in this area has been brought about by irruptions during about the same period and by reason of similar movements in these separated localities. The rocks moreover seem to have been derived by successive irruptions from one magma and have followed successively from ultra-basic to acid in chemical composition. We have thus a case analogous to those described by Brogger and Vogt in Norway, by Iddings in the Yellowstone National Park, and more recently by Dakyns and Teall near Loch Lomond. Following up the same line of researches, into the Mysore State, Mr. Holland has found further magnesite areas and a further display of these ultra-basic rocks near the extensive corundum deposits of the Hunsur taluq. Amongst these, one of the igneous rocks is composed of at least half its weight of magnetic iron-ore, thus similar in origin to the Taberg ore of Sweden.

Iron-ores, magnesite, and associated rocks in Southern India.

Another noticeable feature amongst the rocks collected in the South of India is the wide prevalence of the mineral hypersthene, and, to a less extent, other members of the pyroxene group. This mineral occurs as a constituent of rocks varying in composition from hypersthene-microcline granite to norite and hypersthene-rock. The very wide area over which Mr. Holland's tour for the collection of specimens and information extended prevented his doing more than a superficial examination of these rocks, but I look upon them as a promising sequel to the petrological results obtained by M. Lacroix on the Salem and Ceylon specimens; and they promise to be only an earnest of what may be expected from a more detailed examination of this complex area. It seems likely that many of the rock-masses which have been provisionally mapped as metamorphic will be found, as Dr. Lawson has shown in the Rainy Lake Region of Canada, to be merely rolled-out laccolites and intrusive bosses—some with a well-defined parallelism of constituents, but passing by imperceptible gradations into true granitic structures.

Corundum.

The subject of the development of the very extensive tracts of corundum by the utilization of water-power in Southern India has attracted a good deal of attention; and on this consideration I deputed Mr. Holland later in the season and during the only month in which he could be spared from his work in Calcutta to examine the corundum beds of Mysore. The corundum beds of the Hunsur taluq are traceable from Singanamarayhalli to Ramanhalli, that is, over a length of 25 miles; while, from the evidence of specimens which have been collected, it seems that the same beds extend in one direction into the Coimbatore District, and in the opposite direction (north-west) to the Uppinagadi taluq of South Canara.

Should a cheaper method of manufacture be invented, or some natural source of power like falling-water be employed with present methods, as recently suggested by Professor A. Chatterton of the Madras Civil Engineering College, the value of aluminium, though questionable as an advantageous introduction to steel, is for other purposes undoubted. The very high price of aluminium and the demand which this useful metal, from its exceptional properties, is bound to secure, makes this point decidedly worth attention.

Mr. Holland has prepared a hand-book on the Iron-resources and Industries of the Southern districts, Madras Presidency, for the Imperial Institute, where a collection of illustrative specimens is exhibited; and in consultation with Mr. Edgar Thurston, Officiating Reporter to the Government of India for Economic Products, a further hand-book on Indian Mica is about to be issued.

Mohpani coal.

Central Provinces.—The attention of the Survey was again directed to the possible further extension of the coal-measures at Mohpani, as all attempts on the part of the Narbudda Coal and Iron Company to find any remunerative extension of their colliery basin, by boring, had failed, while the period of abeyance of royalty generously sanctioned by the Central Provinces Government was fast drawing to a close. For this enquiry, Mr. La Touche was despatched to re-examine portions of the field, when in conjunction with a find of typical fossil plants by the Agent and Manager, Mr. Simpson, on the western edge of their land area, he was able to determine extension in this direction. Since then, good seams of coal have been proved by boring, though their extent is still to be ascertained.

Mining exploitation.

Rewa.—Towards the end of the year, a part of the unsurveyed tract in Central India, in the Rewa State, has been taken up with a view to ascertaining the conditions of the lead ore and other minerals occurring in the Sone Valley; while the break in geological surveying between the area of the transition series at this point and the area further eastward south of Bijagarh will be closed up. The lead-bearing zone has been localized and is about to be exploited by the State.

EXTRA PENINSULAR, INDIA.

Burma.—The main force of the Survey, both in geology proper, and as applied to mineral exploration, has been devoted to the eastern side of the Empire; though it is now abundantly clear that until the country is more settled and freer facilities in the way of transport and supplies are arrangeable, that systematic geological work cannot be carried out with any advantageous result, without which no proper generalization can be formed as to extension of such mineral products as do exist in the country, either as to the direction in which they can be looked for or the particular formation in which they occur. On these points, we have as yet only the barest outlines founded on sections and traverses, often very widely separated by densely forest-covered tracts, or regions which are but very sparsely-peopled and unsettled except in the immediate vicinity of the Civil and Military stations. This being the case, geological work, for some time to come, can perhaps best remain centred on certain well-known and approachable lines like that of the oil fields, and the coal in Upper and Lower Burma; the disposition of the Officers being arranged in consultation with the Local Government.

With the close of the field season, the exploitation in Tennassarim under Mr. Hughes's conduct was brought to an end; following upon which, and after conference with the Revenue and Agricultural Department, a plan was arranged by the Supreme Government in conjunction with the Government of Burma for the leasing out of the Maliwun tract on prospecting and ultimate mining leases to Messrs. Ah Kwi and Menzell. The latest report from Captain Menzell shows that the lessees have commenced operations at the foot of the Khow Muang lode, with a strong contingent of Perak Chinamen; while a cheery prospect of success pervades this intelligence. The local authorities are said to be providing for this resuscitation of an almost moribund industry at Maliwun by constructing improved landing and discharge facilities at the river entrance; but the putting on of a fuller service of steamers between Mergui and Victoria Point and between the latter place and Penang cannot be too strongly advocated, as well as the advisability of encouraging immigration. The initial move has been made now for better or worse; and I am urged by Mr. Hughes to leave no opportunity of stating that the future of the development rests on such opening out of the port; and on the hearty co-operation and interest of the local administration.

Mergui tin.

During this exploitation, the examination for other minerals was not neglected; a closer inspection of the coal indications on the Great Tennassarim river revealed an altogether better promise than had been anticipated from the reports of 1838, 1841, and 1855. So much so, that it has been decided to test the new finds by boring and more extended survey; for which work Messrs. Bose and Datta were detailed in November last. As is usual in the inland parts of Tennassarim, the country of these coal outcrops is densely covered with jungle and no map of ordinary accuracy or on a large enough scale was available at the time of the exploration by Mr. Hughes and his party; so that their estimate of the position of the field in relation to the port at Mergui (said to be 24 miles due west of the coal), and its accessibility cannot be taken as fully certified. Since then, a new map of this part of the country has been constructed by the Survey of India, and it is on this and the knowledge to be obtained of the lie of the intermediate country, that the results of Mr. Bose's work will be formulated. The quantity of the coal is abundant. The bottom coal, of which there is a thickness of 4′ 6″, is a hard jetty variety, well fitted to stand the wear and tear of transport, as a large supply of it did on being rafted down the tortuous, and for much of the way, very rocky course of the river. The difficulties of the river course are obviously against every profitable development, but Mr. Hughes was led to infer that the cross-country route will, on being cleared and inspected, afford a greatly shorter outlet.

Coal on the great Tennassarim.

Mr. Hughes's report on the prospecting operations in the Mergui district appears in the current Records: and it closes the enquiry for the present, which I cannot but express myself as having been conducted by him with complete success. It was, in its starting, a very difficult and heart-breaking business owing to the out-of-the-way position, the densely jungle-covered condition, the utter absence of inland communication, the difficulty of getting ordinary jungle food produce, and labour: and above all the lack of interest in the industry exhibited by the dismal decadence of the port surroundings at Maliwun so graphically described in the first report by Mr. Fryer, the Financial Commissioner for Burma. These were only the minor disheartenings; the more serious business of securing, organizing, and then handling a staff of prospectors with their appliances, had to be grappled: and finally, the actual introduction of reliable private enterprise, all of which have been managed by Mr. Hughes in spite of obstacles which few men could have overcome.[1] It is, indeed, with great pleasure that I can here refer to the thanks which have been accorded to him by the Government of Burma "for the vigour which he has shown in organizing the prospecting parties, and the interesting and useful information and advice which his report gives."

Geological research in Southern Burma has been slow, owing to the impossibility of getting over the ground, except by the few forest paths there are, or by such clearing as could be made by the Survey: but Mr. Bose did what was possible and managed to make several traverses around Maliwun, Bokpyin, Bahuni, Lenya, and on the Great Tennassarim river in the Mergui district, and again in the Tavoy district.

Upper Burmah.—Mr. Griesbach had charge of the party consisting of Dr. Noetling and Mr. P. N. Datta; and in his conference with the Financial Commissioner at the commencement of the season with a view to ascertaining the wishes of the Local Government concerning systematic survey, it appeared that the two most important tasks were the final settlement of the oil-bearing area of Yenang-young and the detailed geological survey of the Chindwin coal area. Both these investigations had already been in the hands of the Survey, and for all practical ends as far as the geological survey is concerned, the work was complete. The Chindwin coal-field had been examined and reported on by Dr. Noetling on the map available. But although the coal occurs in full enough quantity and though its utilization is at present hampered by considerable physical obstacles, the illustration of the occurrence of the coal and its peculiar hilly location by maps and detailed observations is on too small a scale to induce opening out. The further large survey desiderated could not be carried out unless larger scale maps could be provided; so this task had to be postponed, pending the operations of the survey of India on a new map. For similar reasons, the large scale topographical survey of the oil lands not being ready, further demarcation in that direction could not be carried out by Dr. Noetling.

Amber and jade.

Opportunity offering for visiting the Amber and Jade mines of Upper Burma, through the starting of the Maingkwan Column, Dr. Noetling was posted for this expedition; his disposition eventually

[1] I may notice here that in some degree, during his exploration among the islands of the Mergui Archipelago, and as a result of outside observations, Mr. Hughes assisted in bringing under notice the "pearl bottoms" which, for the last seventy years, have been in undisputed possession of Chinese traders who paid no revenue to Government. This year, the bottoms have been let for something over R22,000.

resulting in a report as to the mode of occurrence of these minerals. The so-called Amber turns out to be a new variety of this form of fossil resin, to which the name of Burmite has been assigned by Dr. Noetling in conjunction with Dr. Otto Helm (a distinguished authority in this line) of Danzig to whom specimens were forwarded. The peculiarity of Burmite is a fluorescence, giving the mineral an appearance as of solidified kerosine oil: and, as far as has yet been seen, it is of darker colours than is usual with amber proper (succinite); while it is a little harder than the latter. The colour alone is, according to the present fashion in Europe, against the mineral, but some of the darker varieties of brown red colour, present on being cut deeply *en cabochon*, the flat or under force being turned to the observer, a really gorgeous ruby tint which should make the stone desirable ornamentally. Dr. Helm's very interesting preliminary notice appeared in the concluding part of the last volume of the Records of the Survey.

Dr. Noetling reports the Amber mines as occurring in the neighbourhood of Maingkwan in the most northerly part of the Bahmo district, and that the producing mines are at the village of Talaung. The amber-bearing beds are soft blue clays, of probably lower miocene age, in a thickness of some 600 feet, and the Burmite occurs in isolated pockets or lenticular seams of varying extension and thickness, as lumps of various sizes up to that of a man's head, either rounded, or rather flattened, just like pebbles or small shingle on a beach. Mining is of the most primitive fashion, and it is essentially speculative because the miners have no certain indications to go on after having cleaned out one pocket; and thus must just dig a new pit or prospecting tunnel on the chance of striking on a new seam. The local demand is stated by Dr. Noetling to be about 2,000, *viz.*, or say 4,000, lbs. per year at the outside; and he does not hold out any very favourable opinion of the value of the product looking at the prevailing dark colours as contrasted with the colour and non-fluorescence of the European product.

The so-called Jade—for the actual constitution of the mineral as worked in Burma determines it properly as *Jadeite*, is worked by pit and quarry mines, the former for 40 miles along the bank of the Uru river southwards from Sankha, while the latter are excavated on the top of a plateau at Tammaw, 8 miles out of Sankha, in the Mogoung subdivision. In the quarry mines the mineral occurs as a vein of considerable thickness in a trappoid rock of black-green colour. In the pit mines, the jade occurs as boulders which have been doubtless derived from the disintegration of similar veins to that worked at Tammaw. The industry seems to be a thriving one, and rather promising for future more systematic and skilled development; for at least 500 men are engaged every season in working the quarries. White is the commonest colour, the green varieties being of much rarer occurrence; while, in some of the fewer boulders obtained from the laterite beds along the course of the Uru river, a "red jade" appears to have been produced by ferruginous decomposition change.

Mr. Griesbach himself proceeded with the North-Eastern column along the ranges of hills forming the boundary between Burma and the Chinese province of Yunnan. The area visited may be defined roughly as extending between the Taiping river (south) and the Nam Mate (north). After this work, the country between Mogaung and Watu, on the Irrawaddi, was visited. As regards the mineral aspect of this tract of country, he reports that the higher ranges between Burma and Yunnan

Country bordering Yunnan not of much mineral promise.

have been found singularly barren of useful minerals. There are reports current of the existence of lead ores, but he did not meet with any traces of such, and, even if they did exist, he does not see how they could be worth much, considering the distant and wild condition of the country. Nor do the few instances of gold traces in the gravels brought down from these higher ranges offer the least hope of rich sources.

On the other hand the wide trough of the Irrawaddi itself seems to hold out better expectations. Coal has been proved to exist in several localities within the area north of Bhamo. Lignitic coal, which burned well, occurs some 10 miles west of Mogaung, though its area appears to be too limited for much development. A similar limit as to available quantity, as well as position above the navigable part of the river, attaches to the Talang lignite, north of the Pangin Kha, 16 miles north-west of the "confluence" of the Irrawaddi. At present, the Kachins sell this coal at Myithkhyina at the rate of 8 annas a basket, which is of course a prohibitive price, as against imported coal. Gold is found in the form of fine grains and leaflets in the recent deposits of the Irrawaddi and all its tributaries, and it is washed for in small quantities; Mr. Griesbach stating that the surface sands along the bank of the great river contain not less than about 30 grains of gold per ton of stuff. At the same time, he was led to infer that within the great thickness of sub-recent gravels and clays of the Upper Irrawaddi, the source of this river gold might be found in a horizon which it might be well to test by exploitation. Major Hobday of the Survey of India, while exploring the country north of the "confluence," discovered numerous crystals of Spinel in the river deposits near the junctions of the Pangin Kha and Insop Kha with the Mali Kha branch of the Irrawaddi; and on his reporting his find to the local Government, Mr. Griesbach was requested to explore and report on the locality. The disturbed state of the country at the time made it absolutely impossible to reach any point north of Watu without an escort, which was then not available: still, he prospected the deposits up to that place as carefully as the scanty appliances permitted. In his washing for gold, he found a fair predominance of minute spinel sand associated with the iron sand left after the washing, consisting of small water-worn crystals and splinters, which increased in size as the river was followed up. The largest of these were however smaller than Major Hobday's finds. None were, however, found *in situ*, or in any fragmentary matrix, and the inference is that these gems and the few traces of ruby found with them have come from much higher up the drainage area, in regions which are only presumed at present to consist of metamorphic rocks, among which ruby and spinel-bearing limestones occur; such likely limestones or marbles having been also so noted among the gravels of this upper course of the great river.

Coal and gold in the country above the Irrawaddi 'confluence.'

Spinel and rubies.

For the geology, Mr. Griesbach reports that east and north-east of Bhamo, it has now been ascertained that by far the greatest part of the ground is formed by crystalline (metamorphic) rocks, amongst which a coarse porphyritic gneiss is most prominent in the eastern part of the area reported on, though it was also met with in the Mogaung subdivision. Besides these gneissic rocks there are also schists, chiefly phyllites and hornblende rocks. To map each one of these rock divisions would have been absolutely impossible, the country being almost entirely covered by most dense

Geology of Bhamo, east and north-east.

forest, so that all that could be really made out was the general distribution of the main groups.

Thus it was ascertained that the wide belt of hilly and mountainous ranges north of Bhamo are made up of a succession of flexures, leaving a wide depression in the middle which is probably an area of subsidence, the outer flexures being principally formed of older gneiss and granites, whilst the phyllites and other schists constitute the inner and mostly lower ranges bounding each side of the Irrawaddi basin. This seems to be the chief character of the distribution of the different rock groups, but the whole sequence of these metamorphic rocks has evidently undergone most extensive folding and crumpling with subsequent vast erosion: whilst by far the larger portion of the entire area is now obscured by sub-recent deposits, and by enormous forests growth.

It appears, moreover, that certain more or less crystalline rocks, among them limestones, which appear in the midst of the metamorphic flexures, and seemingly conformable to the latter, belong to the palæozoic group. The only evidence of mezozoic beds is furnished by a pebble containing an ammonite which was found by Dr. Noetling near the amber mines. It may be either cretaceous or jurassic, probably the former.

Patches of sandstone, all more or less much disturbed, occur here and there within folds of the crystalline rocks. They probably represent remnants only of a once much more extensive development of Tertiary beds of freshwater origin. Such patches are found in the Endawgyi lake-district, west of Mogaung in the amber mines district, and north of the Irrawaddi confluence. These occurrences may include members of several divisions of the Tertiary system, though in the main the beds forming them resemble the Miocene sandstone series of Upper Burma, and like the latter they are characterized by the occurrence of isolated seams of poor lignitic coal. The amber mines are also situated within the area of Tertiary deposits.

Widespread alluvial deposits, both fluviatile and lacustrine, occupy the wider troughs of the Irrawaddi and its confluents, the most important of which on account of its possible gold indications, lies between Watu and Hokat, and is some 20 to 24 miles in width.

Parallel to the general strike of the lines of disturbance of the older rocks are long strips of igneous rocks which Mr. Griesbach believes have been intruded in fissures of dislocation. They are accompanied by numerous dykes and intrusions penetrating the neighbouring rock formations, the more basic varieties in certain localities carrying the veins of the so-called jade. Broadly speaking, three principal lines of intrusions are found within the area reported on: one running due north and south along the 97° 30′ Lon. as far as the confluence; another between Bhamo and Senbo, within which the grand defile of the Irrawaddi has been scooped out, the intrusive mass being traceable northwards along the right bank of the river; and the third line, of unknown extent, is in the Jade mine district.

Compared with the part of Upper Burma lying south of Bhamo, it seems probable that this northern tract forms but the continuation of the area already partially known to us by the sections from Dr. Noetling's work. Thus, the ranges which bound the Irrawaddi valley west of Katha seem to form the northern extension of the Shan plateau rocks, and to this correlation belong all the Kachin ranges east of the river, which here runs through the depression north of the Bhamo defile, in the flexures of metamorphic and palæozoic strata. North and west of this great area, these flexures are linked to the range forming the most north-eastern parts of India (Assam, Manipur, etc.), and through these to the North-Eastern Himalayas.

Thayetmyo geology.

In the Thayetmyo district, work had been left in the hands of Mr. P. N. Datta, and this was found on subsequent inspection by Mr. Griesbach to have been carefully done as far as the actual survey of boundaries was concerned, though some of the crucial points in the structure of the Arracan Yoma had been left undecided. Two facts seem, according to Mr. Griesbach, to be conclusively established in this area :—(1) That the Arracan Yoma, minor disturbances excepted, appears to be formed on a reversed anticlinal, the average dip of the beds being to east and north-east; (2) The centre and part of what remains of the underlying shoulder (the western half) being formed of sandstones, shales and limestones of possibly cretaceous age; whilst by far the larger portion including the eastern half of the range is formed by fossil-bearing tertiary rocks, from the nummulitic to miocene strata. Some patches of basic igneous rocks occur here and there, though their extent is not clearly seen in the dense jungle covering the hill sides: they are clearly intrusive as shown by the altered character of the adjacent rocks. Of the so-called Axial formation, there is not a trace to be found; at least no part of the Arracan Yoma is of Triassic age.

Baluchistan and the Punjab :—On the north-west frontier, the coal and oil enquiry in Baluchistan was watched by myself, and I posted Mr. La Touche for the Moghul Kot oil investigation on the Punjab frontier. Mr. Middlemiss carried on purely geological surveying in Hazara.

Experimental oil boring in the Chuppar Rift.

At the end of March, I visited Baluchistan and selected a site for what I considered the final experimental boring for oil; for, to all appearance, the oil search so far by Mr. Townsend at Khattan, and by the Survey advice in the Harnai valley had either failed to produce oil in paying quantity, or had encountered hot and sulphurous acid waters in such quantity as to bar any prospect of their being cut off from drowning out the wells or acting deleteriously on the piping. The Khattant area is no doubt productive of a fair amount of oil from the shallower wells but the supply is altogether too small, and the oil itself too dead and thick to warrant the expenditure needed to bring the product over the great distance (40 odd miles) and difficult route lying between the wells and the railway. On the other hand, the structure and indication exhibited in the Chuppar Rift which is on the Sind Pishin railway, or rather through which the line runs, seemed to me to offer fair chances of a subterranean store of oil, if oil was to be got anywhere conveniently in Baluchistan. I was hopeful that oil might be struck in or below the Belemnite shales, much in the same way as it had been struck in the same group of beds at Khattan: and I give the range of depth as from 700 to 1,000 feet probably within the lesser depth. The belemnite beds were soon passed through but without even a show of oil, and then cretaceous limestones were pierced for some hundred feet. Being clearly in cretaceous limestones, and with no 'show,' I was reluctantly compelled to advise the boring being discontinued, and, indeed, all oil exploration in Baluchistan.

Prospect of oil at Sukkar.

The only chance now left, and which I consider worth trying, lies in the Punjab at Sukkar and Rohri on the Indus where it is crossed by the North-Western Railway system. There is here a flat undulation of the Nummulitic series, which rises up as a rocky insular outcrop in the Sind desert. This strange but gentle wave up to the surface of strata from the much more highly dipping and folded representatives of the same group 300 miles away to the north and west in the Baluchistan hills had already attracted the notice of my predecessor in his very careful study of the oil rock conditions in India: and it has been personally before us ever since, as the locality on which we might have to fall back for a last experimental trial on this side of India. The depth, 3,000 feet, in which oil might be expected to occur, were the thicknesses of the groups of rocks as they occur in the Baluchistan hills to remain the same throughout their easterly extension under the Sind plains, would be altogether prohibitive in our present progress of boring in India, but I am inclined to think that the thicknesses must have decreased in this direction, and I have set 1,500 feet as the limit to which the boring might be tried. Of course, the main point, the occurrence of a store of oil underneath the Sukkar undulation, is entirely a matter of expectation founded only on the argument that as oil does occur below these same nummulitic beds in the disturbed and fractured strata of the series in the Punjab and Baluchistan, there is just the possibility of its being stored here. This must ever be the question that will turn up when the subject of the fuel supply becomes urgent; and it can only be settled by the experimental boring suggested.

Moghul Kot oil.

The investigation of the occurrence and prospects of oil at Moghul Kot at foot of the south-eastern slope of the Takht-i-Sulaiman range on the western frontier of the Punjab was completed by Mr. La Touche. Though the oil turns out to be of very fine quality, its issue is only at about the rate of ten gallons a day; and the arrangement of strata is such that very deep boring would have to be made to bring about pumping from any large under-ground area. Mr. LaTouche puts forward suggestions for increasing the discharge of oil in the neighbourhood of the present springs either by sinking a well which might meet the oil-bearing beds at a depth of about 150 feet, and that galleries might be driven thence along the strike of the beds at that depth so as to increase the area of issue: or by drilling a six-inch bore-hole for at least 700 feet through the whole of the strata known to be oil-bearing, though this would be such a costly experiment, in addition to the fact that all the plant would have to be carried for 25 miles inside the foot-hills, that the return might after all be but very poor. This is more properly a subject for the consideration of oil-extraction experts before whom the conditions as made out by the geologist will be laid.

Geology.

While thus engaged on the oil quest, Mr. LaTouche has been enabled to provide a farther contribution on the geology of this part of the country in an admirably detailed report which will be published in April next.

Owing to the investigation being primarily an oil one, Mr. La Touche's geological observations were almost entirely confined to the region occupied by tertiary strata, lying between the Takht-i-Sulaiman and the plains of the Indus valley, forming only a small portion of the territory inhabited by the assemblage of clans known as the Sheranis. To the north and south, the area is bounded by the Zao and Toi rivers respectively, or, roughly speaking, between the parallels of 31°-25′ and 31°-55 N. Lat.

It will suffice here, to give his succession of the rock series met with which he has correlated with the series already made out by W. T. Blanford in the southern Sulaiman, and by R. D. Oldham in the Mari country of Baluchistan.

Geological Age.	Subdivisions.	Sherani Hills.	Approximate maximum thickness in feet.	Mari Region, Baluchistan (R. D. Oldham).	Thickness.	Southern Sulaiman Range (W. T. Blanford).	Thickness.
Recent and sub-recent.	......	15. Alluvium Fan deposits and Talus.	?	Alluvium, Gravels, etc., Sub-recent.	?	Alluvium, Gravels of slopes, etc.	?
Pliocene	Siwalik: Upper	14. Conglomerates, sandstones and clays.	? } 2,000	Conglomerates, sandstones and clays.	? } ...	Conglomerates, sandstones and clays.	2,500
	Siwalik: Lower	13. Sandstones and clays (*Mammalian, bones, etc.*)				Sandstones, clays, *bone-beds*, etc.	5,000
Miocene	Nari	Wanting	..	Wanting	...	Sandstones, clays, etc.	2,000
Eocene	Nummulitic: Upper	12. Olive shales and clays	2,000	Spintangi Group	1,000	Olive clays, shales, sandstones, etc., with a few thin bands of *nummulitic* limestone.	8,000
		11. Limestone with nummulites	40				
		10. Olive shales, highly fossiliferous. Platy limestones at base.	1,500				
		9. Limestone crowded with *nummulites*.	14				
		8. Shales with gypsum bands	550				
	Nummulitic: Middle	7. Shales and sandstones unfossiliferous.	10,000	Ghazij Group	3,000	......	...
	Nummulitic: Lower	6. Massive limestone band	250	Dunghan Group	2,000	Coarse brown sandstone, with a band of limestone breccia.	1,000
		5. Quartzose sandstone (*oil locally*)	1,000				
		4. Shales with minute *nummulites* and other fossils.	1,000	......	...	......	...
Cretaceous	Belemnite Beds	3. Thin-bedded limestones with *belemnites*.	1,500	Belemnite Beds	1,000	Hard whitish sandstone.	1,500
		2. Black shales, with *belemnites*					
	......	1. Massive limestone, with *corals, etc.*	5,000	Massive limestones	?	Dark grey limestone passing downward into limestone shales.	1,000 seen.

In Hazara, Mr. Middlemiss continues his survey, which promises to be closed up by the end of the present season.

Central Himalaya.—Following on the proposal, mentioned in my last annual report, from Professor Ed. Suess of the Vienna University that we should co-operate with the resolution of the Academy of Sciences to send out Dr. Carl Diener to collect a more complete series of fossils illustrative of the Triassic development in the Central Himalaya, than that we had sent to Vienna for determination and description as collected at various times in the course of our work in that region; the Government of India accorded a very liberal grant to what has come to be called the Diener expedition. I placed Mr. Griesbach in charge of the party, as having worked out the particular region himself, and also attached Mr. Middlemiss to it on account of his having had a good deal to do with Himalayan geology. Dr. Diener arrived in Calcutta in April, where he was shortly joined by Mr. Griesbach on return from Burma; and by the beginning of May, the whole party had assembled at Naini Tal. They then marched to Milam where the journeys north-east of that base were arranged: the following localities were successively visited in that area; Topidunga, Martoli and another camping ground in the Girthi valley; then *viâ* the Kiangur pass to Chidamu, the Kiogarh pass and Chitichun, where they had a most successful tour. From here they intended to proceed to the Lissar valley, but failed on account of the road over the glaciers having become impassable. They therefore recrossed into the Milam valley after passing over the Kunjribingri, Jandu, and Uttadhura passes, and made arrangements to get at the Lissar valley by a round-about route. Difficulties arose over transport, but fortunately just then all the restrictions at first imposed on the frontier part of the journey were removed, thus leaving Mr. Griesbach free. The original plan of paying visits to Laptel, Shal-Shal, and Youge was followed out; and eventually crossing the Silakank, they were able to collect fossils in Pethotali, Kiunglung, and the Niti pass itself, where the labours of the expedition came to a close.

Diener Expedition.

The aim of the trip was fully realized; a very large and fine collection of fossils having been made, which will amply supplement that already sent to Vienna. The finds are mostly from the Muschelkalk and upper Trias, and there is also a fine suite of specimens from the Otoceras beds. An entirely new corner of the Tibetan Himalayas was visited on this occasion; a short report on which by Mr. Griesbach is given in the current Records of the Survey. A very satisfactory feature of the mission is that the now established excellence of the stratigraphical details and horizons as given by Mr. Griesbach in his Memoir on the Geology of the Central Himalayas can now be brought into closer correlation with Alpine triassic geology through the independent personal experience and fossil collecting of a deputed specialist in the European region. The expedition proceeded without encountering any troubles other than the usual ones of transport, supplies, and weather: the anticipated political difficulties with the Tibetans did not arise; on the contrary, the Niti people and the few Tibetans met with were most amiable and anxious to oblige.

The party returned by Toshimath and Ranikhet to Naini Tal and broke up on the 14th October; and news has arrived that Dr. Diener has reached Vienna, where the fossil collection must also have been delivered by this time. The agreement is that the collection is to be studied and described by Drs. Mojsisovics, Bittner, and

Uhlig or other specialists, the type specimens being ultimately returned to the Survey Museum.

Exploitation.—It having become necessary to extend the coal operations of the North-West Railway in the Salt Range; the opening up of the Bhaganwála area is under consideration. So far back as 1884, when there was no sphere for the utilization of this field, Dr. T. Oldham visited the place and reported:—

"Taking Bahganwálla, then, as unquestionably the most promising of any of the localities, we can here make a rough approximation to the quantity of 'coal' which will be available at a moderate cost, that is, without going to any great expenditure for machinery or other such appliances. I put aside altogether any calculation of what may occur (and I suppose does occur) at depths to which it most indubitably would not pay to drive the workings for such a coal as this."

Now this is an important opinion because Dr Oldham having been a railway engineer with actual experience in Scotland and having had large knowledge of coal-mining in Great Britain was especially competent to give such, over and above his geological acquaintance with the structure of coal fields.

His estimate of the quantity of coal so available, after allowing for all the deductions for irregularity of beds, working below water level, waste, small coal, dust, and impurities, was 40,000 tons.

In June last the matter was again brought before the Survey in connection with a report and survey which had been made by Mr. Luckstedt of the North-West Railway executive, in which such a vastly increased estimate of available coal was formed, and on what I was unable to accept as convincing data, that I considered that a thorough survey of the field by boring should be made before any large colliery operations should be determined on. Mr. LaTouche was accordingly deputed to this work which is being carried out, in part, with one of the Survey steam borers.

Museum and Laboratory.—The Museum continues in its usual efficient and forward illustrative condition: and a particular section has been more specially utiized this year for the promising class of geological students which has been started at the Presidency College under the professional teaching of Mr. Holland. Several donations, among them a very fine collection of mica, in larger crystalline masses and prepared sheets than have hitherto been known in India, from the recently opened-out mica mines at Inakurti in the Nellore District of Madras, by Mr. E. H. Sargent: as well as handsome specimens of ruby mica from the Gya District and Hazaribágh, by Mr. E. T. Hollingsworth, are especially noteworthy as indicative of the improved aspect of this industry.

Very increased call has been made on the laboratory in the way of outside assays, even to the inconvenient pressing out of the proper research work connected with the Survey investigations, though I have endeavoured to keep the outside assaying as much as possible within the limits which may be considered to bound the reasonable demand for authoritative opinion by the public from this Department. These numerous assays of coal, oil, and ores have been duly noticed in our tri-monthly notes: at which Mr. Blyth, the Museum Assistant, has worked with zeal and admirable integrity.

The research work has been of the highest importance, mainly in connection with the iron ores, the corundum deposits, the associated crystalline rocks and minerals of Southern India; and on the oil from the Punjab. Amongst the specimens collected by Mr. Bose in South Sikkim, Mr. Holland has found the new soda-amphibole, Riebeckite in a granitite. The occurrence of this mineral in India is a point of considerable interest, because at the few other localities in which it has been found in the world, it has been found associated with minerals containing the so-called rare metals, and we may expect that in India also we shall soon be able to record the occurrence of minerals which have hitherto been considered rare, but are possibly rare in the sense that for want of sufficient research they are unfamiliar. This particular feature of petrological research is to be commended, because the paragenesis of minerals, although imperfectly understood as yet, is one of the principal guides in prospecting for minerals of economic value.

Survey Publications.—The year's volume of the Records contains 18 papers and appendices, of which 9 deal with industrial or allied subjects. A very full *Index to the Genera and Species described in the Palæontologia Indica, up to the year 1891*, and *Contents and Index of the first twenty volumes of the Memoirs of the Geological Survey of India, 1859—1883*, have been issued during the year: for the compilation of both of which we are greatly indebted to our retired colleague Mr. W. Theobald. New volumes on the Jurassic Echinoidea of Cutch by Mr. J. W. Gregory of the British Museum; Dr. W. Waagen's Fossils from the Ceratite Formation of the Salt Range; and Mr. Foote's Memoir on the geology of the Bellary District are in press. The preparation of the new edition of the Manual of the Geology of India by Mr. R. D. Oldham is in a forward state, and the issue of the work may be looked for in May next.

Library.—The additions to the library amounted to 1,820 volumes or parts of volumes, of which 1,168 were acquired by presentation, and 652 by purchase.

Personnel.—Consequent on the retirement of Mr. Foote, Mr. Frederick Herbert Smith, Associate of the Royal College of Science, and of the School of Mines, Freiberg, was selected by our referee Dr. W. T. Blanford from Her Majesty's Secretary of State's nominees, and joined the Survey in February last. Mr. Holland, in addition to his regular duties, was appointed Professor of Geology and Mineralogy at the Presidency College in July last.

WILL: KING,
Director, Geological Survey of India.

CALCUTTA; *January 31st, 1893.*

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 1892.

ADELAIDE.—Royal Society of South Australia.
ALBANY.—New York State Museum.
ALLAHABAD.—Committee, Lucknow Provincial Museum.
BALLARAT.—School of Mines.
BALTIMORE.—Johns Hopkins' University.
BASEL.—Natural History Society.
BATAVIA.—Batavian Society of Arts and Sciences.
BELFAST.—Natural History and Philosophical Society.
BERLIN.—German Geological Society.
„ Royal Prussian Academy of Science.
„ Royal Prussian Geological Institute.
BOLOGNA.—Royal Academy of Science.
BOMBAY.—Natural History Society.
BORDEAUX.—Linnean Society of Bordeaux.
BOSTON.—Society of Natural History.
BRESLAU.—Silesian Society.
BRISBANE.—Queensland Branch, Royal Geographical Society of Australasia.
„ Queensland Museum.
BRISTOL.—Bristol Naturalists' Society.
BRUSSELS.—Royal Academy of Sciences.
„ Royal Geographical Society of Belgium.
„ Royal Malacological Society of Belgium.
BUDAPEST.—Hungarian Geological Institute.
„ Hungarian National Museum.
BUFFALO.—Society of Natural Sciences.
CAEN.—Linnean Society of Normandy.
CALCUTTA.—Agricultural and Horticultural Society of India.
„ Asiatic Society of Bengal.
„ Calcutta Public Library.
„ Editor, "The Indian Engineer."
„ „ "Indian Engineering."
„ Indian Association for the Cultivation of Science.
„ Indian Museum.
„ Meteorological Department, Government of India.
„ Royal Botanic Garden.
„ Survey of India.
CAMBRIDGE.—Philosophical Society.
„ University of Cambridge.
„ Woodwardian Museum.
CAMBRIDGE, MASS.—Museum of Comparative Zoölogy.
CASSEL.—Vereine für Naturkunde.

CHRISTIANIA.—Editorial Committee, Norwegian, North Atlantic Expedition.
CINCINNATI.—Society of Natural History.
COPENHAGEN.—Royal Danish Academy.
DEHRA DUN.—Great Trigonometrical Survey.
DIJON.—Academy of Sciences.
DRESDEN.—Isis Society.
" Royal Mineralogical, Geological, and Pre-Historic Museum.
DUBLIN.—Royal Dublin Society.
" Royal Irish Academy.
" Science and Art Museum.
EDINBURGH.—Geological Society.
" Royal Scottish Society of Arts.
" Scottish Geographical Society.
FREIBURG.—Natural History Society.
GLASGOW.—Glasgow University.
" Philosophical Society.
GOTHA.—Editor, Petermann's Geographische Mittheilungen.
GÖTTINGAN.—Royal Society.
HALLE.—Acad. Cæsareæ Leop.-Carol. Naturæ Curiosorum.
" Kais. Leopoldinisch-Carolinische Deutsche Akademie der Naturforscher.
HAMILTON.—Hamilton Association.
HARRISBURG.—Geological Survey of Pennsylvania.
HOBART.—Royal Society of Tasmania.
KÖNIGSBERG.—Physikalisch-Ökonomische Gesellschaft.
LA PLATA.—Museo de La Plata.
LAUSANNE.—Vaudois Society of Natural Sciences.
LEIDEN.—École Polytechnique de Delft.
LEIPZIG.—Verein für Erdkunde (Geog. Society).
LIEGE.—Geological Society of Belgium.
LILLE.—Sociéte Geologique du Nord.
LISBON.—Geological Commission, Portugal.
LIVERPOOL.—Geological Society.
LONDON.—Geological Society.
" Iron and Steel Institute.
" Linnean Society of London.
" Royal Geographical Society.
" Royal Institute of Great Britain.
" Royal Society.
" Society of Arts.
" Zoological Society.
MADRID.—Geographical Society.
" Royal Academy.
MANCHESTER.—Geological Society.
" Literary and Philosophical Society.
MELBOURNE.—Department of Mines and Water-supply, Victoria.

MELBOURNE.—Geological Society of Australia.
" Royal Society of Victoria.
MILANO.—Italian Society of Natural Sciences.
MINNEAPOLIS.—Minnesota Academy of Nat. Sciences.
MONTREAL AND OTTAWA.—Geological and Natural History Survey of Canada.
MOSCOW.—Imperial Society of Naturalists.
MUNICH.—Royal Bavarian Academy.
NAPLES.—Royal Academy of Science.
NEWCASTLE-ON-TYNE.—North of England Institute of Mining and Mechanical Engineers.
NEW-HAVEN.—The Editor of the "American Journal of Science."
NEW YORK.—Academy of Sciences.
OXFORD.—University Museum.
PARIS.—Editor, Annuaire Geologique Universel.
" Geographical Society.
" Geological Society of France.
" Geological Survey of France.
" Mining Department.
PHILADELPHIA.—Academy of Natural Sciences.
" American Philosophical Society.
" Franklin Institute.
PISA.—Society of Natural Sciences, Tuscany.
RICHMOND.—Virginia University.
ROCHESTER.—Geological Society of America.
ROME.—Geological Survey of Italy.
" Royal Academy.
" Royal Geological Commission, Italy.
SAINT PETERSBURG.—Geological Commission of the Russian Empire.
" Imperial Academy of Sciences.
" Konig. Russische Mineralogische Gesellschaft.
SALEM.—American Association for the Advancement of Science.
" Essex Institute.
SAN FRANCISCO.—California Academy of Sciences.
SINGAPORE.—Straits Branch, Royal Asiatic Society.
S. PAULO.—Geological and Geographical Commission.
SPRINGFIELD.—Geological Survey of Illinois.
SYDNEY.—Australian Museum.
" Department of Mines, New South Wales.
" Geological Survey of New South Wales.
" Linnean Society of New South Wales.
" Royal Society of New South Wales.
" Technological Museum of New South Wales.
TOKYO.—Asiatic Society of Japan.
TORONTO.—Canadian Institute.
TURIN.—Royal Academy of Sciences.
VENICE.—Royal Institute of Science.
VIENNA.—Imperial Geological Institute.

VIENNA.—Imperial Natural History Museum.
„ K. K. Geographischen Gesellschaft.
„ Royal Academy of Science.
WASHINGTON.—Philosophical Society, Washington.
„ Smithsonian Institution.
„ United States Department of Agriculture.
„ United States Geological Survey.
„ United States Mint.
„ United States National Museum.
WELLINGTON.—Colonial Museum and Geological Survey of New Zealand.
„ New Zealand Institute.
YOKOHAMA.—German Naturalists' Society.
YORK.—Yorkshire Philosopical Society.
ZURICH.—Natural History Society.
The Governments of Bengal, Bombay, Burma, India, Madras, North-Western Provinces and Oudh, and Punjab.
The Chief Commissioners of Assam, Burma, and Central Provinces.
The Resident at Hyderabad.

Notes *on the* Central Himalayas.—*By* C. L. GRIESBACH, C.I.E., F.G.S., *Superintendent, Geological Survey of India.*—(With Map and Plate.)

The very difficult country north of Milam, including the passes leading from that part of Kumaun into Tibet, was geologicaly examined by me in 1879, but political and other considerations obliged me to abandon my investigations at the frontier; so that the small area between the Laptal ranges and the head of the Dharma valley had to remain a blank, although from the map it is at once apparent that the flexures of the Chiangur (Kiangur on the map) and of the Lissar and Dharma valleys must, to some extent, be continued across the area which I could not visit at the time.

This last season, whilst travelling in the Milam area with Dr. C. Diener and Mr. Middlemiss, an opportunity fortunately occurred to pay a visit of a few weeks to this ground, which proved of considerable interest and stratigraphical importance. From a camping ground, about two miles north of the grazing grounds named Chidamu on the map, we marched to Chitichun *vid* the Kiogargh (Chaldu) pass (17,440′), where we spent about a fortnight. Later on we were in Laptal, and though we could not afford much time for stratigraphical work, some of the results of that visit help to shed light on the difficulty which arose in connection with the geology of Chitichun.

Disturbed structure.

The structure of the Chitichun area shows very considerable disturbance, as might be expected. As far as we were able to observe rhætic strata (with some members of the Upper Trias) fringe the ground on three sides, namely, the range which runs from the Lahur to Chidamu on the west, the high peaks and ranges which form the Jandi, Chitichun No. 2 and Dharma peaks on the south and the long ridges, with fine precipitous cliffs, which extend from the Chanambaniali peaks to northwards and shut off the Chitichun ground from the widely extended hilly area, chiefly formed by mesozoic rocks, which are seen to stretch to north-east and north towards the Sutlej river.

Rhætic beds. System of synclinals.

These rhætic-trias strata might be said to form a great synclinal, or, more correctly speaking, a series of synclinals: this feature is clearly seen when viewing the southern fringe of the ground from the Chitichun No. 1 peak, a view which is given on plate I accompanying this paper. In fact, the rocks of the rhætic system are folded and puckered into a series of flexures striking almost north and south near the western half of the area and approaching a direction nearer south-east to north-west in the neighbourhood of the Dharma ranges; the eastern fringe of rhætics appears to have a south to north strike. The dip in this disturbed ground changes constantly and most rapidly; numerous tight folds and narrow anticlinals alternate with gentle dip-slopes and low arches, where the beds lie almost horizontally. Consequently the younger rocks which occupy the ground within this synclinal have also participated in this folding process; with this difference, that being mostly soft shales and sandstones they have suffered a greater local disturbance, and whilst the result of this compression has been merely folding of the rhætics, it has meant extensive crushing in the case of the shales and sandstones within the synclinal.

The rhætics themselves afforded little opportunities for closer study. They are apparently in no wise different from the rhætics in the adjoining area on which I have already reported*. The different divisions of the system have been sketched in from a distance, but this process is easy enough as the hill-sides, when not entirely obscured by snow-masses, are absolutely bare and their geological structure is plainly visible. Towards the south-eastern part of the ground, however (not on the map) I believe, that beds of the upper trias, developed chiefly as grey limestones, might be separated from the lower rhætic, but I have seen these sections only from a distance when ascending the Chanambaniali peak (18,320').

Profile.

I have given the profile on plate I in this paper in order to show the varying and often complicated dip of the rhætic folds. The view was taken by me from the top-most point of Chitichun No. 1; the hill-slope nearest is formed by Spiti shales, under which these rhætic folds disappear, the contact being absolutely conformable.

Boundary with the Spiti shales.

The rhætic boundary may be followed easily from the Kungribingri pass (18,300') north-eastwards to the Chitichun camping ground, near which a small fault has brought up a portion of the rhætics seemingly into abrupt contact with beds belonging to the Gieumal sandstone. From that point to the Lochambel-ki-chak encamping ground the recent gravels of the river have obscured the boundary partially, but a narrow band of Spiti shales is seen to run along one of the synclinals trending towards south-south-east, evidently a continuation of the strip of Spiti shales enclosed in the Dharma valley synclinal (see map in Vol. XXIII of the Memoirs). Another patch of Spiti shales lies on a rhætic slope (map and profile No. 1), where it forms a thin plastering only of the lower-most (liassic) beds of the formation.

Spiti shales conformable on the rhætics.

All round the inner slopes of the synclinal the Spiti shales are seen to rest conformably on the rhætics. The strip of the former which was recorded by me in 1879 as lying between the rhætics and Gieumal series in Laptal was visited again this year. It forms a narrow belt running southwards towards the Kungribingri pass, and is *in situ* all along the base of the Kungribingri peaks, and at the pass itself; from there the belt turns round to the north and underlies everywhere the Gieumals as far as the Chitichun camping ground. All the comparatively low hills with rounded contours which extend in a north-east direction on the left side of the valley and of which Chitichun No. 1 forms one of the peaks in it, consist more or less of Spiti shales, which are well exposed in most places.

Lithological character of Spiti shales; lowest beds.

The character of the Spiti shales remains wonderfully constant over a very large area. As in other sections, so also here we find the base of it formed by earthy dark brown or black shales with oolitic structure, which are occasionally (as, for instance, on the Chanambaniali) bright Indian red in colour. They are easily distinguishable from the overlying shales from which they differ in lithological character and in their organic inclosures. In my Memoir on the Central Himalayas I considered this horizon as lias; the brachiopods contained in it are certainly liassic forms. *Belemnites* occur very frequently; sometimes there are entire nests of this fossil. Of *Ammonites* only fragments have been found; but several *bivalves* have been collected in the horizon, whilst *Rhynchonella austriaca spec.* is common in some localities.

* Memoirs, G. S. of I., Vol. XXIII.

Jurassics.

The remainder of the Spiti shales show the same structure as described from the Shanki river north of the Niti pass. I think there can be little doubt but that, in the thickness of this formation, the entire Jurassic system is represented.

Gradual passage into the Gieumals.

They certainly pass very gradually into the overlying formation of the Gieumal beds: it would be impossible to fix the line accurately where the one ends and the other begins.

Disturbed bedding. Igneous rock.

The bedding of the Spiti shales is exceedingly disturbed and frequently much crushing may be observed locally. Masses of an intrusive basic rock occur here and there within the area both of the Spiti shales and the adjoining Gieumal beds. Beyond the fact that this rock seems to occur along a line more or less marked and close to the ridge formed by the Spiti shales, it is not easy to map the extent of these trap intrusions, the colour of which resembles closely the dark, almost black Spiti shales.

Gieumal beds.

The centre of the synclinal, if I may so term the complex of folds which forms the Chitichun area, is occupied by a peculiar formation; lithologically it may be classed as a *Flysch* development: it consists of a considerable thickness of greyish-green sandstones with shales, within which there may be seen a hard rock, generally bluish-green in colour, which probably has been formed to a large extent of trappean material. With it are associated densely red earthy beds and black alum shales much resembling the jurassic Spiti shales lower down in the section. With the exception of a few traces of *belemnites*, no organic remains have been found in this formation, but it is exposed in very clear sections in many localities along the Kumaun-Tibet frontier where one may observe the gradual passage from the Spiti shales into the Gieumal beds above, which, according to Dr. Stoliczka, are probably upper jurassic: they are certainly mesozoic and may possibly be lower cretaceous.

Igneous rock.

It perhaps deserves mention that a lithologically identical formation occurs in Baluchistan (Kojak range) which extends north-eastwards to the southern slopes of the Saféd Kóh,—a formation which I have placed in the lower cretaceous system. In common with the Spiti shales below, the Gieumals have also been invaded by an intrusive igneous rock of basic character, which seems to have been injected into the fissures and dislocations which are common in this disturbed area. This further complicates the already disturbed sections considerably: on the map I have not been able to distinguish this intrusive rock, excepting to some extent near the Chitichun peak No. 1 itself, where it forms an important feature. Otherwise this trap is so mixed up with the dark coloured Gieumal sandstone and with beds, which may eventually also turn out to be of igneous character within the Gieumal formation itself, that I had to leave the clearly intrusive masses unmapped.

Distribution.

Near the western and south-western corner of the area now described the Gieumal formation rests in great thickness on the Spiti shales and forms the high range in which are situated the Kiogarh and Kungribingri peaks with the passes between them. The Kungribingri No. 2 as seen from the pass of like name forms a steep scarp, facing west with a long dip-slope inclined to north-east (see profile, plate I.) This dip-slope, more or less broken up by ridges and ravines descends towards the Chitichun stream, which as I believe, runs partly along a minor fault, probably a fold-fault. The Kiogarh (Chitichun) pass (17,960′) is again formed by Gieumal beds.

Detached blocks.

So far the geological structure of the area north-east of the Kungribingri appears simple enough, and excepting considerable folding and consequent crushing the sequence of strata is normal. Nevertheless this area presents features of structure of exceptional interest, features which, as far as I am aware, have, up to the present, not been observed in India. These are nothing less than a series of *Klippen-züge* or *blocs exotiques*, or as we may perhaps call them, detached blocks.

Blocs exotiques in the Alps.

As is well known, such chains of Klippen (or blocs exotiques) form one of the most characteristic features along the northern belt of the Swiss Alps, of the cretaceous (and nummulitic) Vienna sandstone (Flysch) zone and within the Karpathian sandstone zone of the same age. It is therefore of special interest to meet with similar structural features near the northern margin of the Himálayas, and it would be worthy the expenditure of money and time to further explore a country exhibiting such structure.

Chitichun range.

At first sight the inner part of the Chitichun synclinal presents to view a range of comparatively low hills, bare and of the dark, almost black colour, which characterises the Spiti shales and the basic rocks which are found intrusive in the same. These hills form a ridge of slightly varying height which runs from the Kiogarh pass to Chitichun No. 3, Chitichun No. 1, then trending gradually north-eastwards assumes finally almost a northerly direction.

Northern ridges.

North of this range, another (the Chaldu) ridge runs almost parallel with the Chitichun hills, whilst beyond this is seen a series of hill-ranges, the so-called Lal-pahar (of Shikar fame) which as far as one may form an opinion, is structurally similar to the southern ridges.

"Detached blocks."

Several, if not most of the culminating points of these ranges are crowned by picturesque crags, formed of rocks other than those composing the hill-ranges on which these crags seem to rest. These crags are all much eroded, present steep and complicated outlines, often forming sharp needle-points and precipitous cliffs. These crags, I may term detached blocks. At first sight they seem all composed of the same material,—a white to reddish-white highly altered limestone, but as will be seen this is not invariably the case. Neither do these crags occupy only the culminating points in the range, as would seem. Similar detached limestone blocks occur lower down the hill-sides, and even right down in the ravine, as one "block" testifies in the narrow ravine close to Chitichun camping ground. There are several such in the ravine a little higher up the stream, and a block of much indurated limestone occurs close to the peak of Kungribingri No. 2.

Chitichun No. 1.

The block which was closely examined by us during our visit to this part of the Himálayas, was Chitichum No. 1; other and similar such crags were visited, but as we had a large programme of work before us, we had to abandon the mapping of the remainder. The ground is in Tibet and it was not desirable to prolong our stay there.

Since this detached block of Chitichun No. 1 has given rise to some difference of opinion between Mr. Middlemiss and myself, I will give here a short description of the events as they occurred.

We crossed the Kiogarh (Chaldu) pass (17,440,) and encamped at a place north-west of the Chitichun No. 1 peak on Spiti shales. Close to the camp was lying a mass of detached, fragmentary blocks of limestone, which had evidently rolled down from Chitichun No. 1. It appeared to be a whitish red limestone, in which the red portions (argillaceous) formed irregular nests as it were, within the jointed white limestone. In places the latter was much altered and then coarsely crystalline. I detected a coral structure in the limestone, and there were pieces of it showing what appeared to be sections of *Fenestella*.

The following day we proceeded to the other side of the range, and on the way visited the crag which forms the top of Chitichun No. 1. It appeared that on the western side of this peak the saddle leading over the range was formed of Spiti shales, which a little further was obscured by an igneous basic rock, which forms intrusions in the Spiti shales.

White and reddish limestone forms the steep crag on the top of these Spiti shales, and, as far as can be actually observed on the spot, the limestone might be in normal position on the jurassic shales. The limestone appears to be bedded almost horizontally, whilst the Spiti shales below are a good deal crushed with an average dip to north-east. But that alone would not justify us in asserting that the limestone rests unconformably on the shales, as the latter would naturally show a crushed dip in a disturbed region, being soft enough to yield to every pressure.

In loose blocks near the saddle west of the peak we found that day some *Ammonites* in sections, exceedingly badly preserved and with it corals, chiefly of *Fenestella*. Still, in the absence of other and better fossils, and seeing the apparent overlie of the limestones over Spiti shales we assumed that the former must be either jurassic or cretaceous, possibly the former.

This remained our opinion for several days till we returned to the locality and camped at Lochambel-ki-chak about 2 miles east of Chitichun No. 1.

From there we explored the Spiti shales, which form the base and the white limestone cliffs which constitute the top of the Chitichun No. 1. The results were remarkable.

The south-eastern slopes of the range consist of Spiti shales. Their base is seen north-east of Lochambel-ki-chak encamping ground; we met again the earthy brownish black beds with pisolitic structure and *belemnites*, which is followed by the typical Spiti shales, which are *in situ* the whole way up to the limestone crag on the top of Chitichun No. 1, where they are much obscured by debris from above. They are a good deal disturbed and their beds are often much crushed and contorted.

Near the base of the crags above, a basic igneous rock comes in, but is so mixed up with the shales that it would be exceedingly difficult to map it.

The crag of Chitichun No 1 itself shows an almost horizontal stratification; the base of its south-eastern slope is covered with a mass of debris and there is therefore no actual contact seen with the Spiti shales. But north-east, a low saddle leads across the range between the crags on Chitichun No. 1 and the one immediately next in succession. The saddle is seen to be formed of the basic igneous rock which also runs as a vein up the side of the crag, whilst the crown of the latter, a small level space, is entirely composed of that rock. The latter is therefore proved to be of intrusive character, penetrating in succession the Spiti shales and the crag in question.

Further north-east similar limestone crags form the highest points of the ridge. They are mostly surrounded by intrusions of igneous rocks; near the most north-eastern extension of the ridge, where a low pass leads to Chaldu camping ground, a portion of the Gieumal formation seems to come in between the Spiti shales and the limestone on the top.

Fragments of the greenish rock which must belong to the Gieumals strew the lower slopes of the Spiti shale range east of Chitichun No. 1, and I have myself no doubt that the Gieumal formation extends so far eastwards and that there are sections, as Mr. Middlemiss asserts, in which limestone (as the one on Chitichun No. 1) rests *apparently* on Gieumals. This is imp rtant, for if the limestone were to rest on Gieumal sandstone in one section and in another on Spiti shales, it could not be in normal position.

But it will be seen that there are other evidences which prove conclusively that the limestone is not resting normally on mesozoic strata.

We remained several days at this locality and obtained finally a very interesting suite of fossils from the limestone on Chitichun No. 1; to Mr. Middlemiss belonging the honour of having found the first well-preserved *cevphatopods* and the first *trilobite*.

Fossils.

The fauna is rich in individuals and rich in numbers and forms one of the best suites of fossils obtained this season.

They have all gone to Vienna where they are to be described, but in the meantime I may here state that amongst them were species of:

Fenestella, *Lithodendron*, many forms of *Terebratulidæ*, *Spiriferidæ*, *Productidæ* of several *cephalopod* genera and of well-preserved *Trilobite* remains.

The fauna presents therefore a most characteristic carboniferous type and is certainly upper palæozoic. This is an undisputable fact, and it only remains to explain the occurrence of a carboniferous limestone in the position in which we find it on Chitichun No. 1.

We have seen that this limestone lies apparently on Gieumal beds in one section, and on Spiti shells in another; further that the crags are accompanied more or less along their entire line of strike by igneous intrusive rocks, and in one instance at least the latter penetrates the carboniferous limestone, which is partially converted into a semi-crystalline limestone.

I advance therefore the theory that these older rocks have been brought to the surface by faulting. The latter is not directly visible, which, indeed, is rarely the case in a complex of soft shales such as the jurassic beds are in this region, but a fault may be inferred not only from the existence of palæozoic rocks above jurrassic, but also from the fact that the former rest on different divisions of the latter in adjoining sections. The assumption of a fault explains also the presence of intrusive rocks, which may have most probably intruded along a line of fissure. The vast nature of the disturbance, which brought about this result, may be guessed at from the fact that "detached blocks" of other age than carboniferous occur also not far from the one at Chitichun, with apparently no sort of structural connection with one another, a feature which is characteristic of the Alpine Klippenzuge. At least two detached masses of rhætics occur not far from Chitichun and within the strike of the carboniferous crags; similarly near the Balchdhura pass several such "blocks" occur, one of which has yielded *Tropites*, an upper triassic genus.

I cannot here enter into a discussion of the theory and occurrence of the so-called "*Klippen*" or "*blocs exotiques*"; I must refer the reader to the vast literature on the subject, which he will find in the Austrian and Swiss geological publications. Amongst the numerous occurrences of such "Klippen" described already, will be found many which answer in every respect to the crags on the Chitichun range. But however it might be, the fact remains that there are palæozoic (and some triassic) isolated crags which to a superficial observer seem to rest on mesozoic strata. They cannot be in normal position there, neither can their presence be explained by assuming any system of folding or reversing, and we must, therefore, look for an explanation to occurrences of similar crags in other localities. The blocs exotiques of Switzerland and the Klippen in the Flysch of Austria, and the Karpathen Sandstone of Hungary explain fully the structure of our Chitichun crag which is one of those detached blocks, brought up by faulting and denuded out of the surrounding soft shales subsequently.[1]

The Chitichun area of disturbance is of special interest when compared with the structure of the Hundés ranges. A section carried across the Himálayas, the Hundés plain and the Kailás range (between the Sutlej and Indus rivers) reveals the fact that the Hundés plain does not form a synclinal basin, but that a dislocation or system of dislocations runs along the present Sutlej valley, and that the Kailás section is merely a repetition of the Himálayan one, although we might expect, that as we proceed north-eastwards changes in the facies of the different formations will take place, for we should proceed further away from the old coast line.

This great dislocation or system of faults has enabled the basic rocks of Hundés to intrude; we find them in enormous development particularly in the eastern part of Hundés, about the Manasarowar Lakes and the Koilás peak (according to Strachey).

To this system of faults may belong our Chitichun lines of dislocations and the slight change in lithological character of the carboniferous and of the *Tropites* rock of Balchdhura is easily accounted for by the fact, that these occurrences are removed from the sections south-wards and that we are already further away from the original coast-line, where we may expect a change of facies, both palæontologically and lithologically.

[1] It should be stated that Mr. Middlemiss does not accept this explanation, which he believes to be inconsistent with his observations. The analogy of the *blocs exotiques* of the Alps does not necessarily prove their identity of origin, and the *fauna* of the crag of Chitichun No. 1 appears to be a peculiar one for, in addition to the forms mentioned by Mr. Griesbach, some cephalopoda were found by Mr. Middlemiss in the same beds which Dr. Diener took to be *ammonites* of Tithonian facies. It is a pity that the details of the structure and mode of displacement of this *bloc exotique*, if such it be, could not have been worked out more fully: and it is evident that there are still problems of great interest in this region whose solution could not be attempted by this expedition particularly intended for the study of the triassic strata. *Ed.*—

Note *on the occurrence of* Jadeite *in* Upper Burma, *by* Dr. FRITZ NOETLING, *Palæontologist, Geological Survey of India.* (With a map).

1. HISTORICAL SUMMARY.

Amongst the minerals for which Burma has achieved a world-wide fame, a beautiful green stone is one of the foremost, which is known under various names; "Jade" and sometimes "Noble Serpentine" being mostly used: though Mr. Mallet[1] has determined it as Jadeite.

The first information concerning this mineral, which I can trace will be found in Captain Hannay's route from Ava to the frontier of Assam.[2] During his stay at Mogoung he obtained specimens of a fine green stone, which the Burmans called "Kyouktsein"-green stone; the Chinese name is said to be "Yueesh." As far as I know the Chinese name is hardly ever used at present, to Burmans and Chinese alike, the mineral is now known under the name of "Kyouk-tsein." Captain Hannay believes the mineral to be nephrite, and adds, "The Chinese choose pieces which, although shewing a rough and dingy-colored exterior, have a considerable interior lustre, and very often contain spots and veins of a beautiful bright apple-green. These are carefully cut out, and made into ring stones, and other ornaments, which are worn as charms. . . . . All the yueesh taken away by the Chinese is brought from a spot five marches to the north-west of Mogoung, but it is found in several other parts of the country, although of inferior quality."

A more detailed account will be found in Dr. Griffith's Journal.[3] He seems to have been the first European, who visited the mines; the itinerary of his journey from Kamaing to the mines, is very accurate, although he seems to have travelled by a roundabout way, the distance from Kamaing to the mines by the present high road being not more than 31 miles, while Dr. Griffith states it to be 51 miles.

The following is Dr. Griffith's account of the mines:—

"These celebrated Serpentine mines occupy a valley of somewhat semi-circular form, and bounded on all sides by thickly wooded hills of no great height. To the north the valley passes off into a ravine, down which a small streamlet that drains the valley escapes, and along this, at a distance of two or three miles, another spot of ground affording Serpentine is said to occur. The valley is small: its greatest diameter, which is from east to west being about three-quarters of a mile, and its smallest breadth varying from 460 to 600 or 700 yards.

"The whole of the valley, which appears formerly to have been occupied by rounded hillocks, presents a confused appearance, being dug up in every direction, and in the most indiscriminate way; no steps being taken to remove the earth, etc., that have been thrown up in various places during the excavations. Nothing in fact like a pit or a shaft exists, nor is there anything to repay one for the teadiousness of the march from Kamein.

"The stone is found in the form of more or less rounded boulders mixed with other boulders of various rocks and sizes imbedded in a brick-coloured yellow or nearly orange-coloured clay, which forms the soil of the valley, and which is of

[1] Manual of Geology of India, Vol. IV, page 95.
[2] Journal of the Asiatic Society of Bengal, Vol. VI. 1837, page 265.
[3] Journal of Travels in Assam, Burma, Butan, etc., Calcutta, 1847, page 132.

considerable depth. The excavations vary much in form, some resembling trenches; none exceed 20 feet in depth. The workmen have no mark by which to distinguish at sight the Serpentine from the other boulders; to effect this, fracture is resorted to, and this they accomplish, I believe, by means of fire. I did not see the manner in which they work, or the tools they employ, all the Shans having left for Kamein, as the season had already been over for some days. No good specimens were procurable."

Dr. Griffith then adds some remarks on the mode of transport, which are of no particular interest in the present enquiry.

Colonel Yule's[1] remarks on the Jade are apparently based on the notes of Dr. Griffith and Captain Hannay.

It is, therefore, the more surprising that Dr. Anderson, although he nearly literally quotes Dr. Griffith's notes, states[2] that "the Jade-mines the most important feature of the Mogoung district, occur in a semi-circular valley in the vicinity of a hill, 25 miles to the south-west of Meinkhoon." This is of course absolutely wrong, and it is unintelligible how in the face of the clear and distinct description of the situation of the mines and the Hukong valley respectively, Dr. Anderson could have made such a mistake. No wonder that the Jade and Amber mines have hitherto been mixed up in a curious sort of a way, in fact so much so, that hardly any body knew which was which.

2. SITUATION OF THE JADEITE-MINES.

There are at present two groups of mines; the quarry-mines on the top of the hill near the village of Tawmaw, and the river mines in the valley of the Uru river, beginning near Sanka village, and extending for several miles down stream. The geographical position of Tawmaw is Lat. 25° 44'; Long. 96° 14'. Sanka lies about 6 miles towards east.

According to all accounts the river-mines are the oldest, the quarry-mines having been discovered only about 15 years ago. It may be safely said that up to a few years ago most of the jadeite was extracted from the river-mines which extend for about 15 to 20 miles along the bank of the Uru between Sanka and Tawmaw village.

The mines are easily accessible, as very good communication exists during the dry season between Sanka and Kamaing, the latter of which can easily be reached by water from Mogoung. An excellent road exists between Tawmaw and Sanka.

3. GEOLOGICAL SKETCH OF THE JADEITE-MINES.

The country being densely covered with jungle, only the very outlines of the geological constitution of the country west of the Irrawaddi at Lat. 25° 3' can be given.

a.—Sub-metamorphic Shales.

The sub-metamorphic shales, which are found along the Irrawaddi, extend to some distance towards west of Mogoung; in fact the western boundary seems

[1] Yule, Narrative of the Mission to the Court of Ava, London, 1858, page 146.
[2] Report on the expedition to Western Yunan, Bhamo, *viâ* Calcutta, 1871, pay 66.

to be somewhere near the place where the Mogoung river suddenly turns at a right angle from its hitherto southern course, towards east. Near Yinbat, half way between Sinbu and Mogoung, quartzites and quartzite-shales of reddish colour were found; strike north-west, to south-east, dip 85° towards east. Further towards west, near Mogoung, argillaceous red shales will be noticed. No clear section could be observed between Mogoung and the place where the river takes the northern turn, but it may be fairly assumed that the same sub-metamorphic shales prevail, because they appear again on the left bank of the river for a distance of about five miles north of the river bend.

b.—Crystalline Limestone of Silurian (?) age.

On the left (western) bank of the Endawgyi-stream, appear white crystalline limestones which are lithologically exactly the same as those found east of the Irrawaddi; they contain in fact the same accessory minerals. The rumour that rubies have been found near Nanyazeik, has therefore probably some foundation. I consider these crystalline limestones as metamorphosed silurian: west of Nanyazeik the limestone can be seen in its original state, but how far it extends towards west is difficult to say, because the dense jungle nearly hides every trace of the strata, though it is unlikely that they extend beyond Nan-tein choung.

c.—Miocene Strata.

The tertiary strata chiefly consist of yellow sandstones, grey and blue clays; no fossils have hitherto been discovered: but their whole appearance is exactly that of the Upper Miocene, as observed further towards south.

For the first time, they are noticeable west of the Mogoung stream, just opposite the place where on the left bank the sub-metamorphic shales crop out; from which they are undoubtedly separated by a fault, along which the Mogoung stream and the Endawgyi-choung are entirely in tertiary sandstones, which contain here a few coal seams: the best outcrops are exposed in the ravine of the N'saungka-choung, a small feeder of the Mogoung stream, which it joins just above the turn towards north.

The broad valley of the Endawgyi-choung limits this tract towards west, and as the crystalline limestones are found on its western side, we must suppose that another fault runs in the direction of the Endawgyi valley. Tertiary sandstones abruptly appear again west of Nan-tein-Moung and can be traced beyond Tawmaw torwards west.

d.—Eruptive rocks.

The tertiary strata are pierced by dark eruptive rocks, which very much resemble serpentine in outward appearance; the first place where they can be observed lies about four miles east of Sanka, the other one five miles to the west of that village, near Tawmaw. At the first locality, the rock is more like basalt, but at Tawmaw it has the appearance of serpentine.

The locality at Tawmaw is of particular interest, because the question of the geological age of the jadeite was solved here. Although the country is very unfavourable for any kind of geological examination, yet the active digging, that has been going on for some time, has afforded a very good opportunity for the study of the occurrence of jadeite. The dark rock, which for the purpose of this paper we may call serpentine, appears in a fissure of considerable thickness; but apparently of limited length. There is, however, a strange division in this eruptive rock: while the dark green serpentine forms the outer circle, the centre consists of a rock of splendid whiteness, the jadeite in fact, which strangely contrasts by its whiteness with the dark dull serpentine. Jadeite and serpentine are, however, not in direct contact, but separated by a band of clayey soft serpentine of light green colour. This curious mode of occurrence raises of course all sorts of geological questions about the origin of the jadeite, but all such speculations are useless, until the relation of the serpentine and the jadeite has been settled by a chemical and microscopical examination. Two facts are, however, certain:—

1. Jadeite is found in connection with, and enclosed in an eruptive rock closely resembling serpentine.
2. This serpentine pierces strata of perhaps lower, but more probably of upper miocene age.

These two facts have a double interest, scientifically as well as practically; scientifically, because it is now proved that jadeite belongs to a group of eruptive rocks of young tertiary age; practically, because there are indications that serpentine will be found at more than one locality in this part of Upper Burma. Now, as we know in the present case that jadeite is intimately connected with serpentine, it is highly probable that it will be found at other places, where serpentine occurs, once the outer shell of serpentine has been broken into.

4.—METHOD OF EXTRACTION.

Formerly jadeite was only extracted from the mines situated in the Uru valley; here it was found in the shape of boulders, mixed with other rocks in the alluvial deposits of the river; not unfrequently isolated boulders are found imbedded in laterite. Such pieces are particularly appreciated not only because the stone is always sound, but on account of the peculiar red crust, which envelopes a core of ordinary jadeite. This red-jadeite was very likely formed under the influence of ferruginous solutions, percolating the laterite and permeating the outer part of the boulders therein deposited.

The boulders are obtained either by digging holes along the bank of the stream or by diving to its bottom. The boulders brought to the surface are at once broken, and the jadeite separated from the useless stuff. Formerly the diving was carried out by specially trained men, but recently an enterprising Chinaman has introduced a diving bell, which will facilitate the work.

Some years ago the mines near Tawmaw were discovered by the Kachins, in what way, I am unable to say. In a short time most active digging operations were carried out at this place, giving employment to about 700 labourers during the dry season. When I visited Tawmaw in March 1892, there existed a large quarry of about 100 yards in length divided into two pits, which were separated by a wall of refuse. The western pit was deeper than the eastern one, but considerable difficulty was experienced on account of a large influx of water which oozed out from the fissure separating the serpentine from the jadeite. To cope with the water, the natives had constructed clumsy pumping machines, consisting of a large lever to which long bamboos tied together were fastened; a bucket, usually an empty kerosine oil tin, served for bringing up the water. The bucket was lowered to the bottom of the pit and when filled hauled up and emptied in a gutter resting on an elaborate bamboo structure, which nearly covered the whole pit. It is a quaint sight to see these numerous pumps at work, as it looks as if the whole pit were covered with an enormous spider's web, being in constant motion.

The extraction of the jadeite is as primitive, as it is slow and destructive to the stone. Blasting powder being either not allowed, or more probably too expensive, the surface of the rock is heated by large fires, the fall of the temperature during the night being sufficient to crack the rock without pouring water over it. By inserting iron crowbars and wedges into the cracks, large blocks are obtained, which are broken by means of big mallets in order to reduce them to lumps, conveniently shaped for transport. It is intelligible that this crude way of extraction, damages the stone more or less; jadeite from the alluvial deposits is therefore still much more appreciated than that from the quarry mines.

The diggers were very reluctant to give any information about the mines, but as far as I could ascertain, the Kensi Tsawbwa claims the property of the mines: at any rate he receives a royalty on all jadeite exported, which amounts sometimes to half a lakh of rupees a year. There is always one of his subordinate officers present at Tawmaw during the working season, who superintends the digging operations, collects the royalty, and sees that the claims allotted to each digger are properly measured out. It seems that any Kachin can get a digging lease from the Tsawbwa on payment of a small fee: all the jadeite he then extracts is his own property which he is free to dispose of as advantageously as he can, the buyer paying the royalty. There is, however, an additional condition that if a very valuable stone is found, half of the price the seller receives, goes to the Tsawbwa.

5.—THE VALUE OF JADEITE AS AN ARTICLE OF COMMERCE, AND THE FUTURE PROSPECTS OF THE JADEITE MINES.

Jadeite is one of the curious instances of an article which is highly appreciated by certain people, who pay in fact fancy prices for good specimens, while other people look at it with indifference, and would not pay as many pies as the first have paid rupees for one and the same specimen. Burmans, but particularly the Chinese, value a good piece of jadeite as much as gold if not more: for instance, a small piece of jadeite, just big enough to fit into a signet ring, fetches 400 to 500 rupees, but if sold in Europe the same piece would not fetch anything, if it could be sold at all. Although there is no market for jadeite outside Burma and China, it must be remembered that the population of these countries amounts to not less than 450 millions, ready to buy any quantity of jadeite that is produced.

Any how, whatever may be the value of it as an article of commerce, one thing is certain, there is a nearly inexhaustible quantity of this mineral available. This does not of course refer to the jadeite found in the alluvial deposits, but to the mineral *in situ*, as found near Tawmaw. If systematic mining operations could be carried out, if dynamite could be substituted for the crude method of breaking the rock by fire, if one instead of hundreds, would conduct the work, the output would be enormous. But shall we ever see the spectacle of a European Company exploiting the wealth of the jadeite-mines, instead of a disorderly crowd of Kachin-ruffians?

I am afraid not, because the difficulties to be overcome will eventually prove too great, unless they are disposed of with a little high-handedness. Otherwise, I am afraid that the revenue of a concern, capable of paying a handsome sum every year, will dwindle down to a mere nothing.

On *the* Occurrence *of* Burmite, *a new* Fossil Resin *from* Upper Burma: by Dr. Fritz Noetling, *Palæontologist, Geological Survey of India.*

I have to begin this note with the explanatory remark why, instead of the time-honoured name of "Amber," under which the fossil resin of Burma has been known for centuries, I introduce a new name. The reason is, that the preliminary chemical examination has shown that the Burmese amber is totally different from any other known fossil resin, especially from that generally known as amber (Succinite), however similar their outward appearance may be, and I am greatly indebted for this information to Dr. Otto Helm in Danzig who, being a specialist in fossil resins, has kindly consented to undertake the chemical examination of this variety from Burma. His preliminary note on this *new resin* was published in the last part of the Records XXV, page 180. There is, however, no reason why for all practical purposes the name "amber" should not be used, although this term would be inadmissible in a scientific paper, once the fact has been established that the fossil resin in question is different from Succinite. In concordance with Dr. Helm's suggestion, the name of Burmite is adopted for thenew fossil resin.

1. HISTORICAL SUMMARY.

The fact that Burmite is found in a country difficult of access, jealously guarded by those who have every interest that the exact place may be kept dark, lest they should lose the substantial profit they have hitherto enjoyed, accounts for the scanty data about its occurrence. In fact it seems that previous to the expedition of 1891-92, only two Europeans have visited the locality where it is found, and curious to say these two, Captain Hannay and Dr. Griffith, followed each other within one year's time. As no later record can be found proving that anyone else had visited the amber-mines afterwards, we must suppose that all the information on this mineral, contained in numerous descriptions of Burma, may ultimately be traced back to the references just mentioned. It will therefore be useful to give them *in extenso.*

Captain Hannay visited Maingkhwan, and from there the amber-mines in March 1836. An abstract of his journal of a route from Ava to the amber-mines of the Hukong valley was published in the Journal of the Asiatic Society of Bengal, Vol. VI. p. 274, 1837. The following is his description:—

"We set out at 8 o'clock in the morning and returned at 2. P.M. To the foot of the hills the direction is about south 25 west, and the distance three miles, the last mile being through a thick grass jungle, after which there is an ascent of one hundred feet, where there is a sort of a temple, at which the natives, on visiting the mines, make offerings to the ngats or spirits. About a hundred yards from this place, the marks of pits where amber has been formerly dug, are visible, but this side of the hill is now deserted, and we proceeded three miles further on to the place where the people are now employed in digging, and where the amber is most plentiful. The last three miles of our road led through a dense small tree jungle, and the pits and holes were so numerous that it was with difficulty we got on. The whole tract is a succession of small hillocks, the highest of which rise abruptly to the height of 50 feet, and amongst various shrubs which cover these hillocks, the tea-plant is very plentiful. The soil throughout is a reddish and yellow-coloured clay, and the earth in those pits, which had been for some time exposed to the air, had a smell of coal tar; whilst in those which had been recently opened, the soil had a fine aromatic smell. The pits vary from six to fifteen feet in depth, being, generally speaking, three feet square, and the soil is so stiff that it does not require propping up.

"I have no doubt that my being accompanied by several Burmese officers, caused the people to secrete all the good amber they had found. For although they were at work in ten pits, I did not see a piece of amber worth having. * * * On making inquiry regarding the cause of the alleged scarcity of amber, I was told that, want of people to dig for it was the principal cause; but I should think the inefficiency of the tools they use was the most plausible reason:--their only implements being a bamboo sharpened at one end, and a small wooden shovel.

"The most favourable spots for digging are on such spaces on the sides of the small hillocks as are free from jungle, and I am told that the deeper the pits are dug, the finer the amber; and that that kind which is of a bright pale yellow, is only got at the depth of 40 feet under ground."

A little previous to the above (p. 270), it is stated, that "besides the amber which is found in the Payen toung, or amber mine hills, there is another place on the east side of the valley called *Kotah-bhum*, where it exists in great quantities, but I am informed that the spot is considered sacred by the Singphos, who will not allow the amber to be taken away, although it is of inferior description."

The following is Dr. Griffith's description of the amber-mines published in "Journals of Travels in Assam, Burma, etc., by William Griffith, Calcutta, Bishop's College, 1847, page 77:—

"March 26th.—Visited the amber mines, which are situated on a range of low hills, perhaps 150 feet above the plain of Meinkhoon, from which they bear S. W. The distance of the pits now worked is about six miles, of which three are passed in traversing the plain, and three in the low hills which it is requisite to cross. These are thickly covered with tree jungle. The first pits, which are old, occur about one mile within the hills. Those now worked occupy the brow of a low hill, and on this spot they are very numerous; the pits are square, about four feet in diameter, and of very variable depth; steps, or rather holes, are cut in two of the faces of the square by which the workmen ascend and descend. The instruments used are wooden tipped (?) with iron crowbars, by which the soil is displaced; this answers but very imperfectly for a pickaxe: small wooden shovels, baskets for carrying up the soil, etc., buckets of bark to draw up the water, bamboos, the base of the rhizoma, forming a hook for drawing up the baskets, and the Madras lever for drawing up heavy loads.

"The soil throughout the upper portion, and indeed for a depth of 15 to 20 feet, is red and clayish, and appears to inclose but small pieces of lignite; the remainder consists of greyish slate clay increasing in density as the pits do in depth: in this occur strata of lignite very imperfectly formed, which gives the grey mineral a slaty fracture, and among this the amber is found. The deepest pit was about 40 feet, and the workmen had then come to water. All the amber I saw, except a few pieces, occurred as very small irregular deposits, and in no great abundance. The searching occupies but little time as they look only among the lignite, which is at once obvious. No precautions are taken to prevent accidents from the falling in of the sides of the pits, which are in many places very close to each other (within two feet): but the soil is very tenacious.

"We could not obtain any fine specimens, indeed at first the workmen denied having any at all, and told Mr. B. that they had been working for six years without success. They appear to have no index to favourable spots, but having once found a good pit they of course dig as many as possible as near and close together as they can. The most numerous occur at the highest part of the hills now worked. The article is much prized for ornaments by the Chinese and Singhpos, but is never of much value; five rupees being a good price for a first-rate pair of earrings. Meinkhoon is visited by parties of Chinese for the purpose of procuring this article."

These two accounts agree so well that it is unquestionable that Dr. Griffith and Captain Hannay visited the same locality, *viz.*, a low hill to the south-west of Maingkhwan, as the name of the village is spelt now. The most remarkable fact' however, is that both were exceedingly surprised at the scarcity of amber, for which both try to find an explanation. I want particularly to draw attention to this fact, as I noticed a similar small output: I shall however deal with this subject later on.

2. THE HUKONG BASIN AND THE SITUATION OF THE BURMITE-MINES.

The Hukong valley forms an extensive flat basin, which is surrounded on three sides by nearly impracticable hill-ranges rising to something like 7,000 feet in the Patkoi-range; it is only from the south that this secluded valley is accessible, where the low hills forming the watershed between the Chindwin and the Irrawaddi are easily surmounted. This broad basin is intersected by innumerable streams and rivulets, running down towards the centre from all sides. Here they join, to form the Tanaika-choung, the chief branch of the Chindwin. The Hukong valley represents in fact the headwaters of the Chindwin. It need hardly be mentioned that a country which has such an abundant supply of water nearly all the year round, besides a well-regulated drainage, is extremely fertile and therefore dotted with villages.

The centre of the Hukong valley is flat, but towards the outskirts low isolated hills and short hill-ranges suddenly rise from the surrounding plains. It is on one of these ranges, in the south-west corner of the Hukong basin, where the mines famous for centuries for the golden resin are situated. According to the recent survey their position has been fixed at Lat. 26° 15'; Long. 90° 30'. According to Colonel Yule's map, which is undoubtedly based on either Captain Hannay or Dr Griffith's authority, the geographical position of the mines is Lat. 26° 10'; Long. 96° This agrees so well with the position as recently fixed, that there can be no further doubt as to the identity of the mines.

It seems important to me, for reasons which will appear later on, to have proved that Captain Hannay, Dr. Griffith and myself have visited one and the same locality.

The mines which I examined are situated on a low hill-range of approximately five miles in length, bearing nearly north-south, which has apparently no particular name, although there are nine localities distinguished by different names where burmite has been found or is said to have been found. All these localities are, however, situated on the same range and so close to each other that it is quite apparent that they are merely local names. The particular place where I was led to, and where I stayed for nearly a fortnight, is called Nango-tai-maw, on the northern end of the range, and nearest to Maingkhwan; the distance is about three miles in a straight line, but, with the twisting and turning of the road, it is as good as six miles.

Nangotaimaw, as we may call the hill-range for the sake of brevity, rises rather abruptly from the plains, although the height is not considerable, 150 feet at the outside. The top being nearly in one level throughout, it seems probable that it once formed part of a terrace skirting the higher ranges. It is covered with dense nearly impenetrable jungle, which renders a geological examination almost impossible, unless extensive clearings are carried out; as it is, I only could get glimpses of the strata now and then in the steep narrow gullies.

There is, however, a rumour current, particularly among the Chinese traders, that the chief mines are at the southern end of the range. near Laloung village. I was unable to verify this statement, because the column, although visiting Laloung, did not stay to examine the hill to the rear of Laloung, where the mines are supposed to be. I must, however, confess that I fully believe in the truth of this rumour, as it seems impossible that the large quantities of burmite, which have unquestionably been obtained from the mines in the Hukong valley, could only have been extracted from the place which Captain Hannay, Dr. Griffith and myself visited.

3. GEOLOGY OF THE HUKONG BASIN.

As far as I could ascertain, the strata which compose the hills to the west, south and east belong to the Tertiary formation; whether all throughout or only partly is impossible to say for the present, but those hills directly bordering the plains are certainly of Tertiary age. It is highly probable that the hills on the north are also of Tertiary age, although an ammonite found in a pebble, which cannot possibly have come from anywhere else but the hills to the north, tends to prove that there also exist strata of Mesozoic age, probably belonging to the cretaceous formation.

The Tertiary strata consist chiefly of sandstones of yellowish colour with a layer of brown clay now and then imbedded. Blue clay resembling very much in appearance certain beds in the Chindwin group has so far only been found west of Maingkhwan. No fossils have been found, but to judge from the petrographical appearance, I should think that the yellow sandstones which I found on the southern and western side of the valley are contemporaneous with those which I distinguished as Irrawaddi-sandstone in the Irrawaddi basin; these belong undoubtedly to the upper miocene. I am less certain, as regards the age of the blue clay because it has not been found in direct connection with the yellow sandstone, but I rather think it to be of lower miocene age.

Nangotaimaw consists throughout of a blue, more or less hard clay, dipping at a high angle (88°) towards west. The strike is south-south-east to north-north-west, a direction which nearly agrees with the axis of the hill. Although I carefully looked for, I could not discover any fossils in the blue clay; there is, however, no doubt as to the Tertiary age; the only question would be whether it belongs to the group of the Irrawaddi-sandstone or to the Chindwin-sandstone. As already said, its whole appearance is so very much like that of the blue clays of the Chindwin group that I think the clay of Nangotaimaw is equivalent to them.

By fixing the position of the pits as well as I could in the dense jungle, I found that they are mostly situated in the central part of the range; that is to say, there are none on the eastern, and very few on the western slope. Now, considering the strike of the strata, we must suppose that the bed which contains the burmite, traverses Nangotaimaw from north to south in its centre. This renders the probability of burmite mines near Laloung very likely.

It is unfortunate that no characteristics can be given for the present which might lead to the discovery of burmite-producing localities somewhere else. There is, however, no doubt that the burmite-bearing strata once possessed a larger extension; a very careful examination of the Hukong basin, particularly along its outskirts, might lead to the discovery of some other burmite-bearing localities. Concerning this, I especiallv want to direct the attention of would-be-explorers to the northern side of the Hukong basin, along the foot of the Patkoi range, particularly those spurs which fall into the line of Nangotaimaw, if continued towards north.

The blue clay is superficially discoloured, and changed into a dull-brown clay, lying in the shape of a cover of varying thickness on the top of the first. This change is apparently due to the oxydising influence of organic acids, produced by a luxurious vegetation. Burmite found in these parts, is strongly affected by the same causes; it loses its colour, becomes dull and brittle, while a crust of decomposed burmite is formed, which often enough envelopes only a small kernel of sound mineral.

Although my operations could only be carried out on a limited scale, I could establish the fact that burmite occurs in pockets irregularly distributed in the stratum above mentioned. This was not only proved by actual observation, but the arrangement of the old pits in clusters must necessarily lead to this supposition. The pockets vary in size of course, and the bigger the pocket the larger the output. Burmite is usually found in flat pieces resembling very much in appearance the pebbles found along the sea beach, proving that they must have undergone a certain amount of wear and tear before they were deposited at their present resting-place.

4. PHYSICAL AND CHEMICAL QUALITIES.

It is not advisable to anticipate Dr. Helm's chemical examinations to be carried out on a large scale on receipt of more material which has recently been forwarded to him. His views will be found in his preliminary note; the chief interest rests with the fact that burmite does not contain succinic acid, like amber, from which it is therefore chemically totally different, although the physical appearance of the two fossil resins is very much the same.

As regards the physical qualities of burmite, it may be said that it is a little harder than amber, its hardness being $2\frac{1}{2}$ to 3; it is easily cut and takes an excellent polish, qualities for which it has been highly appreciated by the natives as well as by the Chinese.

The specific gravity is 1,033 to 1,042; the heavior varieties containing generally all sorts of inclusions, amongst which thin films of calcspar are not at all uncommon; specimens of perfectly clear color and without any inclusions have a specific gravity of 1·033 to 1·034.

So far as can be judged for the present, burmite shows less variety in colour than amber; in fact there are only three shades of one color. The original color is a bright pale yellow, which might be best compared with the color of light sherry; darker shades eventually lead to a reddish color which turns into a dirty brown in the majority of pieces; the last might be best compared with colophony or better solidified petroleum. I never saw any specimens exhibiting the fine cloudy milk-white color for which amber proper is so highly appreciated, but there are several specimens of the quality known to the German amber dealers as "bone" with which as regards appearance it can in fact be best compared. One specimen of this kind is particularly interesting, inasmuch as it shows a core of perfectly clear resin enveloped in a thick crust of bone: whether this peculiarity is due to the absorption of water, will be shown by the analysis; the bone shows again two varieties, the inner one being of yellowish white exhibits a splintery fracture, while the outer one has a light brown, streaky color and a smooth fracture.

Burmite is particularly remarkable for its strong fluorescence, that is to say a bluish tinge, which appears when light enters it at a certain angle; according to Dr. Helm the darker varieties contain a lot of organic matter, probably minute fibres of wood; others contain films of calcspar, of sometimes considerable thickness; in one case it had 6 mm. thickness near the surface, but thinned quickly out towards the centre. It is very probable that these layers were originally cracks forming in the drying resin which were eventually filled in with the calcspar when the pieces were deposited in the clay in which they are now found. As this peculiarity is very common, it is clear that it must seriously influence the value of the burmite as an article of commerce; because no large pieces for working purposes can be cut off from a mineral thus cracked in every direction.

A few insects have been found enclosed in burmite.

5. Mode of extraction.

Burmite is obtained in a very primitive way: after the harvest, those who feel inclined to dig for the valuable resin, set out for the place where it is known to be found. In selecting the place the digger is not guided by any principles or by any experience, besides the general knowledge that he might get the mineral at the place where he digs. All he does is to keep clear from places where numerous old pits indicate that somebody else has already made a big haul. Frequently enough the digger finds himself disappointed although his pit has reached a considerable depth, as no burmite is found. He then tries another place, perhaps with better luck this time. Of course the result of this wild digging is that the whole hill is covered with pits in all states of dilapidation.

The digger does not require any other tools but his *da* (sword), without which no Kachin can be imagined. With his *da* he shapes his tools; a small, pointed wooden hoe, a wooden shovel, and a basket made of split bamboo; a long bamboo cane, with its curved root still affixed, serves for drawing up the earth; sometimes if the digger can afford it, the hoe is supplied with an iron shoe.

The work of digging is very simple; the clay is loosened with the hoe and the refuse removed by means of the basket and bamboo-cane and thus the shaft is deepened, till a pocket of burmite is reached. The shaft is square and generally just wide enough to allow one man to do the digging; the digger descends and ascends by means of small niches cut into opposite sides. No timber lining is required, because the stiff clay stands without caving in. The pits are very shallow: I never found one exceeding 45 feet in depth; in fact if at that depth nothing is found the pit is abandoned. Three men generally form a party; and while two of them sit smoking at the mouth of the pit, now and then hauling up the baskets filled with earth, the third man works in the pit for about three hours, when places are changed. Progress is of course very slow; the presence of pockets is generally indicated by strings of coaly matter appearing in the clay. If the pocket is too large to be exploited from one pit, a second or third, or as many as are required, are sunk closely to the first pit, and by joining hands underneath, the whole pocket is cleared out. A cluster of old pits indicates therefore the place of a successful digging.

No information could be obtained regarding the annual output, but to judge from the considerable quantity that has certainly been exported, it must have been important in former years. I have seen large bags full of burmite at the houses of the Burmese cutters in Mandalay, which have unquestionably come from Mogoung.

Now the question arises, has this large quantity been obtained from the locality that has been visited by Captain Hannay, Dr. Griffith and myself, or has it been obtained from elsewhere? As I have already pointed out, there is not the slightest doubt that we three have visited one and the same locality, *viz.*, Nangotaimaw-hill. Captain Hannay as well as Dr. Griffith complain of the scarcity of the fossil resin, for which they try to find an explanation. Now I dare say that I did not only stay longer at the mines, but that I worked under more favourable circumstances: I encamped for about a fortnight at Nangotaimaw, I employed about twelve coolies at the time, and I had some twelve pits dug at various places, but the quantity obtained was next to *nil.* Small fragments of absolutely no commercial value were all I discovered; they were sufficient, of course, to prove that burmite can be found at this locality, but they were too insignificant to pay even for the labour. Now it seems convincing that when three different observers record the same fact, burmite must really be very rare at Nangotaimaw; but on the other hand, it is an established fact that large quantities of burmite have been exported from mines situated in the Hukong valley. How can these two facts be brought in concordance? I must confess that this problem has puzzled me for a long time without finding a satisfactory solution of it. All I can say is that the only way to get out of the difficulty is to accept the theory of the existence of richer mines somewhere in the Hukong valley, unless one supposes that the large quantities of the mineral, which have been exported to China and Mandalay, represent the accumulated production of scores of years. I personally feel inclined to think that there are richer mines in existence in the Hukong valley, and the information I received from Chinese traders at the jadeite-mines seem to confirm this view.

6. FUTURE PROSPECTS OF THE BURMITE-MINES.

After the foregoing it seems hazardous to venture an opinion on the probable prospects of the burmite-mines, but although nothing definite is known about the probable quantity of the output, yet certain facts may now be considered as established, which are sufficient to form a general idea as to the value of the mines. Supposing that there are really mines, which are capable of turning out a large production, so that there would be no doubt as to the quantity, if mining operations were carried out in a systematic way: is the material obtained of such quality that it will pay the investment of capital? This question may be safely answered with no, for the following reasons. Burmite possesses the following good and bad qualities:—

(*a*) Good qualities:—1. Hardness:
2. Easy to cut, and polish.
3. Indifference towards solvents.

(*b*) Bad qualities:—1. Color inferior to that of amber.
2. Presence of fissures filled with calcspar, which render even large pieces unfit for cutting.

Of the above five qualities we have of course only to take those under (*b*) into consideration. Now as regards (*b*) 1, it is of less importance, because the fashion may change, and clear colors may come to the front again, although it is not very likely that the disagreeable bluish tinge of burmite will be fancied. But supposing there were a large demand for the mineral, the peculiarity mentioned under (*b*) 2 would prevent its general use; in fact I consider this quality as the most important disadvantage.

It may therefore confidently be said that the bad qualities of burmite so greatly surpass its good ones that it will always be inferior to amber. It is therefore not likely that burmite will ever be a serious competitor of amber in the markets of the world: it is even improbable that it will cut out the inferior kinds of amber, because a process was invented some years ago, by means of which small pieces of amber can be cemented into one big lump. This artificially manufactured amber greatly resembles burmite in its appearance even up to the bluish tinge; large quantities of this artificial product could be turned out and sold for a mere trifle, if burmite should ever appear on the market and endanger the monopoly of amber.

The beginning of this struggle is already noticeable; up to about two years ago burmite was largely used by the Mandalay cutters. When inquiring for burmite in Mandalay in April last, I hardly could get a single piece; "Indian" amber being in competition with the indigenous material! The Indian amber proved to be Prussian amber (succinite); and this amber imported from Europe, after having travelled so many thousands of miles, was sold at a cheaper rate in Mandalay than the product of the country. The cutters further stated that the Indian amber is ever so much more satisfactory for cutting purposes than the Burmese amber.

Matters look therefore serious: if burmite is already being cut out from the limited market which it hitherto commanded, *viz.*, Burma and China; and once being replaced by the cheaper and better amber, it will hardly retake the ground once lost.

It may therefore be safely stated that although burmite will never answer the high expectations which have been entertained about it, it is still good enough to form a profitable article of commerce, provided necessary steps are taken to ascertain whether it really occurs in large quantity. This can of course only be tested by prospecting operations carried out on a large scale. Such operations cannot be strongly enough recommended, even if the result should be contrary to the expectations; in this case we know, however, for a certainty that the quantity available is insignificant, and taking the inferior quality into consideration, it would be conclusively proved that the exploitation of the burmite-mines would not pay.

7. THE NATIVE BURMITE INDUSTRY.

Burmite has been largely used for centuries by the Burmans, and quite an industry for cutting and polishing the raw stone existed in Mandalay, and probably also in the former capital of Burma. The cutters chiefly manufactured beads for rosaries, as used by the religious Burman, nadoungs (cylindrical pieces worn in the hole perforating the lobe of the ear), besides various small trinkets, such as elephants, monkeys, fish, etc. etc. More elaborately and costly, were figures of Gautama, but these have become very scarce now, as there are only two men living at present who understand the art of cutting such figures.

Burmite was rather cheap about three years ago; one viss (3·65lbs.) sold for R25, but the price has considerably risen since, as there were hardly any fresh supplies coming in, owing to the political disturbance in the northern part of Burma.

The manufacture of beads, which chiefly occupies the cutters, is very simple. With a sharp knife the labourer cuts a piece of burmite in small cubes of about 10mm. side-length; these are roughly shaped by cutting off the corners, thus a bead in the shape of two cones united with their basis is produced. The drill which is used for boring the hole, consists of a thin bamboo into which a flat-edged needle is fitted. When drilling the hole the labourer catches the bead with his right hand, presses it against the needle which he sets moving with his left. After being perforated, the bead is smoothened with a file, which is a little curved at the upper end; the polish is produced by rubbing it with a dried leaf, which contains a considerable quantity of silica, and lastly petrified wood is applied to finish the polishing process.

8. THE OCCURRENCE OF FOSSIL RESIN IN OTHER PARTS OF BURMA.

Besides Nangotaimaw, fossil resins similar to burmite have been found at two other localities. At neither place, however, is there a sufficient quantity to be of commercial value.

The first place where I discovered a fossil, amber-like resin, is Mantha on the Irrawaddi; about Lat. 23° Long. 96° in the Shwebo district. Here the resin is found imbedded in a hard coaly clay, which underlies a coal seam. If I am not greatly mistaken this locality falls now within the property of the Burma Coal Mining Company. The strata in which the coal and fossil resin are found belong undoubtedly to the miocene formation. The resin is very common, but the pieces are small and difficult to extract, not only because they are very brittle, but also because the clay is rather hard. In appearance the Mantha-resin looks like burmite, perhaps it is a little darker; the specific gravity, 1·037, being nearly the same.

The second locality, where I found a single small piece of fossil resin of the amber type, is Yenangyat in the Pakoko district; about Lat. 21° Long. 95°. Here I found it among the refuse dug from an old petroleum pit, together with numerous miocene fossils of marine type: although I looked for more I never found another piece, and so far it has remained solitary.

From the foregoing we may conclude that fossil resin of the burmite type is widely distributed through the Tertiary strata of probably lower miocene in Upper Burma. It is therefore not improbable that it will be discovered at other localities in the same geological horizon, but whether in workable quantities seems more than doubtful.

Report *on the* Prospecting Operations, Mergui District, 1891-92. By T. W. H. Hughes, A. R. S. M., F. G. S., *Superintendent, Geological Survey of India.*

In submitting this season's report on the Mergui district, it will be seen that the work has not, as in previous years, been confined to tin, but an exploration of the coal and gold deposits within the area covered by our parties has been carried on.

The main object of my delegation has been fulfilled. I was instructed to ascertain by practical tests and thorough examination, whether the tin deposits were really of such value as to render expenditure on their development and special arrangements for their control advisable.

To this I can now return an affirmative answer, and I feel assured that they are sufficiently large and accessible to prove remunerative under economical management.

The probability of this was foreshadowed in previous reports. There is no doubt now that the stanniferous deposits range over a considerable extent of country; and there is every reason to hope, from the general geological structure of the peninsula, that as these wilds are gradually opened up, further paying deposits will be found both north and east of the ground we have already prospected.

Field operations—Mr. Ross Clunis, etc.

Field operations have been carried on under the care of two officers, Mr. Ross Clunis and Mr. Alexander Primrose, with whom where associated two practical tin-miners from the Duke of Cornwall's Regiment stationed at Mandalay. The experiment of employing men of good conduct, and specially of sober habits, has, in the present instance, proved a great success. There is nothing new in this venture of engaging the services of miners who have enlisted in the army, as several at various times were appointed to the Government collieries of Warora and Umaria, and gave satisfaction in all cases where sobriety was insisted on.

Soldiers as miners.

Gangsmen.

Our gangsmen, instead of being recruited in the Straits, were procured in part locally and in part imported from India, those with Mr. Ross Clunis being Burmans, Chinese, Malays, and Siamese of the Mergui district, and those with Mr. Primrose, Indians from the

Hazaribagh district. The Chinese were found troublesome to deal with, their clannishness and passive obstructiveness being most irritating. Taking all things into consideration, that is, wages and amenability, the Indian coolies were far and away the better bargain.

Thibawleik, good prospects.

Mr. Ross Clunis, to whom I will first allude as having been one of our prospectors of last season, gives in his report the details of his work. He found little to add to our former knowledge of the capabilities of the Maliwun township, but he speaks warmly of the value of the tin deposits in the upper valleys of the Thibawleik stream and its tributaries, and although time did not permit him to locate the actual reefs whence the tin is derived, he sufficiently demonstrates that the source is in the range of hills separating the main Thibawleik stream from the second feeder on the left bank above the Thibawleik stream.

The extent of country traversed by each party was not great, but I wish it to be borne in mind that careful prospecting is in its very nature slow, and that, in such a district as Mergui, where the physical obstacles to progress are unintelligible except to those who have had experience of them, this wearisome quality acquires its most pronounced manifestation.

Great Tenasserim River Party.

Mr. Alexander Primrose was deputed to the charge of the Great Tenasserim River Party, and the most useful outcome of his season's work has been the discovery of further coal on the Great Tenasserim River. The existence of coal in the vicinity of Kawmapyin and the Hinlat river has been long known, and in Dr. Oldham's Report on the Coal-fields and Tin-stone deposits of the Tenasserim Provinces, published in 1856, a list of the outcrops with which he was acquainted is given and the above two localities are alluded to.

Coal in the Htiphanko stream.

I thought it advisable to re-open the investigation of the coal, and Mr. Primrose was directed to carry out the operations necessary for securing information of a practical nature. This he has done thoroughly, the site selected for a trial sinking being on a seam that shows in the Htiphanko stream, a tributary on the right bank of the Great Tenasserim River and not far from the village of Kawmapyin.

Two shallow pits were put down, and the section of the seam was found to be, descending:—

	Ft.	In.
Coal	0	10
Shale	2	0
Coal	2	3
Shale	3	0
Coal	4	6
Total seam	12	7
Total coal	7	7

The quality of the coal constituting the 2 feet 3 inch band and is fairly good, but the real back of the seam is the lower portion, which consists of a hard, black, jetty coal, breaking in all directions with a conchoidal fracture, the surfaces invariably exhibiting a shining lustre. It does not soil the fingers, and in this respect differs from most of the Indian coals of younger age.

The result of analysis by Mr. Holland was—

Moisture	11·34
Volatile matter	36·40
Fixed carbon	43·27
Ash	8·99
Total	100·00

Sinters slightly; ash reddish brown.

Coal tested in Steam-launch *Mergui.*

Notwithstanding the large percentage of moisture, this is excellent coal compared with the ordinary run of Indian samples; and, as our tests in the Government steam-launch *Mergui* have proved, it is well adapted for those purposes for which coal is ordinarily used, there having been no difficulty with untrained firemen in raising and keeping 95 lbs. of steam on a long course. The coal had been stacked in open heaps at the mine, exposed to daily rain for two months, and further subjected to the wash of tidal water for a fortnight before an opportunity of verifying its worth occurred. And as the whole of it was really outcrop coal, we may accept the results of our trials in the launch and analysis in the laboratory as expressing its minimum valuation.

Quantity available.

As to the quantity available, I conclude from the observations of my predecessors and my own personal investigation that the coal extends from the Kyaukmithwè stream to the Htiphanko, a distance of 12 miles. This, with a thickness of 5 feet and a depth of 300 feetr will give, after making very large deductions under the head of waste, and also fo possible breaks in continuation, 1,000,000 tons for disposal. It is impossible to say that these figures are absolutely within the mark, but I have the credit of being cautious, and I am of opinion that we may rely on this amount of coal.

In considering the commercial value of the field, it has to be remembered that the locality in which it occurs is unfavourably situated for labour, transport and shipment, disabilities representing extra cost of coal at the sale terminus.

Labour.

In regard to labour, however, I think we have shown that Indian coolies could be employed with advantage as compared with Chinese or Siamese, and the probable charges for one ton of coal at the pit on an output of 10,000 tons a year would be—

	R	*a.*	*p.*
Labour	2	8	0
Stores	1	0	0
Establishment and supervision	1	0	0
Haulage and contingencies	1	0	0
Royalty	0	4	0
	5	12	0

I have allowed liberally under each item of the above estimate, and R5-12-0 may be accepted as a maximum outlay.

A market other than the local one must be found. Two exist—in Rangoon and Penang—in both of which there would be a large sale for a good steam coal at low rates.

Unfortunately Mergui lies well out of the main steamer routes, while, owing to the shallowness of the approaches, only vessels of somewhat limited draught and size could come in to take coal.

Should a demand for the coal spring up, it would probably prove the cheapest policy in the long run to build steamers specially for the trade.

The cost of transit from the coal-field to Mergui will, while the output is small, probably be R2 a ton, but when the despatch of coal justifies the employment of steam-lighters or shallow-draught tugs, I am of opinion that R1-8-0 a ton will meet all expenses.

It has been suggested that it might in the long run prove most economical to lay a steam tram line from the coal-field to staiths at the selected place of shipment. The nature of the country would not render the construction of such a tram line impracticable, but it would require a large output of coal to meet the interest on the capital required for so extensive a scheme.

There is one prospect, however, that should be kept in mind, and that is,that sooner or later a peninsular railway connecting Burma and the Straits must be an accomplished fact, and the problem of the accessibility of the coal-fields of the Tenasserim will be thus advanced a stage further.

As to my own estimate of the Tenasserim coal-field, I believe the coal it contains is excellent, that there is an abundance of it, and that the outside cost of placing it at Mergui would not exceed R7-12-0 a ton. Commercial men must make up their minds whether, all things considered, it can be worked at a profit, and I would strongly urge the advisability of thorough personal investigation by those who may be inclined to embark in mining operations before they commit themselves to an extravagant expenditure of money.

So far as the local Government is concerned, I think enough has been done in the way of prospecting. Attention has been again called to a field which was practically tested exactly fifty years ago, the analysis of a sample of the coal being—

	1842.	1892.
Volatile matter (inclusive of water)	48·1	47·74
Fixed carbon	45·4	43·27
Ash	6·5	8·99
Total	100·0	100·0

We have practically wrought the coal, and have practically demonstrated its steam-producing efficiency in a steamer. It should now be left to private enterprise to institute further action; and the only recommendation I would make is that the survey of the intervening country between the coal-field and the town of Mergui be completed. With a reliable map to consult, one grasps the geographical situation, and the country is no longer an enigma.

Reliable map wanted.

Mr. Primrose was not successful in indicating any areas of tin-ground that would pay to mine while present prices rule in the Home market, but he indicated localities near Tagu and Thendaw that might be taken up if a return to the rates of 1886 and 1887 ever occurred.

Tin.

Tin-grounds met on tour with Mr. Batten, Deputy Commissioner.

The same remark applies to country passed over by myself when on tour with Mr. Batten, the Deputy Commissioner of Mergui, in the northern part of the district near the head-waters of the Palaw river. But until some such stimulus again arises, I see no probability of any but the better known mining centres already alluded to in my former reports being worked.

Survey of India.

I have much pleasure in testifying to the good work that has been done by the Indian Survey party this season. Mr. Gibson's management has been most satisfactory, and Mr. Higgs has more than maintained his reputation for energy and action. He thoroughly deserves promotion, and, considering how much of the success and value of our own labours depended on the co-operation of the officers of the Suvey of India, I feel I should not be doing Mr. Higgs justice did I not specially mention his services.

Map of Maliwun tin-field.

A most useful sheet of the Maliwun tin-field on the 8-inch scale has been prepared. This shows an aggregate of 40 claims with their areas and boundaries. The sheet, which should be published, will form a valuable skeleton for future filling in and as a model for future surveys of contiguous claims.

Before concluding this report there are a few considerations bearing on the welfare of the mining industry of Mergui which should be borne in mind—

(1) *Special Officer from the Straits.*—This is a necessity which does not press so forcibly now that a proposal has been made by Messrs. Menzell and Ah Kwi to lease the Maliwun township, as they in their own interests will carry out the necessary measures that a Straits Officer appointed to the administration of the district would initiate. They will themselves introduce by degrees the capital and labour which is so urgently required to swell the revenue.

(2) *Labour Law* will have to be framed, as its existence will give confidence to the class of employers without whom nothing can be effected. The Perak Labour Law is before us to copy or to modify as may be suggested by those legislators who understand the requirements of the Mergui district under a Chinese irruption.

Fugitive coolies.

Further, the extradition of fugitive coolies will have to be considered, as our best tin-grounds adjoin the Siamese frontier. I understand that there would be no difficulty in effecting mutual arrangements with the Siamese Government for the arrest and surrender of fugitive coolies, as on all sides the necessity of such an arrangement is strongly urged.

The Rajah of Renong and his brother, the Governor of Trang, have both stated that without a Labour Law and some workable scheme as to extradition, investors will be shy of risking any large amount of capital in Maliwun.

(3) *Local Magistrates.*—The Perak model of one European Magistrate sitting with one or two Chinese assessors might be followed. The suitors prefer the presence of a European for obvious reasons, while the employment of Chinese assessors seems equally advisable.

(4) *Secret Societies.*—There is no need for me to dilate at length upon the admitted evils of these corporations. Their suppression or better regulation is a duty forced upon us by our responsibilities. Messrs. Batten and Merrifield, who have paid particular to the subject, advocate registration rather than suppression, for the present at all events. They are of opinion that ineffectual sub-

pression would only render the societies more secret, and consequently more mischievous in their operations, while registration would admit of some control.

(5) *Collection of mining revenue.*—I would suggest that District Officers should have the power to collect on tour, paying their collections into the nearest sub-treasuries. Ywathugyis should also be allowed to receive mining rents and a commission on them as in the case of land-revenue.

In recommending this I feel that the ywathugyis will have a personal and financial interest in mining matters, and the Chinese will be taught that they must subordinate themselves, whether they like it or not, to the local jurisdiction.

Administration.—It seems to me that, all things considered, it would probably be more advisable to leave the entire administration of the mines in the hands of the local Government and to instruct the district authorities to consider the development of the mines as an integral portion of their regular official programme, thus securing more efficiency at less expense than by creating an entirely new department out of touch with the local executive.

Furnaces.—As far as possible no smelting furnace should be permitted except at a guard or revenue post. If this is done there will be little or no difficulty in seeing that all the tin smelted pays royalty. At present, however, Maliwun is the only station in which matters are so arranged.

At Bokpyin, where there are two furnaces, neither is supervised by the guards; and the smelting works at Karathuri, Yengan, and Thibawleik are utterly uncontrolled.

Police or revenue peons might be sent down to those furnaces which are difficult of access, and where there is no police post, only at such times as smelting operations are to be carried on, and the same men might see the tin safely down to the nearest revenue station. What reliance can be placed on the honesty of such peons is a difficult matter to gauge, but we may rest assured that Government would be the gainer by laying itself open to the timorous venality of an Indian police sepoy rather than reposing trust in the distorted morality of a Chinese trader.

Lampan (*fossicking workings*).—My attention has been called to the very small areas taken up by some of the miners and the short periods for which they require leases. The fact is that the bulk of the miners are really working *lampan* rather than permanent mines. I am not in favour of lampan passes, and I would advocate that persons wanting to work small setts temporarily should have their areas defined and leases drawn just as in cases of occupation of larger areas for longer periods. Further, as the survey of small isolated patches must be expensive, I would place a minimum ground-rent of R5 on any sett or lease. "Fossicking," which only results in making a mess, is harmful to the country and productive of little good to the persons engaged in it. It might not, however, be necessary to interfere with the people who occasionally win a little tin by washing in the beds of streams when the water is low or by raking over old tailings after rain. They are usually very poor, and as their tin pays royalty on smelting, they may be well left to the discretion of the District Magistrate. We should lose rather than gain by suppressing this method of working, as the tin would be otherwise lost, and in all countries this kind of work, which may be compared to gleaning, is tacitly permitted.

Appendix I.

REPORT OF PROSPECTING OPERATIONS IN THE MERGUI DISTRICT, 1891-92, BY R. ROSS CLUNIS.

The prospecting operations of the party under my charge during the field season, 1891-92, have been conducted in the following places:—

(1) The country lying between the Pakchan and the Sungè Balè watershed.
(2) Between Maliwun and the Kamaukgyi river.
(3) From Maliwun to the seacoast in a south-westerly direction.
(4) The Thibawleik stream and the adjacent country.
(5) The neighbourhood of Tenasserim.

1. Owing to the difficulty in procuring coolies, a start could not be made before the 22nd December 1891, when my party, consisting of Private Craze and a gang of Chinese, Malays, and Siamese, left Mergui for the Pakchan in the launch *Mergui*. We arrived at the Namnoi guard, and commenced operations from this base, the more particular objects in view being to determine the rocks exposed in the Namnoi stream and an examination of the watershed.

Proceeding in canoes up the main stream, it was found that the lower portion consisted mainly of hard laminated blue slate overlaid by gravels, sections of both being freely exposed. On advancing further, small shoals were passed composed of water-worn granitic detritus mixed with quartz pebbles.

Granite became more apparent on nearing the source, boulders 3 and 4 feet across being frequently met, but no granite *in situ* was seen until actually on the watershed; where distinct but small outcrops protruded through reddish sandstone. The sandstone is metamorphosed in places, suggesting that the granite has been upheaved through the more recent strata.

The discovery is important as proving the general correctness of the statements made as to the occurrence of granite in the range, though its existence had been a matter of contention. It tends also to strengthen the theory of the continuity of the main granitic axial.

On crossing the range an extensive view over the sea and islands was obtained. The western face is extremely steep, there being an almost continuous precipice between 200 and 300 feet, over which the waters of the Sungè Balè plunge.

We marched downstream to the neighbourhood reached last year from the seacoast. As in the Namnoi, this river contains granitic detritus in small quantities, but has little or no tin. No granite *in situ* was seen on the western slope, but a constant succession of sandstones. On account of its excessive steepness an easier route to the summit was selected, but no change in the rock was perceptible.

On the return journey to Namnoi many pits were sunk *en route*, and a small quantity of good tin ore could be traced of the reddish brown variety and much resembling some of the best Maliwun ore. The feeders are richer in tin than the main stream, but the grain is very minute and quantity far from payable. Garnets of small size were plentiful in some of the pits and were obtainable from the sand in the river-bed.

The country passed through was magnificent, consisting for the most part of slightly elevated flats of considerable area and covered with bamboo and light forest, suggesting the idea that much of this land was once under cultivation. Travelling is easy owing to the absence of undergrowth. The rattan-cutters work the river for cane, the remains of their huts being frequently observed on the banks. Tracks of elephants, wild boar, and deer are common, and black bears were met on two occasions.

Kamaukgyi river as an outlet.

2. Proceeding from Namnoi, I visited the Kamaukgyi river for the purpose of judging its merits as a calling-place for steamers and the expediency of connecting it by road with Maliwun. I arrived at the mouth on the 11th January 1892 and found it to be a well-defined river, the next of any size north of the Maliwun creek and possessing a fine broad entrance.

Geologically the Kamaukgyi valley is of little interest, the rocks consisting of brown shales and hard sandstones.

On the march to Maliwun a few fragments of quartz were observed, but, in testing the streams crossed, no trace of tin could be detected. Although only roughly explored, I think the valley may safely be considered as barren in minerals. In examining the loose rocks obtained from the higher reaches there is little to suggest in its favour. It should be mentioned that several trial pits were sunk last season on a flat near the intersection of the Namnoi road, but with no result.

The Kamaukgyi, about 2 miles from the entrance, is of sufficient extent to allow ample space for small steamers to turn. The average depth in the centre was about 8 fathoms, while the sides varied from 5 fathoms. These soundings were taken approximately at high-water mark, so that considerable reduction should be allowed for low spring-tides.* On continuing up, the river again opens out into a second basin of larger dimensions, but too shallow for steamers, soundings giving only 3 to 5 fathoms at high water. It was necessary therefore to return to the first and select, if possible, a suitable position on the right bank for the erection of a wharf. An admirable place was discovered to be at the foot of one of the hills rising from the river's side, a few yards from which a depth of water verging on 5 fathoms could be relied on.

The journey overland from here to Maliwun was very disappointing, specially after the pleasing impression formed of the river. The course lies west by south from this point of the Kamaukgyi by magnetic bearing, and is about 5 miles distance in a direct line. With the exception of two or three hills at the start, the country for the most part consists of fearful mangrove swamps through which passes a net-work of water courses.

I subsequently revisited Kamaukgyi, starting on the second occasion by land from Maliwun with the intention of avoiding the swamps. The route was northerly at first, then veering round to east and south-east. Though this route is to be preferred, the distance was too great, and many of the hills, rivers, and belts of swampy ground crossed were not in favour of road-making. It must be stated the task of aligning a road from Maliwun to a suitable landing-place on the Kamaukgyi river will be one beset with serious obstacles, and for this reason it would be imprudent to support such a project.

The relative position of this river to Maliwun is sadly inaccurate. In some of the old maps it is placed far above the Maliwun latitude, whereas the embouchure is situated nearly east of that village.

I am still of opinion that the best route to bring Maliwun in touch with steamers is the one introduced in my letter of the 27th January; that the country to the eastward of the Baukachôn road should claim an inspection for the purpose of making a branch road to the Pakchan below the Maliwun entrance. There is apparently no serious impediment to balk this course, but, on the other hand, the Pakchan in conjunction appears to afford every convenience for steamer requirements: it has an easy access, ample turning space, and possesses a suitable site for wharfing. The distance would be a little greater than the routes now upon the tapis, but the expense of construction would be far less. The country has recently been surveyed, and a glance at the new map shows the scheme to be quite feasible.

3. From Maliwun to Pulo Tôntôn along the slope of the main range runs the new bridle-path. Granite is extensively developed and large boulders are met in all the streams, but quartz is not seen in plentitude until approaching the coast, when specimens of the gossan variety were collected. In vanning the sand from the beds of the stream, only a slight trace of tin ore could be recognized.

On hearing of old workings in the Baukachôn neighbourhood a number of trial pits were put down, but as will be seen from the journals, the result was very poor. The flat ground along the base of the range is composed of a thick bed of laterite, but the heavy influx of water frustrated all attempts to penetrate it beyond 15 feet. Below this stage it would only be possible, with the aid of a pump, to keep pace with the water.

The swampy ground in the vicinity is slightly stanniferous with a sandy over-burden of about 4 feet, but under present prices for tin, it would not pay to strip. The mine at Sungè Glama is doubtless utilized as an auxiliary to other produce. The ore is very impure, but easily procured owing to the shallow over-burden.

Among the hills visited, the Baukachôn stands out as the most significant. I made the ascent on the 18th January by a comparatively easy path. Could this hill be denuded we should behold an enormous outcrop of granite.

Being one of the loftiest peaks of the south and cleared on the summit as a topographical station the view from it was superb. The Mergui Archipelago is unrolled to the spectator on the west and an extensive view over the gulf of Siam is obtained towards the east.

It was curious to note the deflection of the magnetic needle on this hill, conveying the impression that a large body of iron is located somewhere, though superficially there is nothing to prompt such an assumption. The Malays hold this hill in awe, and the small pool on the summit has attained extravagant legendary proportions. They entertain the belief that the mineral wealth of the hill is fabulous.

The country at Pulo Tôntôn was next explored and several pits were made in the valley, but only those on the actual shore in a still growing sandbank contained ore. Tin is found along the beach; it is probable therefore that this is derived from the sea bottom and washed up from outside by the monsoon rollers. Several pits were put down at Sungè-Ka-ulu, where mining is carried on occasionally but nothing can be said in its favour.

* The rise and fall of the spring-tides is about 3 fathoms.

From Victoria Point we left for Mergui, being destined for the Lesser Tenasserim Valley.

4. The Thibawleik stannary is known as a payable one, yet the general dilapidation of the place and the accumulation of refuse about the cooly-lines would produce a reverse impression.

Abundance of tin.

On examining the mines in actual working I was surprised at the abundance of tin. It is not of the Maliwun quality, but the crystals are very large. In tracing the tin backwards with the hope of finding the parent lode, the indications were excellent, as the samples testify, yielding as much as 30 per cent. by simply washing the gravel in the river-bed. The ore ceases to exist beyond the 4th mile up the main stream, but on crossing the range to the east within this limit into the second large feeder above the Thibawleik mines, the yield was greater than in the main river.

Across both these streams run a number of quartz reefs, generally dipping northwards and varying from 10 inches in thickness to 2 feet, and charged more or less with tin wolfram and pyrites; they are very irregular both in formation and size. Gigantic boulders are found as erratics from these reefs.

I think the find a valuable one as a prelude to greater discoveries. Owing to the limited number of days at my disposal, it was impossible to strip and trace the lode, the undertaking being a laborious one in this country.

The source of the tin is located in the range separating the main stream from the branch forming the second above the Thibawleik mines on the right side going against stream.

There are remains of old workings up the branch stream now thickly clothed with jungle. Its desertion can be easily accounted for by the extreme difficulty of approach. These obstructions, in the form of a number of waterfalls, will seriously retard any progress, being so prominent that in places the goods can only be transferred with the aid of ropes at great hazards.

The sides of the gorges form great walls of blue slate almost perpendicular. Between these defiles are alluvial stanniferous deposits of small area, the lead being long but narrow.

The other valleys on either side of Thibawleik were explored, but had nothing in them to claim attention.

The tin of Thendaw is excellent in quality but deficient in quantity. It is only found as drift, and is derived from the small quartz veins intersecting the sandstones and other rocks constituting the hill range.

5. On examining the neighbourhood of Tenasserim in search for gold, I can only come to the same conclusion as that of some of my predecessors, which is that the precious metal is wrought gold. I found it 200 feet up the face of a hill, but on continuing to the summit discovered old ruins above me.

On the right bank of the Great Tenasserim River a good show of gold was brought to light, but this again is situated below a pagoda. There is a tale told that the last queen of ancient Tenasserim held the monopoly for the manufacture of gold ornaments, and that the site of the old palace is now occupied by the police guard; this is their reason for the frequent disclosure of trinkets in the compound.

Appendix II.

REPORT BY MR. ALEXANDER PRIMROSE, IN CHARGE OF GREAT TENASSERIM RIVER PROSPECTING OPERATIONS, 1891-92.

Our party, consisting of Private Rowe of the Cornwall Regiment (acquainted with stream tin working in England), one interpreter, a gang of coolies, and myself in charge, left Mergui by steam launch on the 19th December 1891, with instructions to explore the basin of the Great Tenasserim River for tin, coal, and such other minerals as might be contained in it.

We reached the town of Tenasserim on the 20th and proceeded up the river on the 21st, arriving at Tharabwin on the following day.

After visiting one or two spots at the latter place where coal was said to have been found, but which proved incorrect, we moved about 4 miles down the river to Tagu (Takoo) to examine a place in that neighbourhood where tin was reported. This we found to be correct, and particulars are referred to under the special heading of Tin.

When at this place a piece of coal found in the river having been brought to me, and being also told that Mr. Hughes had already seen the tin-ground here, I decided on prosecuting enquiries about coal. I accordingly proceeded up the river, and after a short stay near Tharabwin I went out on the Thendaw, arriving there on the 31st December. In this locality and at Kawmapyin some 15 miles further up our operations have since been carried on.

With this brief summary of our movements I proceed now to give particulars of our work, separating it under the general headings Coal and Tin. I divide these again under headings indicative of their special localities.

Coal on river sandbank near Tharabwin.—At Tagu, about 25 miles above Tenasserim, a piece of coal, as already mentioned, was brought to me by the Myoôk, and on enquiry I discovered that it had been found on a sandbank in the river 2 miles below Tharabwin. I accordingly examined the place in company with the man who found it.

Tharabwin.

At the point where the sandbank occurs there are three other banks, or, more properly speaking, small islands, extending obliquely across the river. On that from which the coal was brought, situated near the left bank, we found several other pieces scattered about. We sank as far as the water would admit, but discovered no indication of a seam. On the other bank no coal could be found, and our informant, who lives close by, told us he had never seen any on these. I therefore came to the conclusion that its occurrence on this particular bank was accidental, having most probably fallen from a passing raft or from a raft that had been upset. I was also informed by the people of the place that no coal was known to have been found nearer than Thendaw. At that date I had no information as to what length of time had elapsed since coal there or at Hinlat had been worked. Finding now that it is so long ago, my conclusion may be open to doubt, and the origin of these pieces may be a coal seam traversing the channel of the river itself.

I spent a day at the locality investigating the matter, and before going on to Thendaw I made further enquiries at Tharabwin, but no additional light was thrown on the coal on the sandbank.

Kyaukmithwè.

Coal on the Kyaukmithwè stream.—Having arrived at Thendaw on the 31st December, I was informed by the Kyedangyi (the headman) of old coal-workings in the neighbourhood, and on the following day we were taken to the place by an old Karen resident. These are situated about 2 miles further up the river and about 1 mile inland from the right bank. The exact position has been laid down by the Topographical Survey party.

Here I found an old shaft 70 feet deep with 50 feet of water standing in it. Another pit some distance to the east of this contained little or no water, but here the coal had not been reached, the depth being 30 feet. There were other shallow pits and excavations here and there extending over half a square mile of area with pieces of coal scattered about. Work, I found, had been carried on many years ago, the remains of a well-made road being shown to me by which the coal was conveyed to the river.

I was occupied for some time with a gang of our coolies in making a clear path to the main shaft and where access to other points was desirable. Lines were also cut from the main shaft as a centre in different directions, along which borings might be made if deemed desirable. I also explored the stream adjoining the workings, the Kyaukmithwè, but found no outcrop of coal.

These workings are evidently the same as those referred to by Dr. Oldham in 1855, but I was not aware of his remarks regarding them until some time after my survey. He mentions that the coal had been extracted by means of open adits sunk on the dip of the bed. In the extract I have seen he made no mention of the 70 feet shaft, which I concluded was the main shaft. From coal debris found in its immediate neighbourhood, it appeared to me to have been used in working the seam.

Mr. Hughes visited the place on the 13th February in company with Mr. Batten, the Deputy Commissioner, and no further work has been done.

I should not omit to mention that attempts with our limited appliances to get the water out of the 70 feet shaft were unsuccessful.

Hinlat.

Coal in the Hinlat.—The name of a stream further up the river, the Mi-thwè (Burmese for coal), suggested the presence of coal there, and on enquiry I was told that it was found in the neighbourhood. It, however, proved to be on the Hinlat, some distance south of Mi-thwè and on the opposite bank. I was afterwards informed that the making of charcoal on the latter stream had been the origin of its name.

On the 27th January, accompanied by the interpreter, the old Karen resident of Thendaw who undertook to show us the coal, and a few coolies, I went up to a point on the right bank about a mile above Kawmapyin.

Our guide along with some local Karens then took us to a place on the Hinlat stream where they told us coal had been extracted many years ago.

Here, on the left bank—the point has been fixed by the Topographical Survey—at the base of some rising ground, was an outcrop of heavy shale presenting a coaly appearance in the lower parts of the exposed seam.

The strike lies a little east of north and west of south. A length of about 60 feet can be traced in the direction of the stream, which it meets at an acute angle. Parallel with it is a ditch filled up with mud into which a bamboo could be driven 5 or 6 feet. From this it was said the coal was taken. A small tongue of land divides it from the stream. The bed of shale dips towards the east at an angle of 35°. Some pieces from the lower portion of the exposed seam burnt pretty well, though slowly.

On a subsequent exploration of the Hinlat I found some small pieces of coal not far from this shale similar to that on the Kyaukmithwè, and possibly a bed may be found associated with it as it is also found in close proximity to a bed of coal on the Htiphankb, to be afterwards described. Near the same place I also found some pieces of sandstone of two different kinds upon which were well-defined fossil leaves. Unfortunately I could not find the bed from which these had come, though I spent some time in searching for them, but I have no doubt they lie somewhere in the neighbourhood of the stream. The pieces of sandstone were handed to Mr. Hughes, and I trust may be useful in throwing light on the age of the coal found in this part of the Tenasserim basin. The same shale appears at another point of the Hinlat about 1½ miles from the mouth, the strike, however, being north-west and south-east, while it dips to the north-east at an angle of 35°. I also met with it at several points on the Htiphanko.

An old Karen who lives near told me he remembered the coal being worked. A sahib with about 100 people, he said, were engaged on it, but they only remained a few months.

I had a footpath cut by which the outcrop could be easily reached and the jungle round cleared away. A thicket of bamboos and other trees, with the usual tangle of creepers, rattan, etc., had closed in upon the place.

Mr. Hughes visited it on the 20th February and gave orders that no further work should be done.

Htiphanko.

Coal on the Htiphanko.—When at work on the Hinlat a piece of coal was brought me by the old Karen who lives near, and which, he said, he had just found. So, according to arrangement he took me on the following day to the Htiphanko, a stream about a mile north of Hinlat and on the right bank of the Tenasserim, and pointed out what proved to be an outcrop of seemingly good coal. This is situated on the left bank of the stream, about half a milelin a straight line from its mouth. The current had laid about 15 lineal feet bare, and it could be perceived under water to near midstream. It occurs just above an elbow formed by high ground which meets the stream flowing south and turns it off at right angles to the west. The stream follows innumerable windings before it reaches the river, and the half mile in a straight line stretches out until its actual course must measure at least 2 or 2½ miles from its junction.

At the outcrop I had the stream diverted, having brought Private Rowe and the remainder of the coolies to work here. Being the dry weather, there was not much water, and the diversion was made without much trouble. This enabled us to expose about 30 yards of the coal in a straight line, and by a pit sunk further on in the bank we traced it for about 20 yards further to the north. High ground north and south prevented our following it beyond this.

The strike I found corresponded with the Hinlat shale, being slightly to the east of north and west of south, and like it, too, the bed dips to the east at an angle of 34° to 35°.

We had completed the diversion and laid bare the position mentioned when Mr. Hughes visited the place on the 20th February. He directed that two inclines be opened at points fixed by him in order that 5 or 6 tons of coal might be got out for trial, and this I set about doing.

I had intended following the instructions I received to sink in the dip, but I found one carpenter was not equal to preparing the timbering which this would require; besides we had no workmen who knew anything of the work. I therefore decided on sinking vertical pits on the bed, in which very little timbering, if any, would be necessary. I did so the more readily as by these pits we would be able probably to pass through the bed and ascertain its thickness. The result was satisfactory, and the double object was attained of getting out the required coal and settling the total thickness of the seam.

After strengthening the bund formed for diverting the stream, we began sinking on the 24th February at two points fixed (which was about 15 feet apart) but a little way back from the outcrop, so that the pits might be just clear of the stream-bed, from which the water had been diverted. The surface area of each pit was 7½ feet × 6¼ feet. On removal of the surface soil we came upon dark-coloured clay hardening as we went down, and at about 4 feet this we found intersected with streaks of coal following the general dip of the bed. Working through this gave some trouble, and some days were occupied before we reached the first layer of coal, which proved to be only 10 inches thick and mixed with clay.

Another 2 feet of clay was passed before any further solid body of coal was met with. This proved to be a seam of 2½ feet thick. In parts the quantity of this seemed good, but it is irregular.

After sinking through this 2½ feet of coal we passed through 3 feet of hard shaly clay containing little or no coal, when a fine bed of solid coal was struck. This was cut through and proved to be 4½ feet thick and quite free from clay or shale.

Finding before we reached this that we should have enough coal for the trial, I had given up work in one of the pits after passing the 2½ feet seam and concentrated work on a smaller area in the other, my chief object now being to get through the bed and ascertain its thickness. The inflow of water was also giving us much trouble, and latterly night-shifts to keep the one pit free had to be resorted to.

By the 1st April we had gone clear through the 4½ feet seam. Below this we sank through 4 feet of very hard clay, light at first in colour, but becoming dark underneath, where it somewhat resembled the Hinlat shale. This was so hard and tenacious that the coolies were sorely tried in getting down as far as they did, and particularly as every foot increased the inflow of water and the height to which the buckets had to be hoisted in baling. At the depth reached I felt satisfied that we had passed completely through the bed of coal. This, however, was only accomplished a few days before Mr. Hughes' next visit on the 17th April.

When we had reached a depth of about 15 feet with the prospect of having to go much deeper, I took the precaution of timbering the upper portion of the pits, and I am glad to say no slip of earth ever occurred.

Mr. Bose visited the place twice when work was going on,—on the occasion of his going up the Tenasserim river and again on his return.

Two bamboo rafts were loaded with the coal, of which, however, only three bags were from the 4½ feet seam, as this was only reached after the other had been loaded and ready for despatch. These were sent off to Tenasserim, and I trust the trial of the coal will prove it to be of good commercial value.

As the stream just below the outcrop describes a curve which brings it round at a point further down at right angles with the strike, I had a point fixed there on the margin of the stream in line with the strike, in hopes that by boring on or near it we might come on the coal. This we tried, but were unsuccessful. But our boring chisel was not in order, and we could only go down some 18 feet. The position of our pits has been fixed by the Topographical Survey.

Regarding the value of the coal from a commercial point of view, I would remark that the full value of the coal has still to be tested. Supposing the seam to yield well and the coal to be of good marketable value, there must still remain the question of labour and transport, which, I reckon, will form difficult elements in framing an estimate.

As the crow flies the coal is only 16 miles from the branch of the river Tenasserim at a point behind Mergui, that place being some 10 miles further west. No road, however, exists. Although on the map the intervening country looks difficult, a comparatively easy trace may be found for a roadway or light railway. The shortness of the line may compensate for a number of difficulties. By river the distance to Mergui is about 90 miles, while the numerous shallows and sandbanks for a distance of some 20 or 30 miles below the Htiphanko makes the navigation in the fine season only possible for rafts and boats of light draught.

Borings may prove that the coal extends over a wide area. It will probably be found that the Thendaw (Kyaukmithwè) bed forms an extension of that on the Htiphanko, and even beyond it will most likely be traced. If a large coal-bearing area be shown to exist, it may prove an attractive field for commercial operations on a pretty large scale. In such case the forming of a railway might be undertaken in connection with the same and labour under these circumstances would be easily arranged for. The tin reefs and deposits at Thendaw would add to the importance of the district from a commercial point of view, as they would form an industry which might be associated with coal.

The whole country, however, is very backward. It may almost be said to have lain fallow since Alompra 150 years ago laid it waste and all but exterminated its inhabitants. It would only therefore be the prospect of ample profits that would draw capital into a field where roads are unknown and population has to be introduced.

I shall now give an account of our work in connection with tin.

Tin at Tagu.—As already mentioned, we heard at Tharabwin of tin having been found near Tagu, some 4 miles down the river, and on the 26th December a guide took us to a place which is about 6 miles inland on the slope of a hill bearing from Tagu west by south.

Here we found channels cut, and we were informed that Chinese were accustomed to work the alluvial.

Private Rowe made several trial washings, but obtained very little tin-stone.

Tin at Thendaw.—On arrival here I at once enquired of the Kyedangyi (the headman of the place) regarding tin. From him I found that alluvial workings had in former years been carried on along the banks of the Thendaw stream. This is a tributary of the Tenasserim, which, issuing from a gap in the line of the hills situated to the east of the river and running north and south, follows a south-west course along the base of the Thendaw hill for about 5 or 6 miles and then enters the river near Bampi.

On the 2nd January a guide was procured who led Private Rowe and a party of our coolies to the ground, both on the right and left bank, about 2 miles above the mouth. There Rowe found that at a depth of 3 or 5 feet in alluvial composed of whitish clay and quartz gravel he was able to wash out tin-sand and gravel in fair quantity.

From two and a half buckets of soil he in one place obtained about 1lb of tin-sand. He also washed stuff from the bed of the stream and got tin.

I visited the ground on the 4th January. Higher up the stream the yield proved variable, but on the whole less than Rowe had found. We came across old workings extending over a considerable area along the course of the stream. These the Kyedangyi informed me had been carried on some ten years ago by a gentleman from the Straits, who worked with Chinese and other labour. I found that this man's ideas as to time were very unreliable: Any period, say 10, 20, or 30 years, was sufficient to indicate that the time in question was long ago. With a Karen guide I went up the stream as far as there was any footpath, this being to a point where it issues from the gap already mentioned. Here the guide washed out a little tin with his hand from the bed of the stream in evidence of its presence. It was crowded with blocks and boulders of rock detached from the steep side of the hill which here flanked it.

After my visit I arranged that Rowe should settle down near the ground and carry on exploration systematically, working up-stream from point to point with the view of discovering the containing reefs from which the alluvial deposits of tin were derived. He accordingly camped in the neighbourhood, where, with seven coolies, he was for more than three weeks daily engaged in this work. During the time I paid him frequent visits he kept me regularly informed of the progress he was making.

He sank pits at intervals in both banks, and washed also in the beds of the stream, finding tin in varying quantity, but such as he considered warranted him in describing the ground as "rich in tin."

I had, on one of my early visits, come upon a detached piece of stone, much weather-worn, in which were quartz veins. The quartz contained traces of tin, and to this I directed his attention, especially as pieces of quartz with tin-stone attached had been picked up in the stream. After entering the gap, he came upon rock similar to the stone, and containing numerous other veins of quartz and tin.

Pits sunk on the banks of the main stream always yielded tin, but it was impossible to go any depth before coming on the solid rock, or meeting with detached blocks. Pieces of quartz holding tin were found in these pits, and I handed Mr. Hughes samples of these.

The containing rock is a very hard bluish-coloured sandstone, intersected with fissure veins of white quartz in which the tin is held. These veins vary in number and width from mere lines up to one inch. An experiment was made by myself and Mr. Clunis, who visited the reefs to ascertain if the body of the stone contained tin. A small quantity was carefully pounded out, being reduced to a fine powder and washed, but we were unable to discover any tin.

A road was cut along the left bank for about a mile and a half up from the gap, and one was also made to the top of the Thendaw hill.

A survey of the stream has been made by the Topographical Survey party.

The small tributary to the north of the Thendaw stream, and on the same side of the Tenasserim river, marked on the map as the Thooletay, also issues from a point in the same range, and I was sanguine it would contain tin. This Private Rowe explored, washing along the banks and in the bed, but he got only the faintest show of tin at one or two places. He followed it up to where it flows over a rocky depression between two hills, and finding he got nothing, I instructed him to go no further, having explored some 2½ or 3 miles.

We heard of no other tin during our stay on the river, nor did we come across any in our subsequent explorations.

Exploration.—The coal and tin having occupied our people during a great part of our time, I was not able to do so much exploring work as I had hoped. It was only towards the end of March, when work was stopped in one of the Htiphanko pits, that any men were available.

I succeeded in examining the bed of the Htiphanko for 6 or 7 miles from its mouth, and the Hinlat for some 18 or 20, including a small tributary. These estimates are, of course, along the winding channel of the streams. They are very tortuous, and, choked as they are at every turn with fallen trees and bamboos, it is no easy task making one's way along.

They both take their rise in the line of hills lying a short distance to the west, but which close in upon the river not far north of the Htiphanko. They drain the eastern slopes of these hills, but before reaching the Tenasserim they wind among the low hills and level country which intervenes, following for a long way a southerly course, until eventually they turn eastwards and enter the river.

The Hinlat shale occurs at three points on the Htiphanko, at one place a short way below the coal and only some 80 yards to the west of it. The other outcrops are further up the stream. I also met with the red sandstone and conglomerate which show out so conspicuously on the bluff about 2 miles above Yebu on the right bank of the Tenasserim.

Beyond what I have mentioned in connection with the coal, I met with nothing on the Hinlat calling for remark. The rocks here are likewise of the sedimentary class, and I was disappointed at not meeting with other fossils besides the leaves in the detached pieces of sandstone already mentioned.

I paid a flying visit to the hot springs near the Yebu stream, which I also examined for about 2 miles. The springs Mr. Hughes also visited, and tested the temperature 130°, so I need say nothing regarding them. On the stream the only outcrop I saw was the coarse conglomerate so frequently exposed on the river.

Private Rowe went up the Kawmapyin stream for 6 or 7 miles. He saw no coal, and a sudden storm having overtaken him and his men, any specimens he had collected were left behind. I had no subsequent opportunity of going up this stream.

General.—The health of our pary has been particularly good. Only a few cases of fever occurred in the earlier months, and these were very mild, lasting only a few days. We have had rain at interevals since the 27th January. For a month or six weeks it has fallen almost daily, still our coolies did not suffer as I feared. It speaks well for the climate in the basin of the Tenasserim that I am able to report their having returned looking stronger and healthier than when they left with me on the 19th December.

I am unable to add any seasoning to my report in the shape of perilous adventure or hair-breadth escape. These often form exciting elements in prospecting work, especially in jungles such as those in which we were so much employed, where the tiger is constantly on the prowl, and the elephant and rhinoceros are not unfrequently met with.

The only event to be noticed was an accident to one of the coolies, which happily did not end seriously. While at work he fell down the coal-pit, a depth of 25 feet. He landed on the back of another at work below. Both seemed to share the shock and neither was much hurt. The effect was a few slight contusions, which only detained them from work a few days.

GEOLOGICAL SURVEY OF INDIA DEPARTMENT.

TRI-MONTHLY NOTES.

No. 14.—Ending 31st January 1893.

Director's Office, Calcutta, 31st January 1893.

The surveying parties remain posted as stated in the last Tri-monthly Notes.

The Director visited Rewa in December, and arranged, in communication with the Resident, Colonel Robertson, for the progress of the mineral exploitation by Mr. E. H. D. Sewell, who is entertained by the State as Mining Engineer, at the lead ore occurrences which have been located at Sihool. Mr. Hughes, who was in charge of the party, is temporarily incapacitated for work through a most severe and regretable accident to his eyes. Mr. F. H. Smith carries on the proper geological surveying in South Rewa.

In Baluchistan, Mr. Griesbach has been able to make some extremely interesting observations on the results of the earthquake which occurred on the Chaman side of the country on the 20th December last. The principal point of interest in this earthquake is the distinct evidence there is regarding its course. A fault appears to run along the western foot of the Khwája Amrán range near Chaman, and along this there was a lateral movement of about 2′ 6″ accompanied by a vertical displacement of about 6 inches. As the railway crossed this line of fault obliquely, the result of the horizontal displacement of the opposite sides of the fault was to shorten the distance between the rails on either side of it, and consequently to bend aside the rails in a remarkable manner. This movement on the old line of fault was the cause of, not as stated in the daily papers, caused by, the earthquake, and is interesting as another proof that the elevation of these hills is still in progress. The earth's crust is consequently here in a state of strain which found a partial relief in the sudden yielding along the old fault line; and so gave rise to the earthquake or wave of elastic compression which was propagated through the earth to the surrounding country. Mr. Griesbach's report, which is accompanied by some excellent photographs which were taken immediately after the earthquake by Mr. L. Gordon, District Traffic Superintendent, North-Western Railway, who has kindly placed the negatives at our disposal, arrived too late for publishing in this number of the Records: but it will appear in the part for April next.

The Tenasserim coal exploitation in the hands of Mr. P. N. Bose, appears to be going on very satisfactorily. He reports that, besides having found fossils in some abundance on the limestone near Theiabwin, which should enable us to fix the age of the rocks with some precision, he has also met with indications which lead him to expect good coal in the neighbourhood of that place. Borings are being put down to settle this point.

List of Assays and Examinations made in the Laboratory, Geological Survey of India, during the months of November and December 1892, and January 1893.

Substance.	For whom.	Result.
Five specimens of copper ore, consisting of green argillaceous schist, with quartz and chalcopyrite, malachite, and tenorite.	Kilburn & Co., Calcutta .	Analysed for copper.
Two specimens of coal from the Lekobin Seam.	Begg, Dunlop & Co., Calcutta.	Proximate analysis, and sulphur and calorific power determined.
A specimen of pyritous lignite.	J. W. McMinn, Comilla.	Proximate analysis.
Chalcopyrite, and purple copper ore, in quartz.	Gillanders, Arbuthnot & Co., Calcutta.	Analysed for copper, gold and silver.

Annual Increments to graded Officers sanctioned by the Government of India during November and December 1892, and January 1893.

Name of officer.	From	To	With effect from	No. and date of sanction.	REMARKS.
C. S. Middlemiss, Deputy Superintendent, Geological Survey.	R 620	R 660	1st November 1892.	Revenue and Agricultural Department No. $\frac{2578}{209}$, dated 20th November 1892.	

Postal and Telegraphic Addresses of Officers.

Name of officer.	Postal address.	Nearest Telegraph Office.
T. W. HUGHES	Allahabad.	Allahabad.
C. L. GRIESBACH	Quetta	Quetta.
R. D. OLDHAM	Calcutta	Calcutta.
P. N. BOSE	Mergui	Tavoy.
T. H. D. LATOUCHE	Haranpur	Haranpur.
C. S. MIDDLEMISS	Abbottabad	Abbottabad.
T. H. HOLLAND	Calcutta	Calcutta.
W. B. D. EDWARDS	Haranpur	Haranpur.
F. H. SMITH	Rewa	Rewa.
P. N. DATTA	Mergui	Tavoy.
F. NÖETLING	Katha	Katha.
HIRA LAL	Abbottabad	Abbottabad.
KISHEN SINGH	Rewa	Rewa.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1893. [May

Notes *on the* earthquake *in* Balúchistán *on the* 20th December 1892, *by* C. L. GRIESBACH, C.I.E., *Superintendent, Geological Survey of India.*

Early on the morning of the 20th December 1892 an earthquake was felt over the greater portion of Balúchistán, concerning which a few facts have been collected by several officials of the North-Western Railway and also by myself, which I have condensed in the following notes.

Through the courtesy of Mr. C. W. Hodson, the Engineer-in-Chief of the Frontier Section of the North-Western Railway, I am enabled to give some particulars which have been reported by officials serving under his orders, and after Christmas I visited the Kójak range in company of that gentleman to inspect the damage caused by the earthquake. Mr. L. Gordon, District Traffic Superintendent, has taken very instructive photographs of the effects of this earthquake, which were obligingly placed at my disposal; reproductions of two of them being given here.

I quote herewith extracts from the report of the Executive Engineer at Shalabagh:

"On the 20th December, at 5-40 A.M. (Madras time[1]), this district was visited by a somewhat severe earthquake. It was followed by several lesser shocks, and at Shalabagh[2] they continued at frequent intervals during the day, and have occurred at frequent intervals up to the present date[3]. The exact time of the shock was shewn by the stoppage of a pendulum clock in my office.

* * * *

"*Effects at Sanzal*[4].—The station building at this place has apparently suffered most. Its close proximity to the line of fissure which runs in a north-east and south-west line about half a mile below the station, being probably the cause. The water tower is standing, but most of the turrets are loose * *. The oscillation of the ground caused the water to spill out of the iron tanks * *. The station building including the station master's and signaller's quarters and out-houses are very badly shaken, and will require rebuilding to a considerable extent. The whole of the chimneys have been thrown down.

[1] At Quetta the shock was felt at 5-46 A.M.; the distance from Shalabagh to Quetta being 53 miles in a straight line.

[2] Shalabagh is a station on the Sind-Peshin Railway at the eastern entrance to the Kójak tunnel.

[3] 22nd December.

[4] Sanzal is the first station on the western side of the Kójak tunnel.

"Lower down the line, at mile 643, * * the only serious damage to the permanent way occurred. There is visible at this spot to the eye, for a considerable distance, as far indeed as the eye can reach, a line of division in the soil, and where this intersects the railway at an angle of about 15° or 20°, the metals of the permanent-way were distorted in a most extraordinary way, the pairs of rails in each line immediately above the crack in the ground having suffered most. They were bent into a sinuous curve which is represented approximately in the annexed tracing and the photograph.

* * * *

"I have followed the line of fissure in the surface of the ground for a considerable distance on each side of the line, and it extends beyond Old Chaman on the one side for several miles I am told; I myself followed it for one mile beyond Old Chaman and could then see it extending far into the distance. In the other direction I am informed by an Achakzai, who had just come from there, it cuts the line of the Khwája Amran range obliquely, and can be traced to the peak of that name, some 18 miles off.

"There appears to have been a shearing action on the surface of the ground, the line of shear being tangential to the line of cleavage.

"The rails having resisted this motion were crumpled up in consequence. The joints in the rails on each side of the contortion have all been closed up, although, of course, originally, clearance for expansion had been left.

"The down line has now been put in order; the rails which were removed consisted of:

4 pairs of	30′	=	120′
1 pair „	24′	=	24′
	Total	=	144′

and these have been replaced by—

5 pairs of	24′	=	120′
1 pair „	21′6″	=	21′ 6″
	Total	=	141′ 6″

thus showing that the line has been contracted approximately 2½ feet.

"While tracing the crack in the ground through Old Chaman, I found that it crossed all the collecting pipes of the Military Works Department at Old Chaman. Most of these pipes crossed the crack at approximately a right angle and had not suffered, but one 1½ inch pipe which cut it obliquely was pushed up and off the ground' and formed a sort of arch over the crack."

In addition to the above, the report of that officer contains a detailed statement of damages to railway buildings at Shalabagh which were very severe, of a slight damage to the defences on the western side of the Kójak tunnel and of the effects on banks and bridges on the line, which, though showing the force of the shocks, can tell us little beyond that there was a severe earthquake, which had found out the weakest parts of those buildings and works.

A week after the earthquake I visited the Kójak range in company of Mr. Hodson. We first inspected the damage done by the earthquake to the houses and works in the neighbourhood of Shalabagh station at the eastern entrance of the Kójak tunnel; though there was much mischief done to buildings, etc., not much could be learned from these effects of the earthquake. If the scene of destruction had been in a closely built town, it might have been possible to detect some method, if I might use the expression, in the damage done, but at Shalabagh the houses are far apart, built on unequal hilly ground, and the workmanship in the buildings, mostly constructed of sun-dried bricks, is also very unequal, so that all one can say is that the shocks of earthquake have affected all the weak points of these buildings, many of which will have to be entirely reconstructed.

The Kójak tunnel fortunately escaped serious damage, though it is interesting to hear that the water-supply from some springs which issue inside the tunnel and which now escapes in a regular drain from the western (or Chaman side) of the tunnel, was considerably increased after the earthquake shocks.

The block-house which defends that entrance to the tunnel received some slight damage in the shape of cracks which have appeared in the solid masonry.

The effects of the earthquake shocks are visible almost all along the made banks on which the permanent-way is laid between the tunnel and Sanzal station. In their case the earthquake acted most beneficially, inasmuch as the artificially built-up material of these banks was well shaken down, and, though the latter have sunk here and there and cracks have appeared in places, their settling down and consolidating was equal to a season's rain, as the engineer of that section reports.

The real interest of the earthquake, however, centred in the damage done between Sanzal station and Old Chaman. A glance at the map of the Kójak pass (No. 87 $\frac{\text{N. W.}}{4}$ & $\frac{\text{N. W.}}{3 \& 4}$, scale 1 mile—2 inches) will explain the scene of the earthquake.

The line of railway descends to New Chaman from the Kójak tunnel in several great curves and in zig-zag fashion. Sanzal station is situated near the upper margin of a great and rapidly descending glacis, which slopes down from the Kójak range to the great plain in which New Chaman is situated.

About half a mile west of Sanzal station will be observed a path which runs from the Khwája Amran peak (8,864') in a north-north-east direction along this glacis. It appears that at the immediate foot of the Kójak range a great number of springs rise, close to which of course there is always a certain amount of grazing to be found, and thus this line of springs has been connected by a regular path, made by flocks passing along these patches of pasture-land. The water escaping from these springs has furrowed and denuded the glacis into an infinite number of small channels which are well shown in the map. There is another feature which is at once apparent, and that is that the path with its springs and patches of grazing grounds all lie as it were in a natural depression, running parallel with the range of the Kójak itself, whilst immediately to the westwards of it the ground of the glacis rises somewhat, before finally descending to the plains. This is well marked near Old Chaman, the foot of which is built on this rising ground.

About 7 to 8 miles south of Old Chaman this insignificant rise of ground becomes an auxiliary range of hills, which runs west and parallel with the Kójak range towards the Khwája Amran peak itself.

I expect to have further opportunities of geologically examining this ground when the weather will permit in the spring; until then I will only state my belief that the present path which connects the springs described indicates, as near as can be, the existence of an old fault line. At the present time I have no further proof for it than this, that as far as I have been able to ascertain during this hurried visit, the line of path is, roughly speaking, also a geological boundary between the slaty formation of the Kójak and a grey earthy limestone, the latter of which is very probably of upper cretaceous or lower eocene age; this boundary being here suspiciously abnormal in appearance. The springs which rise along it tend further to the opinion that they appear along a line of dislocation, which view is further strengthened by the fact that in the neighbourhood of the springs not only a kind of travertine is visible, but a curious breccia, consisting of debris of both the limestone and the slates of the Kójak and cemented by calcareous rock, is *in situ* and in strong force all along the line of path, but not off it, which breccia I now look upon as a fault-rock. The glacis itself is chiefly made up of recent deposits, fans from the range above, but I hope to discover a more exposed section further south, where the structure of this dislocation, if it is one, will be clearly demonstrated. Finally, but not least, the fault seems to be proved by the earthquake itself, which has originated in a further, though slight dislocation along a line, which exactly and absolutely coincides with the present path connecting the numerous springs.

In my theory explanatory of this earthquake, I therefore start with the assumption that an old line of fault exists, which runs more or less parallel with the Kójak range itself. In a mountain range entirely formed by flexures, which chiefly correspond to the strike of the range itself, such faults usually exist on a large scale. The lateral pressure which caused the folding of the strata in such cases frequently results in one or several systems of dislocations, as we may observe in numerous instances within folded mountain ranges.

What I could see of the effects of the earthquake in that region is soon told, and has been already described in the report of the Executive Engineer of Shalabagh. I will omit the damage done to station or other buildings and describe at once the fissure which has been mentioned above. It crosses the line of railway below Sanzal station at mile 643 and absolutely coincides with the line of path aforementioned, never being further away from it than a few yards. It is therefore practically laid down on the large scale map with sufficient accuracy. I followed it north and south of where it traverses the line for several miles, and could moreover see it clearly in the distance following the same direction for very many miles. Mr. Hodson, to whom I am indebted for additional evidence, has had the fissure traced by some of his subordinates as far as the Khwája Amran peak, where it is said to bifurcate, one of the cracks going east of the peak, the other west of it. The country is now under snow, and we shall have to wait till the spring weather permits further explorations.

But a few facts can be learned from the fissure as we see it. All the features connected with it tend to the fact that the entire area west of the fissure has not only slightly subsided, but also bodily moved southwards. The lowering of the area seems to be about 8 inches to a foot, but exact measurements are difficult, and the subsidence is probably not equal at all points of the line of fissure. But it is fairly exactly proved that this area has shifted at least 2 feet to 2½ feet southwards. The fissure itself is mostly closed, the ground on the surface being generally soft debris, but here and there a gaping fissure has resulted, from a few inches in width to several feet, the sides of which seem to be vertical. Fragments of turf and dry masses of the ground adjoining the crack have been carried along by the movement southwards, if the mass came from the eastern side of the fissure, or the reverse if it was detached from the western margin of the dislocation. But where the movement may best be observed is in the permanent-way itself and in pipes crossing the fissure. The mass of the western area having pressed southwards and against the line of fissure, the rails which cross the latter have been forced into curves as already well described in the report quoted, and the joints left open for expansion, have all been closed, as the movement was exerted in a direction more or less parallel with the permanent-way.

Very nicely illustrated was the movement by the damage done to the water-pipes. One, which crosses the fissure obliquely, was bent, having no other means of yielding to the pressure. The others have merely been shifted and lifted out of the surrounding loose earth and debris. Different measurements may be obtained along the various points of the line of fissure. Here and there the dislocation of the pipes does not appear to be more than from a foot to eighteen inches or even less than that. It is probable that also within the mass of the ground adjoining the fissure compression had been active, and here and there where the strata were of a yielding nature has resulted in very little dislocation apparently of the ground itself, whereas along other points the effect is much greater. So far the largest measurement taken amounts to a shift of 2 feet 6 inches; this was the result in the permanent-way at mile 643 and near several irrigation drains, which crossed the fissure at rightangles, and which have suffered a displacement of that larger amount. It is highly probable, considering the variation of the measurements consequent on the difference in lithological character of the ground through which the fissure runs, that the sum total of the movement exceeded 2½ feet considerably, but of that we have so far no direct proof.

From the foregoing it would appear that the process of contracting and folding, with resultant dislocations, of this area in Balúchistán, is still proceeding. At some previous date in the history of the Khwája Amran Mountain range this process of compression, as it must have been, has led to the formation of the line of fault, conjectured in these notes; the process, from whatever cause, is still active, and the tension having become too great has further resulted in a slight increase to the amount of dislocation already in existence. The two areas adjoining the fissure have moved about 8 inches vertically, and a couple or more feet horizontally from each other, which sudden establishment of a temporary equilibrium in this tension is no doubt quite sufficient to account for the vibration of the ground to a considerable distance, which vibration is commonly called an earthquake.

I need scarcely say that there is no indication of any kind which would point to the existence of volcanic activity at, or anywhere near, the area affected by this earthquake; I mention this only, because it was also in this case, as in other instances elsewhere, the popular theory advanced by many of those who personally experienced the alarming symptoms of this perfectly natural phenomenon.

Further Note *on* Burmite, *a new amber-like fossil resin from* Upper Burma. *By* DR. OTTO HELM of Danzig. (Translated from the German by PROFESSOR BRUHL, Civil Engineering College, Sibpur.)

Having received from the Director of the Geological Survey of India additional and sufficient quantities of the amber-like fossil resin occurring in Burma,[1]

[1] See *Records Geol. Surv.* XXV, 180.

I have continued its chemical and physical examination. My researches, the results of which I give in what follows, have rendered it evident, that we have to deal with a remarkable fossil resin, which differs essentially from all fossil resins known hitherto, and to which I have given the name of Burmite. The specimens before me were found at the Nangotaema Hill, near Maingkhwan, and consist of eleven larger pieces and various fragments; two of the pieces having been artificially worked. The majority of the pieces have a colour which varies from light brownish-red to dark-brown, and they are semi-transparent; other pieces are ruby-red and transparent; two are golden-yellow and two wine-yellow. The weathered crust which covers the pieces is variously coloured, and differs also in other respects, according as the pieces, when *in situ*, were exposed to the action of the atmosphere or underwent a process of fossilisation in the absence of air. Those pieces which show least signs of weathering, are surrounded by a thin yellowish-brown or brownish-black crust; the more weathered pieces are covered with a yellowish-brown or dark-brown layer of a thickness of 1-2 mm., beneath which there are often some ruby-red layers. These layers are easily detached. Some pieces are traversed by cracks filled with crystallized calcium carbonate.

The pieces which have not undergone the process of weathering are, generally speaking, harder than succinite; their hardness lies between 2·5 and 3. They also exhibit a greater power of resistance to the action of tools than is shown by succinite. On fracture it breaks into fragments with shining, flat-conchoidal surfaces, which have a resinous feel. All pieces fluoresce more or less, emitting a bluish light, which is especially well seen on polished surfaces of pieces of the dark-red or brownish-red variety.

The majority of the pieces of burmite, and especially those which are semi-transparent and of a dark colour, exhibit under the microscope small roundish and longish, often elongated bodies, which are coloured more or less brown. These bodies owe evidently their origin to sap which exuded together with the resin from the mother-plant and, like the resin, became hardened during the process of fossilisation. On viewing these structures, it frequently becomes clear that we have to deal with cavities the walls of which are lined with dried-up amorphous organic substance. The less a specimen of burmite contains of these by-products, the purer and prettier is its colour.

During combustion, burmite emits a peculiar aromatic colour which attacks the mucous membrane of the nose and throat only slightly. The fusing-point could not be ascertained, because burmite begins to decompose before it fuses.

Already in my first report I have described the behaviour of burmite towards polarised light, and when subjected to dry distillation. The result of repeated experiments was the same. Again I ascertained the presence of formic acid in the distillate, as well as the absence of succinic acid. On the other hand, the aqueous portion of the distillate contained a small quantity of a substance which, from its chemical behaviour, I believe to be pyrogallol. The brownish-yellow empyreumatic oil, which distils over together with the aqueous portion, contains sulphur derived from the sulphur which forms a part of the organic substance of the resin. The resin itself contains 0·013 to 0·021 per cent. of this chemically combined organic sulphur.

The ultimate composition of burmite, as evidenced by an analysis of the substance, is—

Carbon	80·05
Hydrogen	11·50
Oxygen	8·43
Sulphur	0·02
TOTAL	100·00

I determined the specific gravity from recently received pieces; it lies between 1·030 and 1·095.

I have once more studied the behaviour of burmite towards solvents, using average samples. Alcohol dissolves 5-6·8 per cent. The solution is rendered turbid on addition of an alcoholic solution of lead acetate; on warming, the liquid becomes gradually clear. Silver nitrate gives a white precipitate; ferric chloride colours the solution yellow. Ether dissolves 2·4 to 4·2 per cent. of burmite; the solution leaves a light-yellow resin on evaporation. Chloroform dissolves 11·8 per cent. of the resin, petroleum naphtha 2·2 per cent., carbon disulphide 4·6 per cent., oil of turpentine 18·5 per cent. The quantity of ash left by burmite on combustion, varies according to the purity of the substance; the pure clear pieces leave 0·2 per cent., the turbid, red pieces 0·6 per cent. The ash consists of carbonate and sulphate of lime and oxide of iron. Those pieces which are very turbid and impurities leave 4·6 per cent. of ash on combustion, which consists chiefly of ferric oxide.

I have already, in my first report, described the behaviour of burmite towards strong mineral acids. On rubbing, it becomes strongly charged with negative electricity.

According to what has been stated in the preceding account about the chemical and physical properties of this resin, it is distinguished from succinite, the fossil resin of the Baltic, by the absence of succinic acid. From the other known amber-like resins of the group of the retinites, burmite is distinguished by its hardness and toughness, which render it fit for carving and turning; further, by its chemical composition, its vivid colours, and its fluorescence. The latter property, burmite shares with the Sicilian Simetite[1]; but the latter is coloured still more vividly, especially in red tints; further Simetite is richer in organically combined sulphur and less resistant to solvents than burmite. From ambrite, which occurs in Auckland[2], burmite is chiefly distinguished by its low percentage of oxygen and by its being but little soluble in carbon bisulphide.

Wood or other vegetable remains may possibly be found in burmite, from which conclusions could be drawn as to the plants from which the resin exuded; for the present we can only state that especially the typical brownish-red pieces of burmite include cloudy accumulations and grains, lying in cavities, of a substance which I consider as derived from the juices which, together with the resin, exuded from the mother-plant and which, with the resin, was subjected to the process of fossilisation.

[1] Vide *Malphigia, anno I, fasc. II, 1886.*
[2] Vide *Verhandl. der. K. K. geolog. Reichsanst.*, *Vienna*, 1861, p. 5.

Besides the fossil resin, of which the preceding is an account, I received from the Director of the Geological Survey of India two other samples, also found in Burma:—(1) one from Wuntho in the Shwebo district. This consists of pieces which are very brittle and have a golden-yellow or yellowish-brown colour. The resin is included in and respectively combined with, carbonaceous slate; (2) one from Yenangyat in the Pakoko district; it consists of small fragments which are semi-transparent and of a reddish-yellow colour. Neither of these resins contains succinic acid; whether they are identical with burmite, I was unable to ascertain, as the quantity at my disposal was not sufficient for complete examination.

The Survey is greatly indebted to Dr. Helm for this and his previous contribution; and for his thorough examination of the specimens of this new fossil resin which he has enabled us to add to the list of Indian mineral species. I am glad to see the ruby tint which I have already noticed as likely to give some specimens, when judiciously cut, of burmite a better character than is anticipated by Dr. Noetling, is also, distinguished as characteristic. I hope yet to give this charm of the stone some display in the Survey Museum.—*Ed.*

Note *on the* Alluvial deposits *and* Subterranean water-supply *of* Rangoon, *by* R. D. OLDHAM, A.R.S.M., *Superintendent, Geological Survey of India* (With a map.)

Attention has recently been drawn, in connection with the increase of the water-supply of Rangoon, to a number of tube wells, sunk during the last few years in the premises of several of the mills of that city, some of which have yielded a useful supply of fresh water while in others only brackish was met with. In many cases no record of what was passed through has been preserved, and in some it has subsequently been lost, but a sufficient number of sections have been preserved to make it worth while putting them on record.

The borings are situated on or near the banks of the Rangoon river and the Poozoondoung creek, and lie in a roughly semicircular zone round the termination of the Pegu Yoma in the Shway Dagon pagada hill. The sections preserved all present the same type of structure; the surface beds consist of the "newer alluvium" of Theobald, characterised by its finer grain and generally bluish colour, while the lower part of the bore hole lies in the coarser grained "older alluvium," marked by its generally sandy or gravelly texture and buff or reddish colour. They are driven down to beds of gravel in which water of some kind, whether fresh or brackish, was obtained, but in interpreting the section it is necessary to bear in mind the process by which the wells were sunk. They are cased with iron piping of from $2\frac{1}{2}''$ to $4''$ internal diameter, which was sunk by the simple process of forcing a stream of water down a smaller tube of from $1''$ to $2''$ bore, inserted in the centre of the outer casing. The stream of water ascending the annular space between the two tubes carried with it the material washed from the bottom of the bore, and so enabled the two tubes to be sunk simultaneously; when the well was completed, the inner tube was withdrawn and a pump attached to the outer one. This process appears to be simple, inexpensive, expeditious, and effectual, though of course only applicable in soft and not too coarse grained deposits, but it has an effect on the stuff washed out that must be allowed for. The stream of water which is sufficient to wash away fine clays or sands, would be insufficient to bring up coarse grit and small pebbles to the surface. Consequently if pebbles are mixed with fine sand or clayey matter, the stream, which has sufficient power to bring the pebbles to the surface, will wash away all the finer matter, and so what would seem to be a clean gravel, to judge from the washed material brought up, might really be a mixture of pebbles and clayey sand, of very little value as a source of water.

A report on the bearing of my observations on the proposal to obtain an increased supply of water for the town of Rangoon by boring, has been submitted to the Rangoon Municipality, and need not be reproduced here in full, though the main points may be summarised.

The question presents itself in two aspects, that of the quality and the quantity of the available supply. To take the latter first, all the wells on the Poozoondoung creek above Messrs. Zaretskey Bock & Co.'s mill have yielded fresh water of excellent quality, while all those lower down have only given more or less brackish water. It so happens that just where the limit between the fresh and brackish wells lies, there are some lateritic rocks exposed in the Poonzoondoung creek at low water, and these have been supposed to mark the crest of a ridge of rock, separating the fresh water, whose source is supposed to lie to the north, from the brackish water to the south. It is needless to say that this is not so. There is nothing to show that the water bearing gravels are not continuous underground, while there is every indication that they are so, and that there is a continuous outflow of water from the outcrop of the gravels to the sea. The lateritic rocks in the Poozoondoung creek doubtless indicate an outcrop of the older alluvial gravels and as we know that they rise to the surface just across the Pegu river, they are very probably exposed in its bed. Here the salt water would obtain access to the water bearing gravels, and the internal movements set up by the variations of pressure due to the rise and fall of the tide, causes a contamination, which extends as far towards the original source of the water as the outward flowing current will allow. That this is the true explanation of the salinity of some of the wells is shown by the recurrence of fresh water wells up the Rangoon river as soon as they come within the influence of the more extensive collecting ground on the western side of the termination of the Pegu Yoma; the brackish wells being not only close to where salt water can get access to the gravels, but opposite the comparatively limited collecting ground at the termination of the Yoma. It may, therefore, be confidently predicted that wells sunk to strike the same gravels further to the north, that is further away from the outlet to the sea and more within the influence of the principal collecting ground, will be certain to find fresh water.

The quantity procurable from each well is a much more doubtful matter. The yield of the existing wells varies from 2,500 to 70,000 gallons a day, in no case was it anything like the full amount that the tube was capable of discharging; in every case but one, where the trial had not been made, I was informed that more vigorous pumping did not appreciably increase the dischage. We may consequently take it that the amount obtained from the wells is the maximum they are capable of yielding, and as the yield of different wells varies very much, one of the poorest being found within a few hundred feet of one of the richest, it seems that the gravels are subject to local and capricious variations of permeability which makes it impossible to anticipate a large average yield in so many wells as would have to be sunk to obtain the amount required for the supply of Rangoon.

The wells that have been sunk so far are not artesian, the natural water-level in them is from 5 to 11 feet below the surface of the ground. They are indeed situated so close to the outlet of the water in the gravels to the sea that it would be impossible for there to be any pressure sufficient to force the water above the surface. This has the effect of diminishing the effective pressure in the well and consequently its yield. Possibly artesian conditions might be found further inland, where there is a greater resistance to be encountered between the point where the well is sunk and the outlet to the sea, and if so a larger supply would be obtained by pumping, though the elevation of the outcrop of these gravels is so small that no very great increase of pressure, and consequently of yield can be expected from this cause. A large number of wells will, therefore, have to be sunk if the requisite supply of water is to be obtained, and it seems probable that, when the estimates are made out, it will be found that the cost will be nearly if not quite as great as for the construction of a storage reservoir, while the cost of maintenance and uncertainty of success will be much greater.

Appendix No. 1.—Detailed sections of borings.

Most of these sections have been preserved in glass fronted boxes, in which the different layers are arranged one above the other. In some cases this has been done to scale, and there was no difficulty in determining the depths and thicknesses, in others no fixed scale was followed, and the depths are indicated by paper slips affixed to the glass; a much inferior plan for when, as has sometimes happened, any of these labels have peeled off, it is impossible to determine the true thickness of some of the layers. Where I have not seen the specimens, or none have been preserved, the section is given by repute. The term grit is used to indicate a texture intermediate between that of sand and of gravel, the limits of size of the individual grains may be taken as $\frac{1}{32}$ and $\frac{1}{8}$ inch. The horizontal line indicates the base of the newer alluvium.

No. 1. Mohr Bros.

There are two wells, the section of the deepest is—

0—109 ft. fine grey clayey silt.
109—136 „ fine grey sand.
136—180 „ grey clayey silt.
180—190 „ yellowish sand (silt of the newer alluvium mixed with sand grains of the older).

190—210 ft. sand.
210—220 „ fine gravel ranging to ¼" diameter.
220—270 „ coarser gravel, some pebbles as much as an inch in diameter.
below 270 feet, yellow sand again.

No. 2. Bulloch Bros. & Co.

One well, section said to be—

0—90 ft. clay.
90—96 „ sand.
96—220 „ clay.
220—240 „ yellow sand and gravel.

No. 3. Dickmann Barkhausen & Co.

One well, 242 feet deep. No record.

No. 4. Steel Bros. & Co. Upper mill.

Two wells, 50 feet apart. There is a distinct difference in the water of the two. One contains a small proportion of oily matter, probably petroleum, which floats on the surface of the water. Section—

0— 30 ft.	fine brown silt.
30— 40 „	dirty yellowish sand.
40— 60 „	grey sandy silt.
60— 70 „	fine sand.
70— 80 „	yellowish sand.
80— 85 ft.	fine grey sand.
85—100 „	brown earth.
100— „	yellow sand.
—175 „	coarse grit and sand.
175—190 „	coarse grit.
190—210 „	fine gravel.
210—238 „	gravel ranging to 1/2 inch in diameter.

No 5. Steel Bros. & Co. Middle mill. Section—

0— 85 ft.	grey clayey silt.
85 — 99 „	fine sand.
99 —100 „	grey sandy silt.
100—118 „	fine grey sand.
118—122 „	grey sand with yellowish grains.
122—130 „	fine grey silt.
130—145 ft.	clean sand.
145—150 „	coarse grit with some fragments ranging to ¼ inch in diameter.
150—155 „	grey silt.
155—160 „	coarse sand mixed with small ferruginous concretions.
160—176 „	fine clean sand.
176—180 „	fine reddish sand.
180—190 „	coarse sand.
190—195 „	medium grained yellow sand.
195—198 „	grit.
198—203 „	coarse grit with some larger fragments.
203—229 „	gravel ranging to ¼ inch.

No. 6. Kruger & Co.

Section lost. At about 250 feet, a large number of shells in a very good state of preservation and in some cases quite fresh looking were brought up. The forms are all marine littoral, comprising the genera, *Cardium*, *Arca*, *Venus*, *Solen*, besides fragments of polyzoa. The species appear to be living ones.

No. 9. Zaretskey Book & Co. Section—

0— 30 ft.	grey silt.
30— 42 „	fine brownish sand.
42— 55 „	small ferruginous concretions.

55—125 ft. grey clayey silt.
123—217, grey sand.

217—220 ft. sub-angular gravel.
220—249 „ fine pale buff sand.
249—254 „ pale yellow sand.
254—257 „ coarse grit and sand.
257—289 „ pale yellow sand.
289— „ coarse grit and sand.

Through the courtesy of the proprietors this well was pumped for me with an open mouth. It was found that the well gave 1,200 gallons an hour with a lowering of the surface level of 8 feet.

No. 7. Steel Brothers & Co. Lower mill.

No record except that the water was brackish.

No. 8. Rowett & Co.

Two wells were sunk, both were failures. No further record.

No. 10. Bulloch Brothers & Co. Section—

0— 25 ft. fine clayey silt.
25— 52 „ fine sandy silt.
52— 70 „ fine grey sand.
70—108 „ silt.
108—118 „ fine grey sand.
118—170 „ alternations of more or less sandy and clayey silt.
170—256 „ grey sand of various shades.
256—265 „ grey sand with some yellow grains.

265—275 ft. yellow sand.
275—282 „ grit.
282—302 „ sharp yellow sand.
302—320 „ gravel ranging to ¼ inch.

No. 11. Arracan Co.
Two wells sunk to 240 and 245 feet; water bad. No further record.

No. 12. Arracan Co.
One well of 140 feet. Water not good. No further record.

No. 13. Victoria Oil works. Section—

0— 20 ft. grey clayey silt.
20— 80 „ fine grey sand.

80—100 ft. yellowish sand.
100—120 „ fine sub-angular gravel.
120—134 „ pepper and salt grey sand.
134—155 „ sand with small pebbles.
155—190 „ sand.
190—215 „ small sub-angular gravel.
215—218 „ sand.
218—230 „ gravel mostly small, imperfectly rounded, with some fragments of ¼ inch across.
230—236 „ fine sand.
236—240 „ gravel as before.
240—250 „ fine, grey sandy, silt.
250—257 „ coarse grit.

257—265 ft. fine white sand.
265—273 „ sand and grit.
273—276 „ white sand.
276—279 „ white grit.
279— „ gravel, ¼ to ¾ inch.

No. 14. Irrawady Flotilla Co.
One well of 170 feet, water brackish. No further records.

No. 15. McGregor Brothers & Co.
Section said to be—

0— 50 ft. blue clay.
50— 62 „ red clay.
62— 96 „ sand.
96—224 „ gravel, then sand and thin beds of white clay.
224—228 „ gravel.

No. 16. Foucar Brothers & Co.
No record.

No. 17. Bulloch Brothers & Co. Section—

0— 30 ft. brownish silt.
30— 43 „ grey silt.

43— 62 ft. brick red clayey matter (soft laterite ?)
62— 68 „ fine buff sand.
68— 75 „ fine pale greyish sand.
75—110 „ yellow sand.
110—130 „ clean sharp sand.
130—148 „ grit.
148—161 „ yellowish sharp sand.
161—165 „ fine brown sand.
165—171 „ coarse sand.
171—180 „ coarse sub-angular grit.
180—185 „ gravel up to an inch in diameter.

No. 18. Heatherington Gray & Co.
One well of 250 ft. Water bad; no record.

No. 19. Mohr Brothers & Co. Section—

0— ft. fine grey silt.
—196 „ grey silt mixed with grains of reddish sand.

196— ft. grey sand with some small pebbles.
—210 „ clean yellow sand.
210—215 „ coarse sand.
215— „ small gravel.
—224 „ coarse grit.
224—230 „ fine grit and coarse sand.
230—242 „ sub-angular gravel ranging to ¼ inch.

Appendix No. 2.—Analyses of water from the wells, by the Chemical Examiner to the Burma Government.

No. of well.	Total solids.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.
	Grains per gallon.		Parts per million.	
No. 1	8·3	·5	·01	·00
No. 2	12·6	4·1	·27	·02
No. 3	15·3	4·3	·11	·00
No. 4	16·8	3·9	·16	·04
No. 5	5·3	·3	·02	·01
No. 6	8·8	3·7	·24	·08
No. 9	5·7	·7	·02	·01
No. 11	232·4	108·6	·52	...
No. 12	125·3	49·0	·40	·20
No. 15	7·7	·5	·03	·02
No. 16	6·7	·3	·04	·02
No. 17	6·33	·7	·03	·02

GEOLOGICAL SURVEY OF INDIA DEPARTMENT.

TRI-MONTHLY NOTES.

No. 15.—Ending 30th April 1893.

Director's Office, Calcutta, 30th April 1893.

A slight change in the posting of the officers during the present season has been made owing to the desire of the Baluchistan Agency for a more detailed survey of the coal outcrops in what has come to be called the Quetta coalfield, which lies in the Spin Karez, Lés, and Ás Tangi valleys of the hill range to the east and south-east of that town. Mr. Dallas Edwards, on completion of his construction of a map of the Bhaganwala coal-field in the Salt Range under Mr. T. D. LaTouche, was transferred to Mr. Griesbach's survey party in Baluchistan.

Mr. R. D. Oldham was deputed for a short time to Upper Burma at the end of March. In the course of a short visit to the Yenang-young oilfield it was found that the outcrop of the ferruginous band mentioned in Dr. Nöetling's report runs in a closed oval round the oilfield, and that the productive area is confined to the highest portion of a rise in the crest of the anticlinal. The oil appears to have been concentrated in a small area whose limits have already been very nearly defined, and there is no reason to expect any important extension of the area of this oilfield, though others will very probably be discovered in course of time. The marked diminution in the yield of the deeper native wells between the dates of Dr. Nōetling's two reports, which was supposed to indicate an exhaustion of the field, was found to be partly due to a gradual silting up of the wells and consequent apparent diminution of their depth. This filling up has the natural effect of diminishing the yield of oil, and there did not seem to be any means of determining how far the apparent exhaustion of the deeper wells was due to this cause, and how far it was due to a progressive exhaustion of the oilfield. Even if the oilbearing sandstones tapped by the native wells are being exhausted, there seems still a large supply to be procurable by deeper borings, which tap a different series of oil sands.

An investigation was also made into the proposal made by Dr. Pedley to obtain the required increase of water-supply for Rangoon by borings instead of a storage reservoir. A special report was submitted to the Burma Government, and a short paper dealing with the principal points is published in this number of the Records.

The Director was on tour in the Punjab from the 18th March to the 10th of April in connection with the proposed speculative boring for oil at Sukkur on the Indus, and at the Bhaganwala coalfield in the Salt Range. The Sukkur boring still waits arrangement for utilization of the oil-well machinery and plant used at the now discontinued oil operations in Baluchistan, and the securing the services of a Canadian well driller.

The closer examination of the Bhaganwala coalfield by boring under the conduct of Mr. LaTouche is still proceeding, but a visit to the old workings of the eastern end of the field, which have been considerably extended by drifting made under direction of Mr. H. Luckstedt, Executive Engineer of the North-Western Railway Administration, show that a much larger area of the coal seams, with an average thickness of 3½ feet, can be worked out than was anticipated. The continuity of the coal in uniform quality cannot be so safely estimated owing to the presence of thin laminæ of sand which are very variable in their extent and thickness. Over 100,000 tons are estimated as available at this extreme eastern end, to which some considerable additions may be made for a mile further westward, but the main area of presumed coal under the Ara plateau further west presents so many evidences of thinning out of the seams that it would be rash in the extreme to foretell anything regarding it until the test borings have been completed.

List of assays and examinations made in the Laboratory, Geological Survey of India, during the months of February, March and April 1893.

SUBSTANCE.	For whom.	Result.
3 specimens of coal .	Finlay, Muir and Co., Calcutta.	Proximate analysis.

List of assays and examinations made in the Laboratory, Geological Survey of India, during the months of February, March and April 1893—continued.

SUBSTANCE.	For whom.	Result.
A specimen of iron ore (limonite) from Maha Champa Island, Mergui District.	P. N. Bose, Geological Survey of India.	Contains 36·8 per cent. of iron (Fe.).
A specimen of pyritous quartz, and 1 of aphanite with iron pyrites, from Chowk Pazat, Upper Burma.	Surgeon-Major Masani .	Assayed for gold.
	F. Nöetling, Geological Survey of India.	No. "1." A compact bluish green rock breaking with a semi-conchoidal fracture, studded with minute grains of magnetite, pyrites and pyrrhotite, the last two named minerals occurring also in irregular patches. Specific gravity : 2·86. Under the microscope the rock presents the characters of a volcanic agglomerate rather than an ordinary lava or a dyke rock. Fragments of plagioclase felspars, hornblende, and augite in all stages of decomposition are mixed with opaque grains of magnetite and pyrites in a microlithic groundmass. Only the occurrence in the field can decide exactly the origin of the rock, but from the microscope alone it seems like a compacted volcanic ash. It contains a trace of gold, but not enough for estimation. No. "2." A coarser-grained rock than No. "1" but presenting the characters also of a compact and altered agglomerate. There has been a considerable development of epidote at the expense of the decomposing felspathic materials which occur in large quantities. Fragments of amygdaloidal and site are occasionally found included and undergoing the general decomposition. Specific gravity 2·884. No. "3." Pyritous and felspathic quartz considerably weathered and stained with ferruginous matter. Yielded on assay 1 dwt., 7 grs. of gold per ton of material.

List of assays and examinations made in the Laboratory, Geological Survey of India, during the months of February, March, and April 1893—continued.

SUBSTANCE.	For whom.	Result.
		No. "4." Pyritous quartz yielded on assay 4 dwt., 14 grs. per ton of material. No. "5." An undoubted igneous rock of the aphanite group, being composed principally of lath-shaped plagioclase felspars, hornblende, and relics of augites with considerable quantities of granular magnetite. The whole rock has been considerably decomposed, epidote formed and veins of other decomposition products occurring. A sample of carbonate of lead also labelled "No. 5" evidently occurs associated with this rock, apparently in filling cracks. Fragments of rocks petrologically similar to "No. 5" occur mixed with the fragments of cerussite. On analysis it yielded 69·1 per cent. of lead and 33oz., 16 dwt., 4 grs. of silver to the ton of lead Large quantities of this material would therefore be exceedingly valuable as an ore of lead and silver. Nos. "6," "7," and "8." Specimens of excellent coal. They all show, compared with Indian coals, a very low percentage of ash, and fairly high proportion of fixed carbon. As fuels for steaming purposes they are far above the average of Indian coals, but the want of coking power detracts from their value as fuels for smelting purposes. The proximate analysis of the above are as follows:— No. "6." Quantity received . 4 lbs. Moisture . . . . 7·68 Volatile matter . . 34·42 Fixed carbon . . 53·58 Ash . . . . . 4·32 100·00 Ash—light gray. Does not cake.

List of assays and examinations made in the Laboratory, Geological Survey of India, during the months of February, March and April 1893—concluded.

SUBSTANCE.	For whom.	Result.
		No. "7." Quantity received . . 11½ oz. Moisture . . 6·60 Volatile matter . . 34·14 Fixed carbon . . 52·22 Ash . . . . 7·04 100·00 Ash—light reddish gray. Does not cake. No. "8." Quantity received . . 9½ oz. Moisture . . . 8·28 Volatile matter . . 36·14 Fixed carbon . . 48·58 Ash . . . . 7·00 100·00 Ash—dirty gray. Does not cake. No. "9." A compact granitic looking rock, composed of quartz, plagioclase felspar, smaller quantities of orthoclase, hornblende passing into chlorite and magnetite. The quartz occurs in granular crystals, and some of it is secondary. In classification the rock may be placed between the granitites and quartz diorites. Specific gravity 2·70. No. "10." Decomposed steatic rock.
One specimen of coal, from Heinla Chang, Mergui District, Burma.	P. N. Bose, Geological Survey of India.	Quantity received . 5 lbs. Moisture . . . 15·40 Volatile matter . . 35·08 Fixed carbon . . 44·24 Ash . . . . 4·28 100·00 Ash—light buff. Cakes, but not strongly.
A specimen of clay for determination.	Burn & Co., 7, Hastings Street.	Indurated pipe-clay with quartz fragments.

Notification by the Government of India during the months of February, March, and April 1893, published in the "Gazette of India," *Part I.—Leave.*

Department.	No. of order and date.	Name of officer.	Nature of leave.	With effect from	Date of return.	REMARKS.
Revenue and Agricultural Department	[illegible][3], Surveys, dated 16th March 1893.	R. D. Oldham.	Furlough.	1st May 1893, or subsequent date.	...	...
Ditto .	[illegible][4], Surveys, dated 16th March 1893.	Theo. W. H. Hughes.	Ditto .	26th January 1893.	...	...

Notifications by the Government of India during the months of February, March, and April 1893, published in the "Gazette of India," *Part I.—Appointment, Confirmation, Promotion, Reversion and Retirement.*

Department.	No. of order and date.	Name of officer.	From	To	Nature of appointment, etc.	With effect from	REMARKS.
Revenue and Agricultural Department.	[illegible][1], Surveys, dated 26th April 1893.	T. H. D. La Touche.	Deputy Superintendent.	Officiating Superintendent.	Acting, temporary.	26th January 1893.	

Postal and Telegraphic Addresses of Officers.

Name of officer.	Postal address.	Nearest Telegraph Office.
T. W. HUGHES	*On furlough.*	
C. L. GRIESBACH	Hindu Bagh (Baluchistan).	Quetta.
R. D. OLDHAM	Calcutta	Calcutta.
P. N. BOSE	"	"
T. H. D. LATOUCHE	Haranpur	Haranpur.
C. S. MIDDLEMISS	Abbottabad	Abbottabad.
T. H. HOLLAND	Calcutta	Calcutta.
W. B. D. EDWARDS	Quetta	Quetta.
F. H. SMITH	Rewa	Rewa.
P. N. DATTA	Calcutta	Calcutta.
F. NOETLING	Wuntho	Wuntho.
HIRA LAL	Abbottabad	Abbottabad.
KISHEN SINGH	Rewa	Rewa.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1893. **[August.**

Geology *of the* Sherani Hills, by TOM D. LA TOUCHE, B.A., *Officiating Superintendent, Geological Survey of India.* (With Maps and Plates.)

The observations recorded in the present report were undertaken primarily for the purpose of examining the oil springs known to exist in the Sherani Hills, and determining whether the geological conditions were such as to hold out any prospect of there being any large accumulation of oil beneath the surface in the neighbourhood of the springs. They were almost entirely confined therefore to the region occupied by tertiary strata lying between the Takht-i-Suleiman and the plains of the Indus valley, forming only a small portion of the territory inhabited by the assemblage of clans known as the Sheranis. They did not extend beyond the Zao river on the north, and the Toi on the south, that is, they were comprised, roughly speaking, between the parallels of 31° 25′ and 31° 55′ N. Lat. These two rivers, taking their rise on the western slopes of the Takht range, flow through the hills in an easterly direction, and enter the plains of the Indus valley to the west of Dera Ismail Khan. In spite of the forbidding character of the gorges by which these rivers traverse the main range, no small amount of traffic is kept up along them, since many of the caravans, which yearly pass to and fro between Dera Ismail Khan and Khorasan, make use of them. All that has hitherto been known regarding the geology of this area has been confined to the immediate neighbourhood of these routes. It would hardly be safe, even now that the tribes have been brought under control, to wander about these hills in the manner that a geologist finds necessary to a due comprehension of the features of the ground, without a considerable escort, and it is only quite recently that a map of the country, sufficiently accurate to admit of the carrying out of a detailed geological survey, has been published.

Previous observers: MR. GRIESBACH, 1883.

The expedition of 1883, under General Kennedy, undertaken for the purpose of enabling Major Holdich, R.E., to carry out certain survey observations from the highest peaks of the Takht range, was accompanied by Mr. Griesbach as geologist. This expedition, both in going and returning, used the more northerly of the two routes above-mentioned, that by the Zao river. However convenient this route may have been for the main purposes of the expedition, it was not so satisfactory from a geological point of view, as regards the lower hills lying between the Takht and the plains; for not only is the section exposed along the Zao much concealed by recent deposits of drift, but, as it happens, several of the formations to be found in the area to the south are quite unrepresented on that route. Moreover, the character of the inhabitants is such that Mr. Griesbach was unable to carry his observations to any distance from the line of march, without a special escort, which on account of the rapidity with which the expedition passed through this portion of the hills, could not be furnished to him. Mr. Griesbach's observations were included in his 'Report on the geology of the Takht-i-Suleiman.[1]

MR. OLDHAM, 1890.

In November 1890, the southern route, that by the Toi river, was taken by Mr. Oldham, who had joined the Khidarzai Field Force for the purpose of visiting the oil springs near Moghal Kot on that river. In this case also, the rapidity of the march prevented his doing anything in addition to the special object of his visit, beyond noting roughly the geological features observable immediately along the route followed.[2]

Present exploration.

It was not until the past field season was well advanced that I received orders to undertake a more detailed survey of the Sherani Hills, with especial reference to the question of developing the oil resources of the country. I was unable to leave Dera Ismail Khan till the end of February, and entered the hills on the 1st March, with an escort composed of sepoys of the 2nd Sikh Infantry, and a number of Sherani Border Police. The party was under the guidance of Sirdar Masud, an Afghan, Extra Assistant Commissioner in charge of the district, of whose kindness and forethought in supplying our needs, no easy matter in so desolate a country, I cannot speak too highly. Sub-Assistant Kishen Singh, of the Geological Survey, also accompanied me, and I found his knowledge of the geology of the hills further to the south, where he had recently been employed under Mr. Oldham, in Baluchistan, of the greatest value.

Entering the Sherani country by the Zam Chaudhwan, a narrow defile on the outer edge of the hills, by which the Toi river escapes into the plains to the south-west of Draban, we moved by easy stages up the river to Moghal Kot. Here I halted several days collecting samples of the oil, and making a plan and section of the locality. Afterwards leaving the Toi valley, we worked gradually northwards examining the valley of each of the larger streams, which all flow in a more or less easterly direction across the general strike of the rocks, and thus afford good sections, until we reached the Zao river. Thus I was able to compare my observations with those made by Messrs. Griesbach and Oldham. Finally we returned to the plains along the Zao river about the middle of April. The hot weather of 1892 will long be remembered in the Punjab as one of abnormally high temperature, even in the hills there was no exception to the prevailing heat, the thermometer standing at 100° in my tent so early as March 22nd. The barren and stony nature of the country in which there are few trees sufficiently large to afford shelter to even a small tent, added greatly to the discomfort attending such unlooked for heat.

PHYSICAL FEATURES.

Orography.

The area now dealt with forms a fringe of hilly ground, from 14 to 16 miles in width, at an average elevation of between two and three thousand feet above sea-level, extending from the plains of the Indus valley to the foot of the Takht range, under name which the Takht-i-Suleiman

[1] Records, G. S. I., Vol. XVII, Pt. 4, p. 175.
[2] Records, G. S. I., Vol. XXIV, Pt. 2, p. 83.

itself with the Kaisargarh, the Zao range to the north, and the mass of hills culminating in the peak called Mizri Koh to the south, are included for the purposes of this report, all these forming one mountain mass. As a rule the lower hills are disposed in a succession of parallel ridges, corresponding with the outcrops of the harder rock bands, and running in a north and south direction. Some of these ridges rise to a considerable height, notably one which runs parallel to the Takht about two miles to the east of it. This is composed of a hard band of sandstone and limestone and rises to perhaps 6,000 feet or more. It is partly shown, marked as of nummulitic age, in Mr. Griesbach's admirable sketch of the Takht-i-Suleiman.[1] From the western edge of the lower ground, the lofty mountain mass of the Takht range rises abruptly in a succession of bare rocky slopes and precipices, to an elevation of over 11,000 feet above the sea. Facing this at the outer edge of the hills is a belt of Siwalik rocks, very irregular in width and altitude, which forms a kind of rim to the broad trough of softer rocks lying between it and the Takht. This belt is about four miles wide on the Toi river, where it rises to an elevation of probably not less than 5,000 feet, but further north its width is reduced to a mile or less while its elevation is proportionately diminished. The survey made by Sheikh Mohiuddin in 1891 did not include this portion of the hills, and its topographical details are not given in the accompanying map.

Rivers.

The main drainage of the hills takes its rise on the western side of the Takht range. The principal rivers are the Toi which is joined at Domanda by a large tributary, the Shingao, also coming from the west side of the Takht; the Lohara which flows through the gorge called the 'Gut' and issues into the plains to the north of Draban, and the Zao, which issues near Zarkanni. All these rivers flow for several miles of the upper part of their course in a northerly direction, probably in every case following the bands of softer rock which underlie the massive cretaceous limestone forming the highest peaks, as observed by Mr. Griesbach in the case of the Upper Lohara valley.[2] Then they make an abrupt bend to the east, and cut directly through the range, even the hard massive limestone on the eastern flanks of it proving no insuperable bar to their passage.

River gorges or Dhanas.

These gorges, locally called Dhanas, are of the most wild and gloomy description. From the water's edge on either hand perpendicular walls of rock rise to an elevation of several thousand feet, and in some cases approach so nearly that the sky over head is invisible from the stream. A sketch of one of these, the Zao defile, is given in Mr. Griesbach's report, and presents a good idea of their general characteristics.[3]

The gorge called the 'Gut' is perhaps the deepest and narrowest of these defiles. It passes through the highest portion of the range inmediately beneath the Kaisargarh peak, and is almost impassable except on foot. It is difficult to believe that such stupendous gorges are due to the action of water alone, and this difficulty is enhanced by their resemblance to rifts in the hill sides. The term 'rift' indeed would be the most expressive that could be employed in describing them, if it did not imply a tearing asunder of the strata. That no such disruption of the

[1] Records, G. S. I., Vol. XVII, Pt. 4, pl. 1, b.
[2] Records, G. S. I., Vol. XVII, Pt. 4, p. 184.
[3] Loc. cit., p. 176.

rocks has occurred is proved by the continuation of individual bands of rock across the bed of the stream, and by the absence of those irregularities in the gradient of the stream bed which we should expect to find if it were the result of a fissure.

The 'Tiri'.

Issuing from these gorges, the rivers enter a belt of ground from two to four miles wide, to which the name Tiri is locally given, and in which there are two conspicuous ridges running parallel with the Takht range. Of these the inner, nearest the main range, is composed of cretaceous limestones and shales, and the outer of hard sandstones and limestones of nummulitic age. To the north of the Shingao the inner ridge is suppressed, owing to the thinning out of the rocks composing it, before it reaches the Lohara. The outer ridge is suppressed in like manner, and probably from a similar cause to the north of the Lohara, and does not extend as far as the Zao, which, after emerging from the main range, traverses no high ground between it and the outer rim of Siwaliks.

Below the Tiri, the rivers enter upon a broad zone, occupied for the most part by soft shaly rocks, which have been greatly denuded by the drainage from the main range. A large part of this zone is covered by recent drifts, which form an even stony plain sloping very gradually towards the east. At first the river channels are well defined and narrow, enclosed between perpendicular walls of drift, rising to 300 feet or so above the water-level; but lower down the valleys become wider and the terraces on either side less distinct. The whole of the cultivation is carried on along the borders of the streams, often in the narrow spaces between them and the foot of the terraces. For although the level plains above would doubtless be fertile enough, if there were any means of bringing water on to them, works of such magnitude as would be necessary are apparently beyond the ability of the tribesmen. The minor streams, which join the main rivers in this part of their course, are usually waterless during a great portion of the year. Indeed, in the main streams themselves the water often disappears at various points, and flows underneath the shingle for considerable distances. Water springs unconnected with the large streams are of very rare occurrence; in fact, I only know of one of any size, namely, near China on the Shingao.

Of the gorges through the outer belt of Siwalik rocks, that of the Toi is by far the longest. This is known as the Zam Chaudhwan from the town of that name lying near its mouth, and is about seven miles long. The river flows in a zig-zag course between lofty perpendicular cliffs, formed of the inclined beds of Siwalik conglomerates and sandstones, occasionally running for some distance along the strike of the rocks, and then without any apparent cause, breaking directly across them. On the Lohara, as before mentioned, the Siwalik belt is much reduced in width, and the passage cut through it by the river, known as the Zam Drazand, can hardly be called a gorge. Further north again the Siwalik belt broadens out to some extent, and the Zao traverses it by a pass called the Sheikh Hydur, similar to the Zam Chaudhwan, but much shorter.

STRATIGRAPHICAL GEOLOGY.

Structure.

The geology of the Sherani Hills is by no means complicated. As a general rule the formations follow each other in a normal succession, the older being found to the west, and the newer to the east. In fact, the whole of the rocks form the eastern limb of a huge anticlinal, the axis of which runs along the Suleiman range itself, the general dip being in an easterly direction. An exception to the prevailing easterly dip is found just within the fringing belt of Siwalik rocks, where what may be called a sporadic anticlinal occurs, the axis of which passes in a north and south direction through Domanda, parallel to the main anticlinal. Along this line disturbance has taken place at two distinct periods; first, after the deposition of the eocene rocks, which were upheaved, in places into a vertical position and greatly denuded, the overlying Siwaliks resting on their up-turned edges, and containing fragments derived from the nummulitic limestone; and secondly, after the deposition of the Siwaliks, which have been bent into a double fold, synclinal and anticlinal, denuded along the axis of the latter so as to expose the underlying lower tertiary rocks. This latter folding has been in some cases severe enough to bring the lower Siwalik beds also into a vertical position, and apparent parallelism with the nummulitic strata beneath, as at Domanda itself.

An hypothesis has lately been put forward by Mr. E. Reyer which appears to account satisfactorily for the frequent occurrence of such minor anticlinals as this, on the flanks of those greater folds to which mountain ranges are due. According to this theory, an abstract of which was published in 'Nature' of July 7th, 1892,[1] such folds are referred to a gliding down of the softer overlying strata, as the harder rocks beneath forming the core of the main range are upheaved. Without accepting this theory in its entirety, as an explanation of all folding, which would appear from his concluding remarks to be the author's contention, though it is difficult, of course, to form an opinion from a short abstract, yet given the upheaval of a mountain mass, such as the Suleiman range, it certainly does seem possible that minor folds on the flanks of it might be formed by such a "gliding" process, and the aspect of this narrow fold at Domanda lends considerable support to the theory. Besides this Domanda anticlinal, many other dislocations on a smaller scale, in some cases producing overfolds and faults, are to be seen, especially in the higher beds of the lower tertiaries, which might readily be explained on the same hypothesis. A conspicuous instance of one of these was noted on the Toi river between Parwara and Baskai villages (see Sketch, Pl. II).

Formations represented.

The formations represented in the Sherani Hills are given in the following table, in which I have included for comparison the succession found in the Mari country to the south, according to Mr. Oldham,[2] and by Mr. Blanford in the southern extension of the Suleiman range. [3]With those on the north as described by Messrs. Wynne and Griesbach, I have found no correlation possible of the kind that could be expressed in such a table as this. I have also omitted the cretaceous rocks below the massive limestone, the succession of which is given in Mr. Griesbach's paper on the geology of the Takht-i-Suleiman,[4] as these were not visited by me. In his report on the Safed Koh, Mr. Griesbach states that the sequence of the Mesozoic rocks, as observed in that area, closely resembles that in the Suleiman range.[5]

[1] "On the causes of the deformation of the Earth's Crust," 'Nature' No. 1184, Vol. XLVI, p. 224.
[2] Records, G. S. I., Vol. XXV, Pt. 1, p. 18 (Map).
[3] Memoirs, G. S. I., Vol. XX, Pt. 2, p. 34.
[4] Records, G. S. I., Vol. XVII, Pt. 4, p. 182.
[5] Records, G. S. I., Vol. XXV, Pt. 2, p. 88.

The rocks are given in descending order:—

Geological Age.	Sub-Divisions.	No. in Sections, see Pl. 1.	Sherani Hills.	Approx. maximum thickness.	Mari Region, Baluchistan, Oldham.	Approx. thickness.	Southern Suleiman Range, Blanford.	Approx. thickness.
Recent and sub-recent.	Do.	15	Alluvium	?	Alluvium	?	Alluvium	?
			Fan deposits and Talus	...	Gravels, etc., sub-recent.	...	Gravels of slopes, etc.	
Pliocene	Siwalik { Upper	14	Conglomerates, sandstones, and clays.	?	Conglomerates, sandstones and clays.	?	Conglomerates, sandstones, and clays.	2,500
	Siwalik { Lower	13	Sandstones and clays. *Mammalian bones, etc.*	2,000			Sandstones, clays, bone beds, etc.	5,000
Miocene	Nari	—	Wanting	...	Wanting	...	Sandstones, clays, etc.	2,000
Eocene	Nummulitic. { Upper	12	Olive shales and clays	2,000	Spintangi Group	1,000	Olive clays, shales, sandstones, etc., with a few thin bands of nummulitic limestone.	8,000
		11	Limestone with *nummulites.*	40				
		10	Olive shales *highly fossiliferous*, platy limestones at base.	1,500				
		9	Limestone crowded with *nummulites.*	14				
		8	Shales with gypsum bands	550				
	Nummulitic. { Middle	7	Shales and sandstones, *unfossiliferous.*	10,000	Ghazij Group	3,000	Coarse brown sandstone with a band of limestone breccia.	1,000
	Nummulitic. { Lower	6	Massive limestone band	250	? Dunghan Group*	2,000	? Hard whitish sandstone grit.	1,500
		5	Quartzose sandstone (oil locally).	1,000				
		4	Shales with minute *nummulites* and other fossils.	1,000				
Cretaceous	Belemnite beds	3	Thin bedded limestones with *belemnites.*	1,500	Belemnite beds	1,000		
		2	Black shales with *belemnites.*					
		1	Massive limestone with *corals, etc.*	5,000	Massive limestone	...	Dark grey limestone passing downward into limestone shales.	1,000 seen.

NOTE.—Since the above table was drawn up, Mr. Oldham has informed me that he has come to the conclusion that the Dunghan Group is more likely to be cretaceous than eocene, in spite of the nummulites it contains.

I have not thought it necessary or advisable to give local names to the sub-divisions of the lower tertiary system in the Sherani Hills. For, although the area is an isolated one, it seems almost certain that further research will result in correlation of the more important groups on the south at any rate. It appears to me, therefore, better to wait until the intervening area has been examined, in order that a multiplicity of names for what may prove to be identical groups may be avoided.

DESCRIPTION OF THE SECTIONS.

Toi River Section (No. 1, Plate 1).

The most complete section of the rocks composing the Sherani Hills is to be found on the Toi river, which traverses the whole series in an oblique direction from south-west to north-east. I propose therefore to describe the section to be seen on this river in some detail, at the same time noting those points in which the sections found on the rivers further to the north differ from or resemble it.

CRETACEOUS.

1. Massive limestone.

This is the lowest rock seen in the area examined. On the Toi river it is of enormous thickness, and very homogeneous in texture, showing very few bedding planes. It is an intensely hard and compact limestone, almost black in colour, and emitting a slightly fetid odour when struck with the hammer. A few corals occur in it, and sections of gasteropod shells are visible on some of the smooth water worn rock faces in the gorge, but none of these could be extracted. Towards the summit of the range as observed by Mr. Griesbach, it becomes lighter in colour and contains more corals. In the Toi gorge, or Dhana, the rock dips at about 30° to the east, and as far as I ascended the gorge, about a mile and a half, nearly as far as the place marked Dhane Sar on the maps, no signs of its base were visible. The thickness of the limestone is therefore more than 4,000 feet. In the river gorges to the north it presents the same characters, but the dip increases until, at the Zao river, it is approximately vertical. About half a mile below the rock, called the Sar-i-Sang in that defile, there are some more shaly limestones with sandstones which appear to mark the base of the massive limestone. In these beds were found a *Rhynchonella* and a very doubtful fragment of an *Ammonite*. These may be the equivalents of the uppermost beds of Mr. Griesbach's group No. 4, the brown earthy beds, No. 5, of his section, being locally absent. The total thickness of the massive limestone in this section would therefore be something over 5,000 feet.

Belemnite beds.
2. Black shales.

The massive limestones are overlaid conformably by black shales containing *belemnites*, which are found loose on the surface of the ground, weathered out from the shales, but do not appear to be very common, except at certain horizons. They are followed by thin bedded bluish and greenish limestones interstratified with shales.

3. Thin bedded limestones and shales.

This series forms a conspicuous ridge parallel to the Takht and where cut through by the river the individual beds of limestone, averaging perhaps a foot in thickness, and of lighter colour than the bands of shale, are seen to preserve a very uniform thickness for great distances, giving a highly characteristic banded appearance to the cliffs. Near the top of the group the limestone bands become thicker and whiter in colour; *Belemnites*, imbedded in the rock, and somewhat difficult of removal, are not uncommon in some of the beds. No *nummulites* were detected in any of these beds. In every particular this whole group, including the black shales at the base, corresponds with the 'Belemnite beds', overlying the massive cretaceous limestone of Baluchistan, referred to as variegated limestone shales by Mr. Blanford[1] and called at first 'Chapper Shales' by Mr. Oldham in his report of 1890,[2] a name which he afterwards abandoned in favour of the more generally applicable term 'Belemnite beds,'[3] and there can be no doubt that they are identical.[4]

Identical with Belemnite beds of Baluchistan.

On the Toi the thickness of the group is about 1,500 feet. To the north it is found in force on the Shingao river, but beyond this becomes gradually thinner, until on the Lohara, its thickness is reduced to about 200 feet, and further north, on the Zao it is entirely absent.

Northern extension of group.

TERTIARY ROCKS.

I could detect no traces of an unconformable break between this and the next succeeding system, there being a perfect parallelism of dip between them, but the existence of an interval of time between the deposition of the two is denoted by the occurrence, in the basement beds of the overlying system, of fragments derived from the cretaceous limestones These fragments appear to have come from the uppermost whitish limestone bands; at least none that could be referred to the darker massive limestones were detected, and so far it would not appear that it is necessary to imagine that any great interval of time is represented by this break. But, on the other hand, the great change in organic remains, for there is an entire disappearance of the *Belemnites*, accompanied by the appearance of *Nummulites* and other lower eocene fossils, would appear to denote the lapse of a considerable time. It is quite as difficult therefore to estimate the value of this break here, as Mr. Oldham found it in Baluchistan, where the relations of the lowest eocene with the underlying cretaceous beds correspond exactly with those observed by me in the Sherani Hills, except that in the Dunghan group, or lowest tertiaries, Mr. Oldham found in certain localities an admixture of cretaceous with tertiary forms.[5]

No unconformity.

LOWER NUMMULITIC.

Resting with perfect conformity of dip, as before stated, upon the cretaceous limestones, comes a thick series of shales, light olive green in colour, with numerous bands of sandstone, some of which are fossiliferous.

4. Shales with sandstone bands.

Near the village of Kharghwazha (No. 5 on map), Kishen Singh found, in a band of rather coarse sandstone, numerous remains of *Gasteropods*, and minute *Nummuli-*

[1] Memoirs, G. S. I., Vol. XX, Pt. 2, pp. 37, 83.
[2] Records, G. S. I., Vol. XXIII, Pt. 3, p. 93.
[3] Records, G. S. I., Vol. XXV, Pt. 1, p. 19.
[4] When visiting the Chapper rift, last April, I found more than one specimen of *Belemnite*, in the beds exposed in the rift, quite similar to those collected in the Sherani Hills.
[5] Records, G. S. I., Vol. XXV, Pt. 1, p. 22.

tes are not uncommon in some of the finer grained sandstones. These fossils have not yet been properly examined, but so far as could be seen from a cursory inspection of them, there are here no signs of that abnormal mixture of tertiary with cretaceous forms noticed by Mr. Oldham in Baluchistan. Unfortunately the number of the 'Records' containing Mr. Oldham's paper did not reach me till after I had left this section on the Toi, so that my attention was not directed to the importance of a rigorous search for such forms, but it was so close that I cannot think that if such fossils as *Ammonites*, *Echinoconidæ*, etc., had been present, they would have escaped our notice.

5. Quartzose sandstones.

The shales are succeeded by a band of hard quartzose sandstones, reaching a thickness of nearly 1,000 feet, bluish white in colour and weathering to a warm brown. They are generally thin bedded, and contain thin bands of shale, some of which are carbonaceous enough to have given rise to reports of coal occurring on the Toi river. None of them, however, are of any economic importance. It is near the base of these sandstones that the oil springs of Moghal Kot occur, concerning which, and the probability or otherwise of there being a large accumulation of oil in the neighbourhoood, I have submitted a separate report.[1] Fossils, mostly sections of bivalves, occur sparingly in the sandstone beds at the base, and near the top is a band containing an abundance of oysters (?*Exogyra*).

6. Thick limestone band.

Resting upon the sandstones is a cap of massive and very hard grey limestone about 250 feet thick. No recognisable fossils of any size were found in this band, but portions of it are crowded with what appear to be sections of a Foraminifer, perhaps an *Alveolina*; but the sections, which are all that can be seen on the surface of the rock, are so much distorted that I could not determine their nature with accuracy. This limestone band with the sandstone beneath it forms a lofty serrated ridge, rising with a long even slope of about 30° corresponding with the dip from the lower ground to the east, and precipitously scarped on the west, facing the Takht range.

Northern extension of Lower Nummulitic group.

In the three river gorges to the north of the Toi, the various sub-divisions of this group, as observed in that river, are present in full force, and the ridge formed of the two upper members can be traced continuously across the country between them. But between the Lohara and Zao rivers this ridge comes to an abrupt end, and with it all signs of the quartzose sandstones and overlying limestone disappear. The lowest member is represented on the Zao by a great thickness of black shales, in which no fossils were found, passing downwards into lighter coloured splintery shales, much contorted and crushed, and resting directly upon the massive limestones of the main range, the Belemnite beds also having disappeared. It is impossible on this section to fix with accuracy any division between the lower and middle nummulitic groups, owing to the absence of the limestone band which affords a convenient boundary line in the southern sections, marking as it does, an abrupt change of conditions in the deposition of the strata. What the reason may be for the disappearance of two so well-marked bands of hard rock can only be conjectured. That it is not due to any form of dislocation, I am pretty certain, for in the Zao river, only two miles or so to the north of the end of the ridge, a complete section of the rocks is exposed, and though there is a small double fold in the sand-

[1] Records, G. S. I., Vol. XXV, Pt. 4, p. 171.

stone and shales (see Section No. 3), there is no faulting of such magnitude as would account for the entire disappearance of these two bands. I am inclined therefore to think that the feature is an original one, and that the disappearance of these beds is caused by their sudden thinning out due to an abrupt shallowing of the basin of deposition to the north. This hypothesis is borne out to some extent by the highly carbonaceous character of the strata belonging to this group exposed in the Zao river, pointing to the existence of a land surface at no great distance to the north.

MIDDLE NUMMULITIC.

7. Shales with sandstone bands. Unfossiliferous.

Next in order, resting conformably upon the limestone band, follows a great thickness, probably not less than nine or ten thousand feet of shales and sandstones, in the greater portion of which no organic remains are found, beyond a few carbonaceous markings, which may be obscure plant impressions, and a few insignificant strings of coal. A band of nummulitic limestone was found near the top of this group between Parwara and Baskai on the Toi, but the ground was so obscured by talus that it was impossible to say that this band had not been brought into its present position by folding, and really belonged to the next higher group. Near the base greenish and red shales and clays are most conspicuous, interstratified higher up with bands of soft grey sandstone, weathering red, and sometimes coarse gritty bands showing false bedding. The whole aspect of the group recalls that of the Murree beds of the North-Western Himalayas, but its position beneath a group containing several bands of highly nummuliferous limestone precludes its being referred to the same period. On the other hand it agrees in position and appearance, and in the occurrence in it of carbonaceous traces, with the Ghazij group of Baluchistan, in which the workable seams on the Sind-Peshin Railway occur, and in all probability it is represented in the southern extension of the Suleiman range by the eocene sandstones containing coal, in the country of the Luni Pathans, as described by Mr. Ball.[1]

UPPER NUMMULITIC.

No stratigraphical break.

There is no stratigraphical break of any kind between the foregoing group of shales and sandstones and the overlying group of upper nummulitic rocks, the greater portion of which is also shaly The only reason for drawing a line of division here is the evidence of a return to more distinctly marine conditions afforded by the presence of bands of limestone, containing nummulites and abundant remains of other organisms, in the upper group of beds. The change is marked by the appearance of a series of rocks very persistent in character, which is found wherever the base of the upper group is exposed.

8. Shales with gypsum bands.

This series is characterised by the presence of numerous bands of saccharoid gypsum, and of grey limestone, in which gypsum occurs closely mingled with the limestone, and sometimes in cavities. In the latter case the weathering away of the limestone from the rounded masses of less easily dissolved pure white gypsum gives the surface of the rock a peculiar appearance, as though it were studded with

[1] Records, G. S. I., Vol. VII, Pt. 4, p. 153.

snowballs. Mr. Oldham records a similar association of gypsum with fossiliferous limestone in Baluchistan, and notes the difficulty of accounting for their presence together.[1] The shales interstratified with the gypsum are of very vivid colours, green, red, and purple predominating, differing in this respect from the shales accompanying the gypsum in Mr. Oldham's Spintangi group. A section of these rocks measured by Kishen Singh near the village of Zor Shahr on the Lohara, is as follows:—

In descending Order.

		Ft.	Ins.
Dip N. 80° E @ 25°	Nummulitic limestone, soft and shaly, greenish in colour, and full of nummulites (No. 9 in sections)	14	0
	Green shales	60	0
	Gypsum	7	3
	Green shales	3	3
	Gypsum	3	6
	Green shales	3	0
	Gypsum	1	6
	Limestone	1	0
	Green shales with a calcareous band	12	0
	Calcareous sandy band	1	3
	Green shales with a limestone band	22	6
	Gypsum	3	0
	Green shales	6	6
	Gypsum	0	3
	Limestone	0	9
	Green shales	7	0
	Gypsum	3	6
	Green shales	14	0
	Gypsum	5	3
	Green shales	28	0
	Gypsum	11	7
	Dark green shales	0	6
	Gypsum	2	0
Not well seen	Green shales	8	0
Not well seen	Gypsum	2	0
Not well seen	Green and purple shales with 3 layers 8 inches to 1 foot thick of gypsum	55	0
	Gypsum	1	0
	Green shales with purple bands	50	0
	Grey limestone with gypsum in cavities	2	2
	White limestone	0	11
	Green shales with marly layers	49	0
	Purple shales with thin gypsum bands	19	0
	Gypsum	2	10
	Red shales with 1 foot 6 inches marly layer in middle and thin gypsum bands	13	0
	Sandy argillaceous band	2	9
	Green shales with sandy bands at top	24	0
	Foliated gypsum	6	2
	Green shales with red bands	16	0
	Limestone with gypsum in cavities	4	0
	Red and green shales with thin sandstone layers	101	0
Dip N. 80° E @ 20°	Greenish sandstones		
	TOTAL	568	11

[1] Records, G. S. I., Vol. XXIII, Pt. 3, p. 98.

This band of gypsum-bearing rocks can be traced continuously from the Toi to the Zao river, and extends to an unknown distance both to the north and to the south. It was apparently found by Mr. Blanford in about the same position far to the south, west of Dera Ghazi Khan. It is also exposed along the axis of the Domanda anticlinal, on the Toi at Domanda itself, and on the Lohara just within the fringing belt of Siwaliks, but is concealed on the Zao by the unconformable overlap of the latter rocks.

9. Nummulitic limestone band.

This band of rock, although insignificant in thickness, is remarkable not only on account of its composition, but also for the very wide area over which it extends, without any change in character. It is a greyish limestone, slightly tinged with green, entirely made up of the remains of *Nummulites*, apparently belonging to a single species, crowded together in the utmost profusion throughout the whole thickness of the band. Wherever I have measured it, at widely separated localities, the band has an almost uniform thickness of 14 feet. It forms the crest of a well marked ridge, the scarped face of which is composed of the underlying shales with gypsum, and is found wherever that formation is present. It is interesting to conjecture what the conditions may have been under which this peculiar band of rock was formed. The great thickness of unfossiliferous beds beneath points to the existence of a gradually shallowing basin, by the desiccation of which the gypsum beds were formed. Then a subsidence of the surface accompanied by the irruption of salt water brought in conditions favourable to the growth of the nummulites, exceedingly uniform over a very large area. These conditions appear to have ceased as suddenly as they began, for the nummulitic band is followed by thin bedded, fine grained, platy limestones, in which I found no nummulites whatever. These latter rocks range from 30 to 40 feet in thickness and are usually light grey in colour, but on the Toi between Parwara and Baskai they are of a dense black colour, weathering white and occasionally contain nodules of chert. They generally form a dip slope on the reverse face of the ridges, at the crest of which the nummulitic band, above referred to, is found.

Platy limestone.

10. Olive shales, highly fossiliferous.

The limestones are followed by a band of olive shales in which fossils are exceedingly numerous. These are mostly casts, and have not yet been examined. There is no great variety of species but a great profusion of certain forms, a large *Cardita* being very common among the bivalves, also an *Ostrea* with V-shaped markings, Gasteropods, *Cerithium* and *Turritella*, are also found in great numbers. The thickness of this band of shales is about 1,500 feet.

11. Limestone band with nummulites.

This band of limestone having olive shales both above and beneath it, crops out as a more or less conspicuous ridge, parallel to and at a fairly uniform distance from, the ridge formed by the lower limestones belonging to this group. *Nummulites*, which appear to belong to a different species from those in the lower band, are sparingly distributed through the rock, and a few specimens of echinoderms and corals, also a somewhat mutilated carapace of a crab, were obtained from it. The minor dislocations which the strata have undergone are well exhibited by this band of limestone, especially in the valleys of the Toi and its tributaries above Parwara, where it is repeated at least twice by a folding (see Sketch Pl. II). The thickness of this limestone band is not great, 30 or 40 feet, but in common with the other members of this upper group, it is persistent over a very large area.

12. Olive shales.

It is followed by a thick band of olive shales, closely resembling lithologically band No. 10, but almost barren of fossils. This band is about 2,000 feet thick on the Toi, and although of little interest occupies the greater portion of the area covered by the Upper Nummulitic group.

Correlation of Upper Nummulitic group.

I have little hesitation in identifying this group with Mr. Oldham's Spintangi group in Baluchistan, as described in his report on the country adjoining the Sind-Peshin Railway.[1] Although there are differences of detail in the various rock beds comprising the group. It is worthy of remark that 'Olive shales' are of almost universal occurrence in the upper portion of the Eocene division over the whole area occupied by these rocks in the North-Western Himalayas, Sind, and Baluchistan.

Unconformable break.

It is difficult to estimate the value of the break which took place between the deposition of the Nummulitics and Siwaliks. The entire discordance in dip between the Siwaliks and underlying nummulitic rocks, as seen in the Zao river sections (see Section No. 3, Pl. I), would seem to imply the lapse of a considerable amount of time. But the Siwaliks on the Zao belong to the uppermost part of that series, whereas a few miles to the south on the Toi, we find some thousands of feet of sandstones and clays interposed between the Upper Siwaliks and the Nummulitics; and here there is not the same evidence of unconformity. In fact, where the formations have been least disturbed, for instance, in the synclinal west of Domanda, the lowest beds of the Siwaliks rest with apparently complete conformity on the Upper Nummulitics. Too much stress should not be laid, I think, upon the discordance in dip seen on the Zao. The disturbance of the beds beneath, to which it is due, was confined to quite a narrow zone, and need not have taken any very considerable length of time to accomplish. The probability is that this period was one of considerable changes of level in closely adjoining areas, so that upheaval and denudation were proceeding in certain areas, while not far off deposition was going on. This is indicated by the fact that fragments of the limestone beds belonging to the Nummulitic series are found imbedded in the lower Siwalik strata. There occurs a band of gritty sandstone in the latter rocks, some way up from the base, between Domanda and Landai on the Shingao, crowded with broken *Nummulites*.

13. Lower Siwaliks.

Although the lower Siwalik rocks attain a considerable thickness, probably not less than 2,000 feet on the Toi and its tributary the Shingao, they are entirely absent on the Lohara and Zao rivers to the north. How far this suppression is due to the unconformable overlap of the Upper Siwaliks, it is impossible to say, but it seems probable that it partly at any rate arises from original irregularity in the deposition of this formation. In lithological characters it resembles in all respects the formation of the same age, both to the south, in Sind and Baluchistan, and to the north in the Punjab. The prevailing rocks are rather soft grey 'pepper and salt' sandstones, interstratified with clays and shales of bright colours, usually red and orange.

[1] Records, G. S. I., Vol. XXIII, Pt. 3, p. 96.

Occasionally bands of coarse sandstone are met with, but conglomerates, such as characterise the Upper Siwaliks, never occur in these lower rocks. The surface of some of the finer sandstone beds are covered with ripple marks. A fine example of this is to be seen a short distance below the village of Parwara, where the sloping surface of a low ridge, through which the river breaks at right angles, is covered with it for several hundred yards. A sandstone band in about the same position on the Shingao, about six miles to the north, also displays the same structure.

Organic remains.

In a somewhat pebbly band near the base of the Siwaliks on the road from Parwara to Landai, Sub-Assistant Kishen Singh was fortunate enough to discover a few fragments of mammalian or reptilian bones, and of teeth, probably reptilian. The bones were found about two miles to the south east of Landai, and the teeth at two localities, one about three quarters of a mile from Parwara, the other about two and a half miles from the same village. The position of these fossils agrees perfectly with that of similar remains, found by Captain Vicary in the Bugti Hills, and by Mr. Blanford in the southern Suleiman range, in rocks belonging to the same subdivision, and afford a further proof if any were needed as to their identity.[1] From another bed, of green calcareous shale, among these lowest Siwaliks, but at a lower horizon than the beds containing the bones and teeth according to Kishen Singh, a few fragmentary specimens of a strongly ribbed bivalve were collected, which, although not perfect enough to be identified with certainty, belong, I suspect, to one of the species of ribbed *Unios* found by Mr. Blanford to the south, and by Mr. Wynne to the north, associated with the mammalian and reptilian remains.[2]

Distribution of Lower Siwaliks.

On the Toi the rocks belonging to this group form an open synclinal above the confluence with the Shingao, the axis of which runs north and south, and bend over to the east of the Domanda anticlinal, where they are tilted up vertically. Lower down the river the dip becomes easterly, at a high angle, and the rocks disappear conformably beneath the conglomerates and sandstones of the Upper Siwaliks. To the north the synclinal flattens out and is replaced on the Zao by a low anticlinal (see Section No 3 Pl. I), which may partly account for the disappearance of the lower Siwalik rocks in that direction, they having been removed by denudation. To the south Mr. Blanford found a synclinal in these rocks in the same position as on the Toi, and it is probable that they extend continuously from the Sherani Hills into the area examined by him.[3]

14. Upper Siwaliks.

This formation occurs everywhere along the margin of the area examined, forming a lofty range with a gentle dip slope running up from the Indus plain on the east and scarped on the western side, where its precipices overlook the lower ground stretching toward the Takht-i-Suleiman, occupied by the eocene shales and limestones. It is made up, as everywhere else, of thick beds of conglomerate and sandstone, regularly interstratified. The greater proportion of the pebbles forming the conglomerate appear to have been derived from the hard cretaceous limestone, but pebbles of sandstone, probably from the same group, are also common. The thickness of this formation varies

[1] Memoirs G. S. I., Vol. XX., Pt. 2, pp. 21, 57.
[2] Records, G. S. I., Vol. X, Pt. 3, p. 120.
[3] Mem. G. S. I., Vol. XX, Pt. 2, p. 120.

considerably, being greatest on the Toi river, which has cut a deep gorge through these beds. On the Lohara and Zao, the uppermost beds alone seem to be represented, resting with total unconformity on the Upper Nummulitics.

Breccias near Zor Shahr, ? of Siwalik age.

To this period may possibly belong a thick mass of limestone breccia, forming the summit of a hill about three miles to the west south-west of Zor Shahr. The sandstones and shales of the middle nummulitic series, on which it rests, dip steadily in an easterly direction at a high angle, but no bedding planes are to be seen in the breccia which forms a precipitous scarp, some two to three hundred feet in height. A similar cap, but of smaller extent, is to be seen resting on the top of the ridge formed by the limestone and gypsum bands at the base of the Upper Nummulitic series (Nos. 8 and 9 in Sections) east of Ragha Sar, but I was not able to visit this. The material of the outlier near Zor Shahr appears to have been derived from the hard band of limestone, No. 6, at the top of the Lower Nummulitics, and is perhaps a portion of an ancient talus formed at the foot of the high ridge composed of that rock. The breccia, I am certain, belongs to an older period than the terrace deposits of the river valleys, and may quite possibly date back to Upper Siwalik times.

Comparison with Geology of known areas to North and South.

1. Southern area.

Both to the north and south of the portion of the Suleiman range now described, a considerable gap occurs, of the geology of which little or nothing is known. On the south the survey of the range was carried by Mr. Blanford in 1882 as far as the parallel of 30° 30′ N. Lat., or some 100 miles to the south of the Sherani Hills. At the northern limits of Mr. Blanford's survey the aspect of the tertiary rocks appears to correspond very closely with that of the rocks belonging to the same period found further north, there being a great development of shales and sandstones in the Eocene division, as compared with the sections still further to the south.[1] These rocks also occupy a large portion of the area to the west of the main range traversed by Mr. Ball.[2] Mr. Blanford notes the occurrence of a section on the Charchar Pass[3] of a thin band of limestone intercalated in the olive shales which form the topmost sub-division of the Eocene, and forming a low continuous ridge running north and south, beneath which there are several beds of white gypsum. This band also appears in several streams to the north,[4] and probably corresponds to the band characterised by gypsum layers (No. 8) at the base of the Upper Nummulitics in the Sherani hills. Again, near the northern limits of the area, on the Sangarh stream, a thick band of limestone appears in the middle of the Eocene system,[5] forming a distinct and well marked ridge continuing for a long distance to the north, and known as the 'White Range.' This is possibly the equivalent of the thick band of limestone, forming the top of the lower division of the Eocene in the Sherani hills (No. 6), and immediately overlying the sandstones in which the Moghal Kot oil occurs, where it also forms a conspicuous ridge.

(1) Memoirs, G. S. I., Vol. XX, Pt. 2, pp. 44, 109, 112.
(2) Records, G. S. I., Vol VII, Pt. 4, p. 153.
(3) Memoirs, G. S. I., Vol. XX, Pt. 2, p. 109.
(4) Loc. Cit., pp. 112 to 121.
(5) Loc. Cit., p. 122.

The uppermost beds of the cretaceous series in the southern area were found by Mr. Blanford to consist of hard white sandstones, forming the core of the main range.[1] If these are, as Mr. Griesbach suggests, the equivalents of his group No. 4,[2] the massive limestones and Belemnite beds must be entirely absent in the southern area, a supposition difficult to accept in regard to their great development within so short a distance to the north, and their occurrence also within no very great distance to the west in the country between Thal Chotiali and the Sind-Peshin Railway. It is equally difficult to suppose that the cretaceous limestone and Belemnite beds have been removed by denudation in the southern extension of the Suleiman range, for in that case we should expect to find conspicuous traces of unconformity between the Eocene and cretaceous rocks there, whereas Mr. Blanford distinctly states that all the formations exposed in that section, from Upper Siwaliks to cretaceous limestone shales, are conformable.[3] It seems more reasonable to suppose that the white sandstones observed by Mr. Blanford are, if cretaceous, of local occurrence only, and are not represented at all in the Sherani hills. No fossils were found in them, and Mr. Blanford's reason for placing them in the cretaceous system was the occurrence immediately above them of a band of limestone breccia, which he supposed to mark the base of the Eocene. But, in a recent paper Mr. Oldham takes the 'limestone breccia' as marking the division between the Ghazij and Dunghan groups,[4] the latter of which, from the character of its fossils, holds a doubtful position between secondary and tertiary, though, as he points out, Mr. Blanford considered it to be nummulitic, and he discusses the contradiction involved. The difficulty, however, does not affect the present argument, for whether the Dunghan group is cretaceous or eocene, or intermediate between the two, I should be inclined to consider the white sandstones as the equivalents of that group, which is subject, as Mr. Oldham observes, to abrupt changes of character, rather than to imagine so great a discontinuity of deposition, or such an enormous amount of denudation unaccompanied by any unconformity, as would be necessary to account for their being the equivalents of Mr. Griesbach's Takht-i-Suleiman sandstones.

There is a decided similarity between the physical features of the northernmost part of the area described by Mr. Blanford and of the Sherani Hills. The great anticlinal which forms the main range, and has resulted in the upheaval of the enormous mass of the Takht-i-Suleiman, is continued into the southern area, but it becomes much flattened in that direction, and moreover appears to be divided up into several rolls, so that the tertiary rocks may be traced continuously from the east across the crest of the range to the west. On the east of the main range Mr. Blanford notes the appearance north of Sakhi Sarwar (west of Dera Ghazi Khan) of a double roll in the uppermost tertiaries, a synclinal on the west nearer the main range, followed by an anticlinal to the east. This feature I found to be distinctly represented on the Toi and Shingao rivers in the Sherani hills.

More recently a large tract of country, adjoining and partly included in the area described by Mr. Blanford, and lying to the west of the main range, at a distance of about 150 miles to the south-south-east of that now described, has been geologically mapped in detail by Sub-Assistants Kishen Singh and Hira Lal, under the

(1) Memoirs, G. S. I., Vol. XX, Pt. 2, pp. 43, 113, 123.
(2) Records, G. S. I., Vol. XVII, Pt. 4, p. 185.
(3) Memoirs, G. S. I., Vol. XX, Pt. 2, p. 44.
(4) Records, G. S. I., Vol. XXV, Pt. 1, p. 22.

direction of Mr. Oldham, whose report was published in Part. 1 of the 'Records' for the present year.[1] In a previous paper, published in the 'Records' for 1890,[2] Mr. Oldham had also described the formations existing in that region. The similarity between the various sub-divisions of the tertiary system, as determined by Mr. Oldham, and those observed by me in the Sherani Hills is most striking, and I have little hesitation in correlating the sub-divisions with those named by him, I have no doubt that when the intervening tract of country comes to be surveyed, it will be found possible to trace these sub-divisions from one area into the other. Kishen Singh was able to recognise several features in the composition and disposition of the formations corresponding to those with which he was familiar in the area to the south, and his knowledge of them was of great assistance to me. After leaving the Sherani Hills, I had an opportunity of paying a flying visit to a part of the area surveyed by Mr. Oldham, bordering on the Sind-Pishin Railway, and what I saw there tended to confirm my view as to the general identity of the formations in the two areas.

2. Northern area.

To the north of the Sherani Hills occurs another considerable gap, occupied by the Waziri Hills, regarding the geology of which we have very little knowledge. On comparing the geology of the tertiary rocks in the districts lying beyond this gap, as described by Messrs. Wynne and Griesbach, with those of the same age in the Sherani country, we find that they have little in common, and it is evident that great changes must occur in the interval.

Several considerations tend to show that the Lower Tertiary formations in these hills are more intimately connected with those found in the regions to the south, than with those on the north. Indeed it appears quite possible that a barrier existed in the area now occupied by the Waziri Hills, from later cretaceous to Siwalik times, between the basin of deposition of the Suleiman range, and that of the Safed Koh and North-West Punjab. In support of this hypothesis may be adduced the thinning out of the more distinctly marine beds, the limestones, in the uppermost cretaceous and Lower Eocene formations towards the north in the Sherani Hills. Also the gradual extinction of the Miocene Nari beds in the same direction. In the Sheikh Budin hills, which are clearly visible to the north-east from the Takht-i-Suleiman, Mr. Wynne found that the Eocene nummulitic rocks were entirely absent, and the cretaceous very poorly represented, (3) but that they are found increasing in thickness towards the north-east, in the direction of the Maidan range. Again to the north of the Waziri hills, on the section between Kushalgarh and Thal on the Kurram river Wynne found the Eocene limestones gradually disappearing in a westward direction, (4) while in the Salt Range and North-West Punjab that formation is almost entirely composed of limestone. The Murree group also, so highly developed in the North-West Punjab, was found to become gradually thinner in the same direction. Mr. Griesbach has pointed out that elevation had taken place in the hill area on the north-west frontier in Miocene times. (5) Considering the discordance in strike between the rocks composing the Suleiman range and the Safed Koh with their skirting

(1) Records, G. S. I., Vol. XXV, Pt. 1, p. 18.
(2) Id. Vol. XXIII, Pt. 3, p. 93.
(3) Memoirs, G. S. I., Vol. XVII, Pt. 2, pp. 74, 91.
(4) Records, G. S. I., Vol. XII, Pt. 2, p. 113.
(5) Id. Vol. XXV, Pt. 2, p. 66.

ranges, the former striking due north and south, while the latter strikes east and west, notwithstanding the fact that the upheaval of each of these great ranges was to a certain extent contemporaneous, it does not seem unlikely that in the angle between them the disturbance, which culminated in the production of the two ranges, should have been more intense, and perhaps dates back to a more remote period. An indication of intense disturbance in this region is afforded by the discovery by Mr. Wynne of an outburst of volcanic action to the west of Thal on the Kurram river,(1) whereby beds of Subathu aspect have been greatly altered. The observations of Drs. Stewart and Verchere, comprising the little we know of the geology of the Waziri country, point in the same direction, since they note the occurrence of metamorphic rocks in that district. In the Sherani country itself there is evidence of greater crushing of the strata as we proceed from south to north. The cretaceous rocks which slope at an angle of about 30° to the east in the gorge of the Toi become vertical in the Zao defile, while signs of intense crushing of the supra cretaceous rocks on the latter river are more conspicuous than to the south.

The question cannot be decided until the unexplored area between the Suleiman and Safed Koh ranges is examined, a task that will doubtless be of great difficulty, but of still greater interest geologically, for it is not often that two ranges agreeing so closely in their period of upheaval, but differing so entirely as regards the direction in which the forces that caused the upheaval were exerted, are found approaching each other so nearly. There is little immediate prospect of this examination being carried out, for it is likely to be many years before the Waziris are brought sufficiently under control to allow of an observer moving about in their country with the freedom which will doubtless be necessary to unravel so complicated a piece of geology.

Later Tertiaries.

With regard to the deposits of later tertiary age, the information now obtained from the Sherani Hills supplies a fresh link connecting the Siwalik rocks of the North-Western Himalayas with those of Baluchistan and Sind. The resemblance of the two divisions of the system in the former area with those found to the north and south is complete, both in their lithological aspect and in the occurrence of those mammalian and other organic remains so characteristic of the system.

SUB-RECENT DEPOSITS.

Terrace drifts (See Pl IV).

A few words must be given to the remarkable deposits of river gravels and boulder drifts with which a very large part of the area occupied by the Lower Tertiaries is covered, although drifts of the same character are so universally found at the foot of the hills surrounding the northern boundary of the Indian plains that it would require a far wider knowledge of them than I possess to do justice to the subject. These drifts form an even plain with a very gradual slope from west to east, only broken by the deep, often vertical-sided ravines, cut into it by the rivers of the present day. The ravines are excavated to a very uniform depth of about 300 feet below the upper surface of the terraces, but except near the mouths of the gorges which break through the hard ridges near the main range, the whole

(1) Records, G. S. I., Vol. XII, Pt. 2, p. III

of this depth has not been excavated in the drifts alone, but has been carried down into the rocks beneath, forming the original floor of the valleys in which the drifts were deposited. Thus as we descend the rivers, we find this ancient floor, which is concealed, even in the river beds, higher up, gradually rising to a greater and greater elevation above the present river level, the capping of drift at the same time becoming thinner and thinner. This is well seen on the Toi, where at Moghal Kot the drifts are fully 300 feet thick, forming a vertical wall on either side of the river, whereas opposite Parwara they are reduced to 50 feet or less, although their upper surface is about the same height above the river as at Moghal Kot. From this it would appear that the inclination of the ancient valley floor was less than that of the present river, and yet the size of many of the boulders included in the drift, as compared with the shingle now moved by the rider indicates that the fall of the river in former times cannot have been less, and was probably greater than it is now. If this be the case, it follows that since the deposition of the drifts, there has been a gradual tilting of the ground in a direction parallel to the folding that took place after the deposition of the Siwaliks. It is possible that the earlier folding may have partly determined the position in which the drifts were deposited, but the coarseness of the material of which they are composed appears to require that the flow of water in former times was greater than it is now, and that a great change of climate has taken place in these regions. In some instances the drift terraces extend upwards into the gorges cut through the main range, as in the Zao defile (see sketch in Mr. Griesbach's report, Figure 5), (¹) and they are very conspicuous in the 'Tiri' or belt of country between the main range and the lofty ridge of Lower Tertiary rocks facing it (see Plate V).

Evidences of recent elevation.

ECONOMIC GEOLOGY.

The only mineral of practical importance found in the Sherani Hills is the petroleum which occurs in small quantities near the village of Moghal Kot on the Toi river, where it oozes at several points from the thick band of quartzose sandstone near the top of the Lower Nummulitics, and is collected from shallow pits dug in the sand on the river bank at water level. The oil is of excellent quality, as determined by analysis made by Mr. Holland in the laboratory of the Geological Survey, but does not occur in sufficient quantity under present conditions to be of commercial value. I have already pointed out that it is possible that the flow may be increased to some extent by borings, but that the geological conditions are not such as to lead us to expect that a large accumulation of oil can be tapped within a reasonable depth from the surface.

Mineral oil.

Before leaving Dera Ismail Khan for the hills I was informed by the Deputy Commissioner that some of the military officers who had visited the hills had reported the existence of coal on the river Toi near Moghal Kot, and Mr. Griesbach also mentions the report of coal being found in the same locality, "in the neighbourhood of the Dana pass," *i.e.*, the Chuakhel Dhana.(²) In the gorge above Moghal Kot, in which the oil springs

Coal.

(¹) Records, G. S. I., Vol. XVII, Pt. 2, p. 183.
(²) Records, G. S. I., Vol. XVII., Pt. 4, p. 188.

occur, there are certainly some bands of carbonaceous shale, which I have marked in the section of that gorge attached to my report on the oil, but these are of no value whatever. In the middle nummulitic sandstones also there are occasional thin strings of coal, but no seams, nor did I discover or hear of any in the whole area examined by me.

Gypsum.

There is an unlimited supply of gypsum in the basement beds of the upper group of Nummulitics. In the section at Zor Shahr given at page 87, there are twelve beds of this mineral one foot thick or more, with a total thickness of 50 feet. But gypsum is of such common occurrence in the more settled districts, both to the north and south, that its existence in the Sherani Hills cannot be said to possess any practical importance at present.

Sulphur.

Traces of sulphur were observed in the upper Nummulitic rocks near Domanda, apparently derived from the decomposition of iron pyrites, but I could not discover that it occurs any where in sufficient quantity to enable the people of the country to make use of it as they do in the hills west of Dera Ghazi Khan, where sulphur is found and worked in several localities, as described in Mr. Blanford's Memoir. (1)

Carboniferous Fossils *from* Tenasserim: *by* FRITZ NOETLING, Ph. D. F.G.S., *Palæontologist, Geological Survey of India* (with a plate).

The first information about the occurrence of a fauna of carboniferous age in Tenasserim was given by Dr. T. Oldham in his "Notes on the Coal-fields and Tin-Stone Deposits of the Tenasserim Province."[2] A fauna consisting of corals, gastropods, brachiopods, crustacea was found in a series of sandstones, and grey shaly beds over these sandstones. This is, however, all that is known about this carboniferous fauna except a few remarks by Mr. Theobald,[3] merely stating that a few fossils had been found at Zwah-ga-byn, a limestone hill near Moulmein.

It is, however, not known what has become of the fossils mentioned by these gentlemen. They are not in the collection of the Geological Survey of India, and they were certainly never described in detail.

Under these circumstances it is most satisfactory that Mr. Bose has lately obtained a small series from the limestone hills near Therabwin in Tenasserim, which though rather ill-preserved is sufficient to decide definitely the question of the age of the Moulmein group. The fossils were found weathered and sticking out on the surface of a hard dark limestone, having apparently undergone a partial silicification. This mode of preservation has been most fatal to the finer structure of the foraminifera and corals, it being nearly entirely destroyed. There still remain, however, such characteristics as are sufficient for determination. As regards the

[1] Memoirs, G. S. I, Vol. XX, Pt. 2, p. 126.

[2] Records of the Government of India, Home Department, No. X, 1856; reprinted in Papers on Burma, page 375.

[3] On the Geology of Pegu, Memoirs, Geol. Surv. of India, Vol. X.

brachiopods and gastropods, they are so badly damaged that their specific identity cannot be established; in one case, however—that of *Productus cf. sumatrensis*—there is still a sufficient number of characteristics visible to say that the Burma species is closely related to either *Prod. sumatrensis*, F. Roemer, or *Prod. sub-costatus*, Waag. and Wentzel.

As according to Dr. Oldham's division, the limestone series is younger than the sandstone series, the fauna from Therabwin must be of younger age than that mentioned by Mr. Oldham, though probably of the same age as that from Zwah-gabyn hill. The following species have been distinguished :—

1 Schwagerina oldhami, spec. nov.
2 Lonsdaleia salinaria, Waag. and Wentz.
3 Lithostrotion, spec. nov.
4 Aræpora cf. ramosa, Waag and Wentz.
5 Polypora cf. biarmica, Keyserl.
6 Productus cf. sumatrensis, F. Roemer.
7 Athyris, sp.
8 Spirifer, sp.
9 Bellerophon, sp.
10 Pleurotomaria aff. durga, Waagen.
11 Murchisonia, sp,

So far as any conclusions may be drawn from the above species the chief interest lies in the fact of the association of Indian forms with those known from Sumatra. The genus *Schwagerina* does not occur in the Salt Range, but it is very common in the carboniferous limestone of Sumatra: on the other hand, the characteristic form of *Londsdaleia salinaria* from the middle productus limestone (Salt Range) is represented amongst the Burma fossils, while apparently a new form is represented by *Lithostrotion, sp.* As regards the *Productus* described as *cf. sumatrensis*, it is difficult to say, owing to the state of preservation, whether it represents the Sumatran species or that of the Salt Range, or whether it takes altogether an intermediate place. For reasons stated in the description, I think it to be closer allied to *Prod. sumatrensis*. The remainder of the fossils calls for no special remarks. The fauna may therefore be said to represent one in which Indian and Sumatran types are mixed; thus forming the connecting link between both areas. This is not astonishing; in fact it might have have been expected *à priori*: considering that Therabwin in Tenasserim is, in a straight line, only about 500 miles from the coast of Sumatra, while it is more than four times the distance from the Salt Range; one might in fact have expected a smaller number of Indian forms. I have no doubt that, once the Tenasserim carboniferous fauna is represented by more and better preserved specimens, it will be found that it bears a closer affinity to the Sumatran than to the Indian carboniferous strata.

Regarding the age, the fauna seems to tend to the upper carboniferous period.

Schwagerina oldhami, spec. nov. Pl. fig. 1, 1*a*.

This form is the most common species among the fossils from Therabwin, and although it is never well preserved the examination of a large number of specimens affords sufficient reason for establishing a new species. As already stated, it is impossible to arrive at an exact information as to the internal structure because subcrystalline infiltraticns have largely obscured it.

The average size full-grown specimen has a diameter of 5 mm., and is about 3 mm. in thickness. In lateral aspect the full-grown specimens are therefore flat elliptical, while the younger ones are globular. The depressions marking the longitudinal septa are well marked and nearly evenly distanced, but they do not extend to the edge of the shell, where a smooth well-defined space remains.

Schwagerina oldhami is closely related to *Schwagerina verbeeki, Gein. sp.*, but the latter is easily distinguished by the more globular shape of full-grown specimens while the smooth keel on the edge of the shell is also absent.

Lonsdaleia salinaria, Waagen and Wentzel. Pl. fig. 2.

1886. *Lonsdaleia salinaria*, Waagen and Wentzel, Palæont. Indic., Series XIII, Salt Range Fossils. Productus Limestone Fossils, IV, 2, page 895, pl. C., figs. 1, 3, 4.

The only specimen shows distinctly the specific characters as described by Waagen. The corallum, an irregular-shaped mass, is astræiform, corallites prismatic five to seven-sided. The columella is strongly projecting. The secondary wall is exceedingly well developed, but in thin sections the septa are seen to extend uninterruptedly from near the columella to the outer wall of the calices, and there is no distinct peripheral vesicular zone.

Lithostrotion. sp. nov. Pl. fig 3.

One of the most frequent species is a form which undoubtedly belongs to this genus. It generally occurs in large fasciculate masses, the corallites are tall, and some reach up to 26 mm. in diameter; they are cylindrical and slightly flexuous, frequently cemented together, without, however, affecting the general circular section. The epitheca is thin, the striae always well marked, calices deep and irregularly circular. The columella is rather thick and round; the septa thin and slightly curved; there are plenty of interseptal vesicles.

The species from Tenasserim closely resembles *Lithostrotion affine*, Ret., but it seems that it is generally larger. Milne-Ewards[1] states that *L. affine* is the largest of all fasciculate Lithostrotions, except *L. canadense*, which is, however, easily distinguished by the shape of the corallites. As the Burma species is undoubtedly larger than *L. affine* it probably represents a new species, to decide which more material is, however, required.

Aræpora cf. ramosa, Waagen and Wentzel. Pl. fig. 4.

1886. *Aræpora ramosa*, Waagen and Wentzel, Palæont. Indic., Series XIII, Salt Range Fossils. Productus Limestone Fossils, IV, 2, page 839, pl. CVI, fig. 8-9.

There are several fragments of a massive, arborescent corallum, apparently parts of the branches, which are composed of numerous cylindrical or polygonal corallites, radiating from an imaginary longitudinal axis. The surface is still partly covered with rather small calices, of irregular round shape, but very ill-preserved. Internal structure entirely destroyed. The chief characters by which the specimen from Burma differs from the Indian type, seem to be that the corallites are generally thinner and the calices smaller. The specimens are, however, not sufficient to allow for the establishment of a new species.

[1] British Fossil Corals, page 200.

Polypora cf. biarmica, Keyserling.

1886. *Polypora cf. biarmica*, Waagen, Palæont. Indic., Series XIII, Salt Range Fossils Productus Limestone Fossils, IV, 2, page 791, pl. XC, figs. 5, 6, 7.

There are a few fragments of a Bryozoon that might be referred to the above species; as far as its characters can be observed, it agrees fairly well with Waagen's figure of the above species, but, of course, only more and better preserved specimens will decide the question.

Athyris, sp.

A small brachiopod, the larger part of which is still imbedded in the rock, might be referred to the above genus. The apical angle is a little above 90°; the beak thick and depressed. The surface is covered with fine radial ribs, which occasionally bifurcate; these are crossed by not very numerous but strong striæ of growth, which are on both valves well marked. These characters are insufficient for a specific determination, but it undoubtedly belongs to the group of *Athyris royssii*, Leo.

Spirifer, sp.

A small ill-preserved dorsal valve might perhap belong to this genus.

Productus cf. sumatrensis, F. Rœmer. Pl. fig. 4, 4*a*.

1880. *Productus sumatrensis*, F. Rœmer, Ueber eine Kohlenkalk fauna der Westkueste von Sumatra. Palæntographica, Vol. XXVII, page 5, pl. I, figs. 4*a* and 4*b*.

This single specimen of a Productus is too ill-preserved to allow of an absolutely correct definition. From the sculpture of the valves it is, however, quite certain that is closely related to either *Productus subcostatus*, Waagen, or to *Productus sumatrensis*, F. Rœmer. Waagen states that for a long time he himself considered *Prod. subcostatus* identical with *Prod. sumatrensis*, but he eventually came to the conclusion that the Indian species must be different from that of Sumatra, and therefore receive a new name. Now the main difference between *Prod. subcostatus* and *Prod. sumatrensis* consists in the presence of long and strong spines scattered over the whole surface of the ventral valve, and three or four deep grooves on each side of the dorsal valve which correspond to the strong spines on the other valve in the first species. The Burma specimen is unfortunately too fragmentary to allow of the examination of such delicate differences. There is only the dorsal valve open to examination, and of the ventral valve only a small part can be seen; besides being badly damaged on both sides. The sculpture consists of strong radial ribs, broader than their interstices, which are crossed near the apex by a system of concentric folds in the ventral valve, and a similar structure in the dorsal valve, except that the concentric folds extend as far as the visceral part of the valve. No traces of spines being noticed on the dorsal valve, I am inclined to compare this specimen with *Prod. sumatrensis* rather than with *Prod. subcostatus*.

Pleurotomaria sp. aff. durga, Waagen.

Pleurotomaria durga, Waagen, Palæont. Indic., Series XIII, Salt Range Fossils. Productus Limestone Fossils, IV, 2, page 119, pl. X, fig. 1.

A small, depressed, conical shell, consisting of about four whorls: seems closely related to the above species. There seem to be three principal ridges on the last whorl, between which fine thread-like ribs are observable. The specimen is altogether too badly preserved to allow of any exact determination.

Bellerophon, sp. Pl., fig. 5, 5*a*.

There are four specimens of one or perhaps two species of Bellerophon, which are, however, so badly preserved that a specific determination is impossible.

The larger specimen measures 44 mm. in diameter: the height from the top of the preceding to the bottom of the last whorl being 32 mm. No surface sculpture is traceable, but the species is remarkable for a deep though narrow umbilicus which was certainly not closed. Amongst the Salt Range species I cannot find any resembling this one as regards the deep and open umbilicus, and as *Bellerophon asiaticus*, Rom., is not sufficiently described and figured I am unable to say how far the Burma species is related to that of Sumatra.

Three smaller specimens resemble the big one by the deep umbilicus; no surface sculpture noticeable. These are probably only young individuals.

EXPLANATION OF PLATE.

Fig. 1. *Shcwagerina oldhami, spec. nov.*
Fig. 1*a*.—*b*. *Ditto* *ditto* double natural size.
Fig. 2. *Lonsdaelia salinaria*, Waag. and Went.
Fig. 3. *Lithostrotion, spec. nov.*
Fig. 3*a*. *Ditto* *ditto.*
Fig. 4 and 4*a*. *Productus sumatrensis*, F. Rœmer.
Fig. 5 and 5*a*. *Bellerophon*, sp.

On a deep Boring *at* Chandernagore: *by* R. D. OLDHAM, A.R.S.M., *Superintendent, Geological Survey of India.*

Through the courtesy of M. Aubrey Lecomte, Administrateur Principal of Chandernagore, I have been favoured with a detailed section and very fine series of specimens of the beds passed through in a boring sunk at that town in the hopes of finding water. The experiment has now been abandoned, and it is consequently desirable that the detailed section should be put on record. It is accordingly printed here *verbatim* as received, the only addition being the insertion of the total depths to the bottom of each stratum and the equivalent of the metres in feet.

The section requires but little comment. The bed No. 13 is evidently the equivalent of the peat bed found near Calcutta at depths of from 30 to 35 feet; No. 32 is peculiar as containing numerous sub-angular fragments of felspar which must have been derived from some exposure of gneiss, a granite in the neghbourhood, which has since been covered up by alluvium owing to the subsidence which has taken place in the Gangetic delta; the specimen also contains a fragment of bone, apparently, of a turtle, converted into oxide of iron.

Tableau indiquant le nombre et la nature des couches rencontrées pendant le forage des puits artesien de Chandernagor.

			Thickness.	Depth.	Thickness.	Depth.
			Metres.		Feet.	
No.	1.	Terre végétale	0·80		2·62	
"	2.	Sable fin micacé d'un blanc sale mêlé de coquilles et de nodules calcaires	1·35	2·15	4·42	7·05
"	3.	Sable fin micacé d'un blanc jaunâtre mêlé légèrement de nodules calcaires	0·45	2·60	1·47	8·52
"	4.	Sable fin micacé d'un jaune rougeâtre	0·25	2·85	·82	9·34
"	5.	Sable fin micacé d'un blanc jaunâtre .	0·30	3·15	·98	10·32
"	6.	Sable fin micacé d'un gris cendré .	0·60	3·75	1·97	12·29
"	7.	Argile sableuse d'un gris foncé . .	0·35	4·10	1·15	13·44
"	8.	Argile grisâtre mêlée de débris de coquilles et de nodules calcaires .	0·65	4·75	2·14	15·58
"	9.	Argile d'un noir grisâtre . .	2·50	7·25	8·21	23·79
"	10.	Sable fin micacé grisâtre . . .	1·40	8·65	4·59	28·38
"	11.	Argile noire plastique mêlée légèrement de concrétions ferrugineuses .	0·54	9·19	1·77	30·15
"	12.	Argile noir stratifié mêlée légèrement de bois pourris	0·65	9·84	2·13	32·28
"	13.	Tourbe	2·36	12·20	7·75	40·03
"	14.	Argile gris-noir mêlé de toutes petites concrétions ferrugineuses . .	1·66	13·86	5·44	45·47
"	15.	Argile grise mêlée de petites concrétions calcaires	1·00	14·86	3·28	48·75
"	16.	Argile colorée en jaune et noir mêlée de concrétions calcaires . .	1·90	16·76	6·23	54·98
"	17.	Argile micacée colorée légèrement en jaune par du carbonate de fer .	2·10	18·86	6·90	61·88
"	18.	Argile d'un jaune pale mêlée de nodules calcaires et souillée légèrement de carbonate de fer . .	2·29	21·15	7·51	69·39
"	19.	Argile bleuâtre tachée en jaune par du carbonate de fer	0·40	21·55	1·31	70·70
"	20.	Argile jaunâtre mêlée de concrétions calcaires	2·25	23·80	7·38	78·08
"	21.	Argile bleuâtre colorée en rouge et en jaune par du péroxyde de fer et de carbonate de fer . . .	0·95	24·75	3·12	81·20
"	22.	Argile colorée en jaune par du carbonate de fer	8·38	33·13	27·50	108·70

		Thickness.	Depth.	Thickness.	Depth.
		Metres.		Feet.	
No. 23.	Argile sableuse mêlée de graviers .	0.55	33·68	1·80	110·50
„ 24.	Argile d'un gris pale colorée en jaune par du carbonate de fer et mêlée de nodules ferrugineuses . . .	4·60	38·28	15·10	125·60
„ 25.	Argile d'un jaune sale micacée stratifiée colorée en jaune par du carbonate de fer	1·15	39·43	3·77	129·37
„ 26.	Argile d'un blanc sale micacée .	1·55	40·98	5·09	134·46
„ 27.	Argile sableuse micacée souillée d'oxyde de fer	0·55	41·53	1·80	136·26
„ 28.	Argile colorée en jaune par du carbonate de fer	1·03	42·56	3·37	139 63
„ 29.	Ocre jaune	3·40	45·96	11·16	150·79
„ 30.	Sable argileux micacé mêlé de nodules ferrugineuses	0·90	46·86	2·95	153·74
„ 31.	Sable argileux micacé souillé d' oxyde de fer	1·35	48·21	4·44	158·18
„ 32.	Sable moyen et fin micacé mêlé de pétrification cailloux anguleux nodules ferrugineuses.	24·30	72·51	79·81	237·99
„ 33.	Sable fin micacé grisâtre . .	1·46	73·97	4·79	242·78
„ 34.	Sable moyen micacé d'un blanc grisâtre	?	...	...	...

Note *on* Granite *in the districts of* Tavoy *and* Mergui, *by* P. N. BOSE, B. SC., (Lond.), F.G.S., *Deputy Superintendent, Geological Survey of India.* (With a plate).

The occurrence of granite in the districts of Tavoy and Mergui has an economic importance owing to the usual restriction of tin-ore in its vicinity. It is mainly met with in, though it does not entirely form three parallel ranges running in a general north-south direction. The easternmost of these ranges runs along or close to the boundary between Siam and the districts mentioned above, forming a well-marked watershed, the rivers on the Siam side flowing into the Gulf of Siam, and those on the Burma side running into the Mergui Archipelago. In this range, granite is known to occur at the following places:—

1. Renong, east of the Pakchan river.
2. The head waters of the Lenya and of the Little Tenasserim rivers.

3. The Siam frontier, east of the town of Tenasserim.
4. Parts of the Siam frontier in the district of Tavoy.

The middle one of the three ranges mentioned above forms the western boundary of the Pakchan, the Lenya, and the Tenasserim valleys. In it, granite has been noted at the following localities:—

1. Victoria Point—southernmost extremity of the district of Mergui.
2. Maliwun.
3. Sangái Bále (west of Namnwe).
4. Chaungtanang.
5. Inner Bokpyn.
6. North-west and south-west of Tenasserim.
7. Sixteen miles west of Tavoy, on the way to the Siamese frontier.

In the western range, granite has been found to occur in the southern part of the Henzai basin at a place called Oblingwin and at Maungmagan ten miles north-west of Tavoy. In the district of Mergui, the continuity of this range has been interrupted by submergence. But portions of it are to be met with in some of the islands of the Mergui Archipelago, as, for instance, the King's island, west of Mergui, and Silver island, west of Bokpyn.

The intrusive character of the granite was clearly observed at various places. Schists, the result evidently of contact-metamorphism, were found in contact with it at Maliwun and several other places. On an island west of Bokpyn in the Mergui district which is called Silver island, from the abundance of silvery white mica in the granite occurring there, small branching veins of it were found penetrating through micaceous schists. The junction is well seen here. Close to it the micaceous schist has lost its schistosity and has developed in it numerous crystals of tourmaline which are relatively very large at the line of junction (Pl. fig. 1). A sample from Chungtanang, some distance south of Bokpyn, shows similar junction. Here, however, the tourmaline crystals are not specially well developed at the line of junction (Pl. fig. 2). The intrusion of the granite appears to have affected the adjacent rocks for some distance; and several outcrops of phyllites and slaty rocks in its vicinity (as at Maliwun and Victoria Point), which the season before last I took on a hurried examination to belong to the transition series, appear to me now in the light of what I saw last season, to belong probably to the Moulmein Group which is of carboniferous age. About four miles west of the village of Tenasserim (between that place and Marton) I encountered some slaty rocks of a distinctly transitional aspect. They are within two miles or so of a great mass of granite; and though, owing to absence of good sections, they could not be satisfactorily brought into relation with the less altered members of the adjacent Moulmein Group, it appeared to me highly probable that they belong to it, and that their greater metamorphism was due to contact action.

GEOLOGICAL SURVEY OF INDIA DEPARTMENT.

TRI-MONTHLY NOTES.

No. 16.—Ending 31st July 1893.

Director's Office, Calcutta, 31st July 1893.

All the officers of the Survey are now in recess, their field work having gradually come to a close during the last three months. Mr. Superintendent R. D. Oldham left India on fifteen months' furlough on the 18th July 1893, and Dr. Noetling availed himself of privilege leave on the 15th idem.

The most important feature of our progress has been in the literary work of the department, as signalized by the completion of the second edition of the Manual of the Geology of India, by Mr. R. D. Oldham. As stated in the Prefatory Notice of this new edition :

> In the beginning of 1887 my predecessor, Mr. Medlicott, wrote as follows in his Annual Report of the Geological Survey :—" The two first parts of the Manual of the Geology of India, issued in 1879, have been out of print for some time, and the question of re-writing it has been much upon my mind. Parts of it would require abridgment, leaving local information to be sought for in the special Memoirs ; and parts of it would need alteration and addition in view of extended information. The greater part of the two volumes was written by Mr. Blanford, who was for the time relieved of other work. To re-write the whole while carrying on the manifold current duties of the Survey has been more than I could attempt in India with any justice to either."
>
> The directing of the Survey since Mr. Medlicott's retirement is even fuller of current duties, not the least of which has been a considerably increased system of frequent tours over the length and breadth of the land ; so that, however pressing it may also have been on my mind, I have been unable even to venture on the elaboration of a revised form of Messrs. Medlicott and Blanford's most excellent work ; and I therefore gladly accepted Mr. R. D. Oldham's offer to prepare a fresh issue, accordant with our progressive survey of the Empire.
>
> Mr. Oldham had had a varied experience of survey work over widely separated tracts in India where he had opportunities of studying most of our representative formations in their peninsular and extra-peninsular development: while of his own motion he devoted his first period of well-earned leave to a comparative study of our Gondwána representative, in Australia. His close acquaintance with the literature, as evidenced in the careful *Bibliography of Indian Geology*, compiled by him in 1888, had already indeed predisposed me in favour of a possible ultimate placing of a second issue of the Manual in his hands; and in now authorising that issue I would fain hope that my choice may be justified.

I may add that a considerable part of the book has been largely re-written by Mr. Oldham ; while the subjects of the Carboniferous and Triassic rocks of Extra-Peninsular India, the age and origin of the Himalayas, and the Geological history of the Indian Peninsula are discussed with a newness entirely attributable to his varied travel in India, and his grasp of the results worked out by his colleagues and himself. The issue of the book in the more convenient form of a single volume which, according to the whim of the reader, may be broken up into even more handy sections through the page separation of the chapters; and a re-adjustment and increase of the plates and illustrations will be, it is hoped, an acceptable change on the aspect of the original edition.

A new fasciculus (Part I, Vol. II, Sec. IX) of the Palæontologia Indica, on the Echinoidea of Cutch, by Mr. J. W. Gregory of the Natural History Department, British Museum, was issued in July.

The gratifying intelligence was received in June from our friend Professor Ed. Suess of Vienna, that the large series of fossils collected last year during the Central Himalayan Expedition is now under active study and description. Dr. Diener himself is hard at work with the lower triassic Cephalopoda, towards the illustration of which we have already received ten of the fifteen plates which it is presumed will complete this section of the work. It is understood that all these Muschelkalk forms are new except two. Oberbergrath von Mojsisovics, who is investigating the upper trias forms, notes that the lower Himalayan trias contains several forms of the Siberian trias, and that Austrian types occur in the higher beds. Professor Uhlig and Dr. Francis Suess are engaged on the fossils of the Spiti beds, which will require from forty to fifty illustrative plates; while Dr. Bittner has undertaken the Rhœtic fossils.

The interest attached to this remarkable and richly representative collection of fossils may indeed be estimated from the consideration that our publication of the results is expected by the Austrian savants to bring about quite a change in the aspect of a good part of the Mezozoic marine faunæ. The whole series, including the fossils previously sent to Vienna, which were originally collected by Stoliczka, Godwin-Austen, Theobald, Hughes, Griesbach, and Lydekker is so far-reaching in its bearings that it has been brought into comparative study with the fossils collected by Bogdanovitch and the Russian geologists during their sojourn in the Pamir and Kuenlun, which have been sent down to Vienna from the St. Petersburg Institute of Mines.

The Bhaganwala coal-field exploration was closed on the 6th July. It is gathered from Mr. LaTouche's abstract report on the field that:

"The evidence of the distribution of coal in this field is of two kinds, (*a*) that afforded by the natural outcrops, which surround the greater part of the area, and (*b*) that afforded by the drifts, which have been put in at various points along the outcrops.

(*a*) A study of the first shows that the distribution of coal is extremely irregular, and that the good coal of workable thickness which is exposed at certain points dies out, if traced along the outcrops, and becomes replaced by sandstones and shales.

(*b*) This evidence is borne out by that of the drifts, none of which, except those that were started in good coal at the outcrop, have proved the existence of a workable seam further in, or even an improvement in the outcrop indications.

"The conclusion to be drawn is that in making an estimate of the quantity of coal available, we are justified in taking into account only those areas in which the existence of good coal has been proved, and adding an amount, not actually proved, depending on the distance beyond those areas, to which the coal seam may be reasonably supposed to extend.

"The amounts thus calculated are—

From the areas actually proved, 88,480 tons.

From those in which the existence of good coal may be reasonably assumed, about 900,000 tons; or a total of, say, one million tons of coal.

"The conditions under which the coal is found are distinctly favourable for mining purposes, as the workings will have a good flour and roof of sandstone, and except where the mines are carried to a considerable depth, no great influx of water need be anticipated."

Field operations in Burma were closed early in May; and reports have been sent in to the Burma Government by Dr. Noetling for the Wuntho Division of the Katha District, and by Mr. Bose for the Tennassarim District.

The Director returned from touring in Burma on the 13th of May, whither he had gone on the 18th of April, closing the month with a short visit to the Warora Collieries in the Central Provinces. At Rangoon, he conferred with the Financial Commissioner on the examination of the reported gold finds in the Wuntho Division; and then proceeded to an inspection of the coal tract on the great Tenasserim river which was being explored by Mr. Bose, assisted by Mr. Datta. The auriferous tract in Wuntho, which may extend over a very large area, some 2,000 square miles, has only been touched as it were; the efforts of Dr. Noetling having been devoted to an examination of several spots indicated by applicants for prospecting or leasing blocks, adjacent to which block surveys were being made by the Survey of India party. The area so far appears to be one of extensive development of volcanic agglomerates and diorites, occasionally traversed by quartz veins some of which are auriferous; but a fair estimate of the possibilities of the region cannot be formed until a more extended geological examination is made, after the rains and their effects in such a wild jungly region have cleared off.

The coal exploration in Tenasserim is closed; and Mr. Bose's report confirms the previous estimate by Mr. Hughes, namely, that the presumable quantity of available coal under not difficult working is about a million tons; extended and deeper working might yield half as much again.

While prosecuting this exploration Mr. Bose was fortunate in obtaining a small collection of fossils from the strange cavernous limestones in the formation below the series in which the coal just mentioned occurs, which prove the long apprehended carboniferous age of this yet lower series; though the few carbonaceous traces occurring in this series are too poor to be considered of any commercial value. A description of these finds is furnished in the present number of the Records by Dr. Noetling, the Palæontologist.

Mr. Middlemiss has completed his survey of the Hazara District; and is now engaged on the preparation of a Memoir on its geology. Towards the end of this season a further find of what seemed to be a promising outcrop of coal was made near Juswal among the hills, four miles south-east of Abbottabad in the valley of the Dore river, though at a height of 2,500 feet above the level of the river, up the very steep slope of a rather inaccessible ridge. The coal is much like that in Hewson's locality, to the north-east of Abbottabad, *i. e.*, much crushed up and mashed by being cut through and through by shear planes; and being locally from 10 to 17 feet thick, it looked much more promising than that of Hewson's shaft. A very careful extraction of foot by foot of a large sample was sent down to Calcutta, but on assay (given in the list of assays appended further on), the percentage of ash in 9 feet, averaging 46·03, is altogether prohibitive. At the tenth foot, there is a decided improvement, with only 17·20 of ash and 65·80 of fixed carbon, but below this the average ash percentage is again as high as 31·95; so that the best we can say is that the better portion of the seam can only be useful for brick and lime burning.

List of assays and examinations made in the Laboratory, Geological Survey of India, during the months of May, June, and July 1893.

Substance.	For whom.	Result.
1 specimen of coal.	Anara Valley Coal Syndicate Calcutta	Proximate analysis, with calorific power and sulphur determination.
16 specimens of coal, from Begarmal near Juswal, Hazara.	C. S. Middlemiss, Deputy Superintendent, Geological Survey of India.	(see below)

	1	2	3
	"No. 1 from the top; first 4 feet."	*"5 feet from the top."*	*"6 feet from the top."*
Quantity received.	*4 lbs.*	*3 lbs.*	*3 lbs.*
Ash percentage.	53·04	58·70	37·12
Colour of ash	Reddish grey.	Light red.	Light red.

	4	5	6
	"7 feet from the top."	*"8 feet from the top."*	*"9 feet from the top."*
Quantity received.	*4 lbs.*	*3½ lbs.*	*2 lbs.*
Ash percentage.	54·52	37·60	35·20
Colour of ash	Light red.	Reddish grey.	Dark red.

7

"10 feet from the top."

Quantity received	*3 lbs.*
Moisture	5·20
Volatile matter (exclusive of moisture)	11·80
Fixed carbon	65·80
Ash	17·20
	100·00

Does not cake. Ash—light red.

List of assays and examinations made in the Laboratory, Geological Survey of India, during the months of May, June, and July 1893—continued.

Substance.	For whom.	Result.			
			8	9	10
			"11 feet from the top."	*"12 feet from the top."*	*"13 feet from the top."*
		Quantity received	*4 lbs.*	*3½ lbs.*	*3 lbs.*
		Ash percentage.	33·20	34·12	22·60
		Colour of ash	Light red.	Light red.	Red.
			11	12	13
			"14 feet from the top."	*"15 feet from the top."*	*"16 feet from the top."*
		Quantity received.	*4 lbs.*	*4 lbs.*	*3 lbs.*
		Ash percentage.	21·20	35·80	22·48
		Colour of ash	Red.	Reddish grey.	Red.
			14	15	16
			"17 feet from the top."	*"18 feet from the top. Bottom ft. 8 seam."*	*Selected specimen. Begarmal near Juswal.*
		Quantity received.	*3 lbs*	*4 lbs.*	*9½ lbs.*
		Ash percentage.	32·92	56·12	22·20
		Colour of ash	Dark red.	Light red.	Light red.
"One specimen of ore for determination" from Hazaribagh.	B. L. Trizoni .	Iron pyrites.			
One specimen of Coal from Pwela at Nan-Kon, Burma.	C. G. Bayne, Revenue Secretary to Chief Commissioner, Burma.	*Quantity received*			*7 lbs.*
		Moisture			17·42
		Volatile matter			38·66
		Fixed carbon			32·32
		Ash			11·60
					100·00
		Does not cake. Ash—buff			

List of assays and examinations made in the Laboratory, Geological Survey of India, during the months of May, June, and July 1893—continued.

Substance.	For whom.	Result.
11 specimens of coal.	R. A. Donnithorne, Secretary to the Commissioners for the Port of Calcutta.	Proximate analysis, with calorific power.
3 specimens of coal.	Finlay, Muir and Co., Calcutta.	Proximate analysis.
5 specimens of coal from the "Hosannah Seam, Pit I."	Finlay, Muir and Co., Calcutta.	Proximate analysis.
1 specimen sent as "Ruby Silver Ore."	C. M. P. Wright, Wuntho, Burma.	Micaceous iron ore.
Three specimens of iron ore, and one specimen of limestone from Burma.	P. N. Bose, Geological Survey of India.	Iron ore (limonite) from Maha Champa:— *Quantity received 4lbs.* Contains . . . . 37·58 % Fe. Iron ore (limonite) frow Therabwin:— *Quantity received 9lbs.* Contains . . . . 50·49 % Fe. Iron ore (limonite) from above Banlaw, Tenasserim Valley:— *Quantity received 1 lb. 6oz.* Contains . . . . 36·06 % Fe. Limestone from Therabwin:— *Quantity received 1 lb.* Insoluble in dilute hydrochloric acid . . 13·40 Oxide of iron and alumina . . . . ·61 Carbonate of lime . . . . . 85·85 Carbonate of magnesia (by difference) . . ·14 100·00
One specimen of pyritous quartz, from Kabiotoung, about 3 miles west of Pinlon Village, north of Wuntho, Kawlin Sub-division, Burma.	Fritz Noetling, Geological Survey of India.	*Quantity received 5 lbs.* Contains no gold.
One specimen of galena and one of iron pyrites.	R. A. D. Sewell, Prospecting Officer, Rewah State.	Galena, with quartz from the "Workings at Orgari":— *Qnantity received 22 lbs.* Yielded on assay—61·60 per cent. of *lead*, and 7 oz. 16 dwt. 19 grs. of *silver* to the ton of lead. *Quantity received 4 lbs.* Iron pyrites. Contains no gold.

List of assays and examinations made in the Laboratory, Geological Survey of India, during the months of May, June, and July 1893—concluded.

Substance.	For whom.	Result.
2 specimens of supposed Tremenheerite.	P. N. Bose, Geological Survey of India.	Carbonaceous shale from "Tagu"—Tenasserim :— *Quantity received 2 lbs.* Contains 87·12 % ash. Ash—Dark brick red. Carbonaceous shale from Woona, Tenasserim Valley, Mergui District :— *Quantity received 1 lb.* Contains 88·00 % ash. Ash—light buff.
1 specimen of coal from Nazira, Assam.	Kilburn and Co., 4, Fairlie Place, Calcutta.	Proximate analysis.
1 specimen of coal from Makum, Dibrugarh, Assam.	Kilburn and Co., 4, Fairlie Place, Calcutta.	Proximate analysis.
2 specimens coal .	R. A. Donnithorne, Secretary to the Commissioners for the port of Calcutta.	Proximate analysis with calorific power.
A rock specimen from top of Parasnath Hill, Hazaribagh.	W. Saise, Giridih.	Granitite or quartz diorite—quartz, plagioclase felspar, augite under process of uralitization, hornblende, garnet, with radiating fibrous reaction zones, and biotite. Structure granitic, in places granular.
2 specimens of coal from Darjeeling.	John King and Co., Limited, 30, Strand Road, Calcutta.	Proximate analysis, with calorific power and sulphur determination.
6 specimens of coal.	Finlay, Muir and Co., Calcutta.	Proximate analysis.
One specimen, of quartz with iron pyrites and visible gold.	Gillanders, Arbuthnot and Co., Calcutta.	Assayed for gold.

Notification by the Geological Survey of India during the months of May, June, and July 1893, published in the "Gazette of India," *Part II.—Leave.*

Department.	No. of order and date.	Name of officer.	Nature of leave.	With effect from	Date of return.	REMARKS.
Geological Survey Department.	925, dated 20th June 1893.	F. Noetling, Palæontologist, Geological Survey.	Privilege	15th July 1893.	...	...

Annual increments to graded officers sanctioned by the Government of India during May, June, and July 1893.

Name of officer.	From	To	With effect from	No. and date of sanction.	REMARKS.
	R	R			
R. D. Oldham, Superintendent, Geological Survey.	900	950	1st May 1893.	Revenue and Agricultural Department No. $\frac{1249}{127}$, dated 25th May 1893.	
W. B. D. Edwards, Assistant Superintendent, Geological Survey.	380	410	1st July 1893.	Revenue and Agricultural Department No. $\frac{1719}{159}$, dated 18th July 1893.	

Postal and Telegraphic Addresses of Officers.

Name of Officer.	Postal address.
T. W. H. HUGHES	

VI

..y between ..ear Sháhrág.

..scription of the geology ..oirs, Vol. XVIII; with regard ..o differing from mine, but as these do ..y nere described, I have determined to postpone ..'s criticism until I have not only re-visited some of my old ..., but also until I can give a more complete outline of the geology of Baluchistán, and for the same reason I abstain from discussing points in the geology of the ground lying beyond the limits of the map accompanying this paper. For the present it will suffice to mention one single point of this discussion which materially affects the geology of the Khóst-Harnai sections. At page 11 of his Memoir Blanford says "that his lowest stage of the eocene system in the Bolán pass and near Quetta, the *Alveolina* limestone, cannot be accepted as a definite subdivision"—and after stating that *Alveolinæ* occur also in higher horizons in the eocene, he mentions on page 15,—"there is no distinct band of limestone, whether characterised by the abundance of *Alveolina* or not, of sufficient importance to be distinguished as a primary subdivision or stage, either in the Bolán pass or near Quetta, at the base of the eocene system." I have since been in communication with the author;

B

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 4.] 1893. [November.

On the Geology *of the country between the* Chappar Rift *and* Harnai *in* Baluchistán, *by* C. L. GRIESBACH, C.I.E., *Superintendent of the Geological Survey of India.* With map and three plates.

I.—PRELIMINARY OBSERVATIONS.

The area described in these pages was geologically examined by me during the winter months of 1892-93 and comprises within it all the collieries opened out by the North-Western Railway between Khóst and Harnai.

Previous observers; W. T. Blanford.

The ground has been visited and reported on several times; the first geological description is contained in Dr. W. T. Blanford's Memoir "*Geological notes on the hills in the neighbourhood of the Sind and Punjab frontier between Quetta and Dera Ghazi Khán*"; chapter VI of this memoir notices some of the geological features of the country between Quetta and Sibi, and the author describes in some detail a section near Sháhrág.

In that Memoir the author discusses at some length my description of the geology of the Bolán and the Quetta area contained in Memoirs, Vol. XVIII; with regard to some points of it he comes to conclusions differing from mine, but as these do not affect the geology of the country here described, I have determined to postpone my reply to Dr. Blanford's criticism until I have not only re-visited some of my old sections, but also until I can give a more complete outline of the geology of Baluchistán, and for the same reason I abstain from discussing points in the geology of the ground lying beyond the limits of the map accompanying this paper. For the present it will suffice to mention one single point of this discussion which materially affects the geology of the Khóst-Harnai sections. At page 11 of his Memoir Blanford says "that his lowest stage of the eocene system in the Bolán pass and near Quetta, the *Alveolina* limestone, cannot be accepted as a definite subdivision"—and after stating that *Alveolinæ* occur also in higher horizons in the eocene, he mentions on page 15,—"there is no distinct band of limestone, whether characterised by the abundance of *Alveolina* or not, of sufficient importance to be distinguished as a primary subdivision or stage, either in the Bolán pass or near Quetta, at the base of the eocene system." I have since been in communication with the author;

Dr. Blanford still believes that a distinct limestone stage at the base of the eocene division cannot be otherwise than a local development, the limestone passing into shales and sandstones, both in Sind and Baluchistán. This may be the case but it is remarkable that up till now I have found that the lithological character of the tertiary sequence remains very constant, excepting near the centres of the then volcanic activity along the Kójäk-Zhób line of country. At all events in the Quetta sections and the country here described the lower eocene is represented by far the most conspicuous formation, and perhaps,—excepting the Siwaliks,—by the greatest thickness of beds found to belong to any one of the rock-divisions of Baluchistán. Even palæontologically it is distinguished; whilst in the lower nummulitic limestone practically nothing but foraminiferæ, chiefly *nummulites*, in very large number have been found, the middle eocene (green shales, etc.) have so far yielded very few *nummulites;* but on the other hand numerous eocene *gasteropods, bivalves, echinoderms* and in some places even fresh-water mollusks. I think it is highly probable that the green shales, etc., of the middle eocene are a local development as seen near Khóst and Sháhrág and that elsewhere the fauna assumes a more pelagic character. Dr. Blanford himself has noticed the great development of the limestone which forms the base of the eocene, and I may here quote his notice of the rock-series near Harnai which is given on page 49 of his Memoir, namely:—

a. Olive shales and sandstones.
b. Nummulitic limestone.
c. Olive shales and sandstones.
d. Nummulitic limestone.

He says:—"Throughout the Harnai route below Kach the lower nummulitic limestone (*d*) forms immense hills, including the Pil and Chappar ridges, the upper part at least of the huge mountain mass north of Sháhrág and Harnai, and a number of hog-backed elongate hills of smaller elevation." This is essentially the position I take, excepting that I believe that this lower nummulitic limestone forms a constant horizon over a considerable area, and that it extends both into Khorassan and over the larger part of South-Western Afghanistán, and in fact is part of the great Mediterranean development of the eocene,—whilst Blanford considers it a local facies only.

E. I. Jones.
Dr. W. King.

The first, rather more detailed examination of the area about Khóst was undertaken by the late Mr. Jones of the Geological Survey, who has left a manuscript report behind, which I have used in this paper, quoting him when doing so. Dr. W. King has given some extracts of this report in the Records, Vol. XXII, p. 149, and these consist chiefly of the economic side of the coal-fields near Khóst.

R. D. Oldham.

In 1889 Mr. Oldham was detailed for work in Baluchistán and the outcome were two papers which appeared in the Records of the Survey, namely:—

(1) *Report on the Geology and Economic Resources of the country adjoining the Sind-Pishin Railway between Sharigh and Spintangi, and of the country between it and Khattan,* Records, XXIII, p. 93; and

(2) *Report on the Geology of Thal Chotiáli and part of the Mari country,* Records, XXV, p. 18.

The substance of these papers is also contained on pages 289 to 293 of the second dition of the Manual of the Geology of India brought out by Mr. Oldham this year.

Generally agreeing with Oldham's views, I must differ from him in two particulars. In the first place I doubt the utility of adopting local names for subdivisions, the homotaxial positions of which are known. I have adopted the terms, *lower*, *middle* and *upper* nummulitic in place of his Dunghán, Gházij and Spintangi "groups."

The second point on which I differ from Oldham is of more importance.

This author described the thick-bedded limestone with *nummulites*, which I believe to form the base of the eocene division, as underlying the Gházij shales and to be nummulitic, but later he included this subdivision with the cretaceous system, which view he takes in the new edition of the "Manual."

In this, our interpretations completely differ. It has frequently been pointed out, and it is the opinion of most modern continental geologists, that the base of the tertiary system should be placed much lower down than it is at present, and that certain upper cretaceous beds, as for instance the upper hippuritic limestone of the Mediterranean, be included in the tertiary system. At all events until more is known of the organic life of the rather barren formations of the upper cretaceous, it seems a dangerous move to change from the old order, if for no other reason than that of convenience. And for this purpose it is perhaps best to accept it as a general rule that all beds with true *nummulites* be included in the tertiary system, making the beds below cretaceous. This I believe is now the view of most authors on the subject, and most continental geologists therefore separate a well-defined upper hippuritic horizon in Greece, Egypt, etc., with *nummulites*, from the lower *rudiste* limestone, which is cretaceous. Mr. Oldham, on the other hand, has done the reverse; he has extended the range of the cretaceous of Baluchistán into the confines of the lower eocene. In his second paper above quoted, he simply mentions of the "Dunghán group,"—my lower nummulitic limestone,—that its fauna is anomalous, and although in the absence of sections and detailed statements it is difficult to form an opinion whether this anomaly is confined to one particular point of observation or is shown elsewhere, it appears that he found *crioceras*, *baculites* and *ammonites* with an abundance of *nummulites*.

In the "Manual," however, this formation is boldly spoken of as cretaceous. and thus one of the most thickly developed and conspicuous formations of Baluchistán is removed from the tertiary system.

Without going into the discussion of the fossils closer, I may at once state that however interesting a find of *belemnites* and *ammonites* would be in *tertiary* beds of Baluchistán, it could not quite be looked upon as an anomaly.

In the eocene of Europe occur several genera of belemnites (in Zittel's sense), and some genera of *ammonites* have been described from the eocene of California. On the other hand, the upper hippuritic beds of the Mediterranean hitherto generally classed with the lower limestone horizons, as cretaceous, contain *nummulites* and are now included in the tertiaries. If, therefore, Mr. Oldham's observations were substantiated, the Dunghán limestone ought rather to become lower eocene, and this only in deference to the general usage of relegating to the eocene all beds with an abundance of true nummulites. And this would also be more in accord with stratigraphical facts, which point to a division of the tertiary system from the cretaceous immediately after the great post-cenomanian "transgression."

But fortunately I have had an opportunity of viewing Mr. Oldham's "anomalous" fauna since my last return to Calcutta, and in this I was advised by Dr. Noetling. It seems that all the cephalopods are true cretaceous forms, some of them in very fine preservation; they point to a lower rather than upper cretaceous age of the beds. There were *no nummulites* in the collection from these fossil-bearing beds, but well-preserved *orbitolites*, which occur in the cretaceous as well as tertiary systems. It seems, therefore, most probable to me, bearing in mind the fact that so far nothing but true tertiary forms with *nummulites* have been found in other localities in the "Dunghán limestone," that the observation referred to is not complete. I hope to have an opportunity this year of further studying this special locality.

Hill-ranges.

Geographically the area belongs to the system of ranges and valleys which form the eastern part of Baluchistán. These ranges are disposed in a series of parallel lines east of Quetta, where they continue in a gentle curve towards east, gradually turning north-east and northwards until they merge into the system of the Sulaiman range which forms the natural and mountainous barrier between the Punjáb and Baluchistán. The most striking feature of these parallel ranges is the great bend near which the cantonment of Quetta is situated; the re-entering angle formed by them is occupied by a very complicated series of parallel ridges composed of rocks of Siwalik age, which have grouped themselves round the great massif of the Zarghún. Between these ranges which are chiefly made up of Siwalik strata, and the next adjoining chain of hills, a depression or trough extends all round the Zarghún massif with its skirt of parallel ridges,—which trough forms part of a series of wide valleys. I shall have occasion to refer to this feature in this paper and propose to call this depression made up of a series of valleys,—the "trough." The area immediately under discussion in this paper may be defined as lying between the system of Siwalik ridges to the south and south-west, and the precipitous limestone range of the Khaliphát, near the western termination of which the Chappar Rift is situated.

South of Mangi, a station on the North-Western Railway, an absolutely bare limestone range closes the valley on its right side; it is one of the most perfect examples of a simple anticlinal. About four miles west of Mangi this fold is seen to gradually dip conformably below younger beds which surround the hog-backed range on three sides near its western termination. From that point the range may be followed eastwards; it forms at first a slight bend to south-east and then trends away due eastwards,—always preserving its character of an anticlinal fold. About six miles north-east of Sháhrág station another range of similar composition and structure commences and follows an easterly direction.

These ranges form the northern margin of the depression or trough to which I have been alluding.

The southern ranges are of simpler structure; a scarp, formed by a sequence of tertiary beds, faces northwards and is skirted along its face by several secondary flexures made up of the same beds,—the whole forming a ridge or ridges about 2,000 feet above the level of the "trough."

The northern margin of the latter, formed by the limestone anticlinals described, rises to much greater altitudes; varying in height a good deal, there are elevations of 10,000 to 12,000 feet to be found in it, and it generally presents a very imposing aspect, particularly in winter when it is covered by masses of snow.

The drainage of this area is roughly speaking directed from north to south; the trough or depression aforementioned does not form one valley but is divided into several catchment areas by low passes, mere swells of the ground, whilst the drainage escapes through the ranges by a series of narrow defiles,—true transverse valleys of erosion.

Rivers.

The first stream which we must notice, and at the same time one of the best known amongst them, is the Khóst river. It flows along the valley in which Mudgorge and Mangi are situated, receives some slight additions before reaching Mangi and then escapes through the Chappar range by way of a narrow defile, eroded out of the hard limestone anticlinal. After traversing this range almost at right angles to its strike the river flows in the natural trough of Dirgi and Khóst running in a more or less south-easterly direction to a point about 2 miles south-west of the village of Ombo, whence it flows through a succession of narrow defiles eroded out of the parallel ranges of tertiary strata which form the southern margin of the "trough." On its way to this defile the Khóst river receives a number of small tributaries on its left side, which drain and erode both the southern slope of the Khaliphát range and the great fans which stretch from the latter southwards. East of this system of drainage is the rising ground of Sháhrág with the great buttress formed by a hill south of it, which together make up the watershed between the Khóst river and the Punga stream, which also works its way through narrow defiles and escapes south. East of the Punga stream, another rise in the ground forms a watershed between the latter and the Nasak drainage. The latter has its source amongst the high hills of the Khaliphát range near Ziárat; after flowing in deep and narrow ravines in this range it breaks through the Wangi range in two defiles, mere slits in the hills, and after traversing the fans in numerous deep channels the river collects near Nasak and has cut its way through the ranges south of it forming a succession of narrow tangis or defiles.

The Harnai drainage is similarly formed; separated from the more western Nasak stream by high ground, the Harnai river itself rises in the eastern continuation of the Khaliphát range, flows through a narrow valley scooped out of the southern range (north of Harnai), called the Wam Tangi, and then flows southwards as the rivers further westwards are doing.

This drainage brings us face to face with one of the great and interesting problems of frontier geology,—namely, the transverse valleys. I cannot here discuss the many theories which have been advanced to account for these defiles; the literature concerning these and similar valleys is immense and the views often very divergent. The common belief no doubt is that these narrow defiles have been caused by some great cataclysm, which had torn asunder the hill ranges and so opened the road for the waters to escape. I need hardly say that there is no evidence to support this view, and though it is quite possible that one explanation could never be applicable to all cases, it may be assumed beyond doubt that the defiles in Baluchistán are in the vast majority of cases the result of gradual erosion by the existing rivers, that is to say that the erosion took place simultaneously with the folding and consequent elevation of the strata and that the softer ones of the latter have suffered more by this gradual erosion than the harder rocks, which would account for the gradual widening into broad valleys of those parts which are composed of softer beds, mostly shales and clays. The possibility is not excluded,—it is even highly probable,—that as erosion went on simultaneously with the folding that occasionally the drainage became dammed up and thus lakes were formed, only to disappear again as erosion cut down deeper into the confining rim.

Structure.

The ground described here has in common with the rest of Baluchistán undergone great disturbance in the manner of folding and crushing of its strata. One remarkable feature which must be noticed is the frequent coincidence of mountain ranges with natural anticlinals on the one hand and the marked regularity of what Prof. Suess called a scaly structure in other cases, which latter produces the recurrence of parallel hill-ranges, which present a scarp on one and a dip-slope on the opposite side. Whilst the anticlinal ranges are commonest seen in the lower limestones (upper cretaceous and nummulitic), the latter structure is repeated with strange regularity in the areas occupied by beds of Siwalik age. Partly the structure of these latter rocks is owing to an alternation of harder and softer beds, which, yielding to sub-aerial denudation in a different manner, assume the appearance of a "scaly" structure where the beds are inclined. But I am convinced by the evidence of what I saw in the field that this alone will not account for the apparent enormous sequence of such beds and that the explanation of it is frequently a combination of unequal denudation with a series of parallel faults which have repeated sequences of beds, thus producing the semblance of what would otherwise constitute an enormous thickness of beds forming a natural sequence.

Besides these two great features of mountain formation which are even noticeable during a flying visit to Baluchistán, we have often considerable areas occupied by softer strata (sandstones and shales of middle eocene) which are tremendously crushed and folded between the harder series of rocks within which they occur. Such for instance is the case in the " trough " aforementioned and along which the line of railway to Quetta has been laid. This area shows the beds, where they are exposed below the recent alluvium and fans, crushed and folded in such a manner that a correct estimate of their thickness or nature would be quite out of the question. Only where such beds have been protected by a great weight of overlying strata is their section at all clear.

The anticlinal ranges are running more or less from east to west within the area under description, and they may be said to be echelonned and advancing southwards from the eastern flank. The Khaliphát range (of which the Chappar is the westernmost extension) is a fine example of such an anticlinal. The hill-ranges which form the southern margin of the " trough " show the scaly structure, whilst the " trough " itself is occupied by the crushed and much-disturbed beds of the middle eocene.

One more structural feature remains to be noticed, and that is the large extent and perfect development of fan deposits which slope down gently and evenly from the high (anticlinal) ranges af the Khaliphát and Wám hills, and which to a large extent fill the "trough," at the same time obscuring the underlying beds.

Disturbing causes.

It would be impossible to enter here into a discussion of the causes which have led to the wrinkling and folding of the strata of Baluchistán. Scarcely enough material for such discussion has been collected yet, and all we can say at present is that the disturbance in this country belongs to the extended system of mountain folding which has been termed the Iranian system of folds; this system of mountain formation extends far into Persia and there forms wide zones of parallel folds, which are closely connected with the loops and zones of the hill-ranges of Baluchistán, and through the latter with the ranges of the Mari country, and finally merge into the north-south chain of the Sulaimáns.

The period when the greatest disturbance—contraction into folds—took place, probably belongs to late miocene times, though many changes in the distribution of land and sea had already taken place during the latter end of the eocene age.

Whether there was a period when this tendency to contract the sediments into folds lessened in intensity, is difficult to say, but certain it is that the same forces were still at work at a much later period and are probably being actively continued now. That this is the case is shown plainly by the tremendous disturbance which the younger tertiaries (Siwaliks) down to the recent (Indus) gravels have suffered, which are laid into folds and frequently raised up vertically.

Frequent earthquakes and even dislocations (see Records, Vol. XXVI, p. 57) which are a common experience in Baluchistán and indeed all along our frontier, are no doubt closely connected with this folding process.

Dislocations.

That such crushing and folding could not pass off without leading to dislocations and faults must be evident. Within the area described here larger dislocations are absent, though smaller faults and slips are so common, particularly along the scarp facing north of the southern margin of the "trough," that it has not only rendered a really detailed and correct survey of the geological features difficult if not impossible, but has proved a most unpleasant feature in the coal-mining operations which the North-Western Railway carries on along this scarp. Several of the more evident of these faults I have entered on the map, more to show the system of these slips diagrammatically than intending to place on record any individual fault.

Joints.

In like manner large cracks, or rather joints, run through the harder rocks (mostly limestones) of the anticlinal ranges which bound the area northwards. They may be seen on the absolutely bare hill-sides, mostly dip-slopes, as for instance on each side of the Chappar; they run in long straight lines, intersecting each other at all angles and are frequently widened out by the eroding agency of water which percolates into these joints, and converts some of them into small defiles.

"Rifts."

The "rifts" have been eroded out mainly and almost solely by the agency of flowing water, and they represent true cases of transverse valleys as already stated; but at the same time it could not be denied that the joints and cracks spoken of, which in several instances may be observed in all the stages of mere cracks to miniature defiles, must have frequently been the first cause of the formation of such defiles, although as the erosion progressed the original direction given perhaps by a small fissure, or joint, would be altered until finally it would be impossible to recognize in the tortuous course of the defile any original main joint plane.

II.—Formations.

Passing from south to north across the ground here described an entirely normal sequence of rocks is met with from the younger tertiaries (Siwaliks) to beds which may belong to the cretaceous system.

In descending order I observed :—

		Rocks.	Thickness in feet.
PLIOCENE	Upper	Grey sandstone	3,000?
	Lower	Red and purple sandstones with shaly beds	2,000?
		Grey sandstone, near base calcareous grits and conglomerate	700?
NUMMULITIC	Upper	Nummulitic limestone, concretionary. Sandstone, near base conglomerate	500
	Middle	Bright coloured sandstones and shales, fossils. Gypsiferous shales, sandstone and olive-coloured beds with coal-seams	650
		Greenish sandstone and shales	800
	Lower	Grey limestone with nummulites, etc., about	200,5
Upper cretaceous?		Red and purple shales, sandstone, etc.	300

Cretaceous beds.

The transverse valleys of the Chappar Rift and of the Wám Tangi (north of Harnai) are the only localities where rocks older than the nummulitic formation have been met with in this area. The outcrop seen in the Wám Tangi is of small extent and not very characteristic. The Tangi traverses a single anticlinal of hard dark-grey limestone with nummulites, which represents the lower eocene subdivision; near the centre of the anticlinal light green, marly limestone with shaly partings appears in which I have found no fossils. But there is no difficulty in correlating this horizon with similar shales which occupy the same stratigraphical position in the hills further eastward and in which Mr. Oldham has found *belemnites*, and which horizon may be looked upon as forming approximately the upper limit of the cretaceous system.

Better developed are similar shales with marly and sandstone beds, which occur in the Chappar Rift in a similar stratigraphical position below the lower nummulitic limestone. There they consist of green shales with sandstone layers and deep purple to reddish shales which contain strings of gypsum. I have not found any fossils in this subdivision, but *belemnites* have been obtained from these beds by Mr. LaTouche.

Lower nummulitic limestone.

The following subdivision forms by far the most conspicuous series of strata in Baluchistán. Range on range running in long parallel lines, consist almost entirely of the grey limestone beds of this series. The long line of hills, beginning some few miles west of the Chappar Rift and continuing eastwards as the Khaliphát range, is formed of a simple anticlinal of lower nummulitic strata. North of the Harnai hills extends another anticlinal range made up of the same limestone. The total thickness of this series of beds can hardly be less than about 3,000 feet; at the Takatu hill the same series may possibly reach a thickness of 4,000 to 4,500 feet, and this I believe is the maximum thickness of the formation.

Lithologically there does not seem much difference between this subdivision of the nummulitics and the massive limestone of the cretaceous system (the hippuritic limestone) which I have met with elsewhere in Baluchistán. It is a hard dark grey, occasionally almost white limestone consisting mostly of thick beds. The surface of the dip-slopes, which usually form the bare hill-sides are honeycombed and deeply cut into by cracks and fissures, which render the climbing of even very steep ascents a peculiarly easy task.

Within this thickness of dense grey limestone are several horizons at regular intervals, which at least in the Chappar Rift section seem to increase in frequency and thickness. These horizons consist of a concretionary limestone, which from a distance and on weathered surfaces strongly resembles a conglomerate. A similar facies of rock occurs in the upper nummulitic limestone (Oldham's Spintangi's) and I could discover no very marked difference between the two. Similar rock, well known to German geologists as "Knollenkalk," I have seen in other formations and localities. The softer portions which fill the space between the limestone concretions disintegrate on the weathering surfaces and thus leave the individual lumps of limestone isolated, giving the whole rock a conglomeratic appearance. Nodules and concretions of chert are not uncommon in this horizon.

The only fossils which I have found in this limestone are casts of gasteropods and bivalves with numerous *nummulites* and *alveolinæ*.

During my first visit to Baluchistán in 1880 I distinguished this horizon as the "*alveolina* limestone." Mr. Oldham has described the same subdivision as the Dunghán limestone; but there seems to be some uncertainty whether beds in which Mr. Townsend has found true lower or middle cretaceous *ammonites* and which Mr. Oldham doubtfully included in his Dunghán group, as well as other beds from which Mr. Oldham collected *ammonites, belemnites, echinoderms* and *bivalves* of true lower or middle cretaceous type, together with *foraminiferæ*, not *nummulites*, and which Oldham includes with the Dunghán limestone, should be really correlated with the limestone of the Chappar, the Khaliphát and the upper limestones of the Wám Tangi, while all of them have up to the present not yielded anything else but true eocene types of fossils.

The occurrence of *nummulites* together with what are usually considered upper cretaceous forms, as for instance *rudistes*, is well known; and in Egypt, Asia Minor and Greece *nummulites* are numerous and common in the Upper Hippuritic limestone, hitherto considered upper cretaceous: indeed there are not only palaeontological but stratigraphical reasons why the tertiary system should have been fixed at the base of the cenomanian rather than is done at present. But this difficulty does not affect the present question; neither does the established fact that both *belemnites* and *ammonites* do occur in the tertiary system, several forms of the latter being unquestionably represented in the tertiaries of California.

The difficulty seems to me to lie in the circumstance that (1) not sufficient proof has been given that the lower nummulitic limestone of the Takatu, the Chappar and Khaliphát ranges are really identical with the *ammonite*-bearing limestone, (2) the supposed *nummulites* which have been collected with these lower or middle cretaceous forms are not *nummulites* but species of *orbitolites*. Probably an opportunity will occur of studying this locality once more during the coming season, and I will defer further remarks until this has been done.

Middle eocene.

From an economic point of view the most important formation represented in Baluchistán is the considerable thickness of shales and sandstones which forms the middle portion of the eocene, and rests conformably on the lower nummulitic limestone in all the sections examined. Whilst the latter is obviously a pelagic formation, the character of the beds which overlie it, points to the probability that it was formed either in a lagoon or close to, and in between shallow portions of a coastline, some of its deposits possibly even within the delta of a river.

Not only the lithological character of the beds but also their fossil contents point to such conclusions. Sandstones, generally of a greenish-brown colour, occur locally near the middle portion of the series, which are clearly of fresh-water origin as the numerous specimens of *Unio* show. The rest of the strata consist mostly of greenish-grey sandstones (often extremely like the lower Siwaliks in appearance), shales and clays and subordinate layers of impure limestone with coarse grits higher up. Gypsum in leaflets, nests and veins is common throughout the formation, but especially frequent in the lower half of the subdivision.

The usual phenomena may be observed which are connected with the occurrence of gypsum; the expansion of it (of the anhydrite associated with it) and subsequent dissolving of it by the percolating atmospheric waters have caused the immense local disturbance which we may observe wherever these middle eocene rocks are exposed to the surface and to the influence of weathering.

The coal-bearing beds of Much in the Bolan belong to this subdivision; indeed the outcrop of these beds is continuous from Harnai, *viâ* Mudgorge, Gandak, Spintangi, and then extends from Astangi to Much, the section across the eocene into the overlying Siwaliks being quite identical throughout. In 1880 I adopted theterm "Ranikot beds" for them, comparing and correlating them with the beds of that name in Sind. I have not seen the latter myself, but I thought that both in stratigraphical position and lithological character they corresponded so closely with the Much beds that I could use the term in the same manner as we include in the word Talchirs, rocks of very differing character forming the base of the Gondwanas. Dr. Blanford, who has seen both Much and the Harnai development of the eocene series, prefers not to use the term Ranikot for the green shales and sandstones of the middle eocene, though admitting that they correspond very closely. I prefer not to use new and local names for geological horizons, when the approximate age of the same is known,and therefore am only too willing to drop the term " Ranikot beds," and shall continue to call them middle nummulitic in this paper.

For the same reason I do not adopt Oldham's name of Ghazij beds which he has given to this important horizon.

The general sequence of beds within this subdivision of the eocene is as follows, in *descending* order[1]:—

Horizon.	Description of beds.	Thickness in feet.
MIDDLE NUMMULITIC	6 Bright coloured shales with sandstone, which weathers a brick-colour.	200
	5 Brown sandstone; partings of shell limestone .	60
	4 Gypsum shales	30
	2 and 3 alternation of shales, sandstone, gypsiferous clays and coal seams.	370
	1 Greenish sandstone and shales, about . . .	800
	TOTAL, ABOUT .	1,460

[1] The numbers in this subdivision correspond with the numbers in Plate 2.

This series of beds is of some considerable importance, as it contains a large amount of coal just above the lower half of its thickness. Thin coaly partings and seams of a few inches in thickness are found at various horizons of the series, but they are frequently only of small extent laterally, and thin out rapidly. But in one horizon (2-3 in above section) at least two seams occur, parted by an irregular layer of shales, which are of great importance for Baluchistán. The seams have an average thickness of perhaps two feet, and it pays to extract the coal on scientific principles. The horizon is rather extensively worked between Dirgi and Sháhrág under the superintendence of Mr. Hope, and there is every prospect of further supplies, though not on a more extensive scale, being obtained from Sháhrág itself, where systematic mining will be commenced.

Coal seams.

In all sections between Dirgi and Harnai and above the middle nummulitic shales and sandstones, a very characteristic formation may be observed, namely a series of light-coloured limestones full of fossils, which stratigraphically and palaeontologically must be assigned an upper eocene age, and which Mr. Oldham has termed the Spintangi beds, so-called from a locality where these beds are strongly developed. I distinguished the horizon in 1880 as "nummulitic limestone" overlying the "Ranikot beds;" Dr. Blanford terms the same simply *upper nummulitic* and, as such, I shall speak of the subdivision in this paper. I do not see any necessity to distinguish this series of beds by any local name, since we know its exact geological horizon.

Upper Nummulitic.

The lithological character of the upper nummulitics is generally very constant; the greater thickness of it consists of light coloured grey or yellowish white limestones, sometimes with shaly intercalations, but containing fossils almost throughout its thickness. The series of beds is perhaps best seen (within the area under description) in the sections south of Harnai, where they seem to be developed in greater thickness than in the sections further west or north-west, but that may be due to the fact that in both instances the upper nummulitics are overlaid by the lower Siwaliks, and so may have suffered in some localities greater erosion than in others.

South of Harnai may be seen to perfection the very considerable alternation (in the upper portion of the series) of yellowish white earthy shales with a greyish white concretionary limestone. I noticed this rock-facies in the lower Bolan in 1880 and described it in Mem. Vol. XVIII, p. 30; lithologically it belongs to the same development as the concretionary limestone of the lower nummulitics (Chappar Rift, Wám Tangi, etc.), but I think it is more largely represented in the upper nummulitics. Similar rock is seen in the limestone beds of Sukkur and Rohri on the Indus (Kirthars of Blanford), where a peculiar red clay forms irregular masses and particles between the limestone nodules, which are often replaced by chert concretions with numerous fossils. This red clay reminded me of red clay inclusions in beds supposed to be representatives of deep-sea deposits.

Fossils are common throughout the upper nummulitics; they form a considerable collection and await determination.

The thickness of this subdivision of the eocene varies in the different sections; at Khóst and Sháhrág it certainly does not exceed 500 feet in thickness, but it may thicken out to quite 1,000 feet in the Harnai section. I doubt, however, whether it will be found of much greater thickness elsewhere.

Siwalik formation.—Next in importance to the eocene division of the tertiary system in Baluchistán is the immense thickness of beds of the Siwaliks, which range in age from the upper miocene to pliocene times. Large tracts of country in Baluchistán are made up of rocks belonging to this facies of the middle and upper tertiary system. I think it is quite possible that an unconformity will be found between the lower and upper portions of this formation, which so far I have not met with as a connected sequence. There are some considerable variations in the lithological character of these beds, but it is not difficult to divide them into the following subdivisions, each distinct enough to be recognized in most instances without any trouble.

Age.	Divisions.	Character of beds.	Approximate thickness in feet.
PLIOCENE.	Siwaliks. Upper.	(e) Buff coloured and grey sandstone with shales and gypsum in veins and flakes.	3,000 to 5,000
		(d) Grits and variously coloured clay and shales with gypsum.	1,500
		(c) Brick-red and reddish purple sandstone and shales; sandstone often mottled.	1,500 to 2,000
MIOCENE; UPPER	Siwaliks. Lower.	(b) Grey, often greenish grey sandstone with shales, towards base calcareous grits.	700 to 800
		(a) Grits and ferruginous breccia; conglomerate of chert nodules In the grits rolled specimens of *nummulites* often form regular layers.	50 to 100

The upper Siwaliks, though largely developed on that part of the frontier, are not found within the area described in this paper, whereas the lower beds of this facies form the greater mass of the hills which confine the "trough" along its southern side.

The boundary between the upper nummulitics and the lower Siwaliks is very marked indeed and nothing could be more in contrast than the white or ochre coloured limestones and the grey sandstones of the upper nummulitics with the ferruginous grit of the lower Siwaliks, which generally weathers a deep brown, almost black, and might be taken for a trap intrusion when viewed from afar off. The bottom bed of the Siwaliks is almost invariably composed of this grit; only here and there, dark yellow to brown ochreous deposits replace the conglomerate, but even then the boundary is very clear.

With this contact bed at the base, occurs locally a chert conglomerate of very peculiar nature. It is almost entirely made up of chert nodules, often of very large size, cemented together by a ferruginous matrix. Some of these chert nodules may have been derived from the upper cretaceous or lower nummulitic limestones, but I think the greater number of them come from the upper nummulitic beds, which in some localities (as for instance near Sukkur on the Indus) contain great quantities of chert concretions which yield well-preserved *foraminiferæ*. Immediately above the bottom bed (which is of very insignificant thickness, though prominent in colour and lithological character) occur fine-grained grey and greenish grey sandstones with irregular beds of grits and calcareous gritty sandstone in which fossils, *i.e.*, mammalian and reptilian remains, are not scarce. They are most frequently found in the gritty parts of the formation, and they come out of the stone in very fair preservation.

Bones are found right through the lower Siwaliks, but I never obtained any but very poorly preserved specimens much above the lowest horizons.

The grits and chert breccia at the base pass gradually into thickly stratified grey sandstone of the common pepper and salt appearance, which sometimes show a greenish tinge, in which case they are difficult to distinguish from the middle eocene sandstones. An occasional bed of reddish sandstone comes in, and these become very frequent near the upper boundary of the series (b) and finally pass into the great thickness of brick-red to purplish mottled sandstones (c) with shales. They have yielded some friable fragments of bones.

Grey sandstones.

The beds of the lower Siwaliks form the scarp on the southern side of the "trough," and south of it, range on range appears to be composed of this formation. These ranges show true "scaly" structure, not monoclinal folds; the repetitions of grey with brick-red coloured sandstone seem to point to a system of parallel faults, and the lateral compression resulted in a certain degree of dove-tailing into each other of an otherwise moderate thickness of these two main subdivisions of the lower Siwaliks. If we looked upon this belt of Siwaliks as forming a continuous sequence of beds, we should have to assume a very much larger thickness for this formation than we are justified in doing. The upper Siwaliks are not represented in the country described in this paper, and I believe it will be found that a considerable unconformity divides the lower from the upper series, which are always met with in separate areas.

As far as parallelism of strata goes no sort of unconformity can be detected between the eocene beds and the lower Siwaliks in most of the sections northwest of Sháhrág. But apart from the fact that the upper eocene is developed essentially as a marine series of strata, whilst the Siwaliks, as their fossil contents close to the boundary show, is a fresh-water, probably lacustrine formation, there must also be taken into consideration the peculiar nature of the beds at the base of the latter. They are all of them such as form either in shallow water or close to the banks of a river or the shores of a lake. They are grits and conglomerates with thin beds made up almost entirely of the destruction of eocene rocks with their fossil contents rolled and worn.

Whilst there is no deviation from the parallelism of strata visible in the Khóst and Sháhrág valleys, we may observe splendid examples of the latter in the neighbouring area of Kach where lower Siwalik strata, with the bone grits at their base rest on the eroded edges of the cretaceous beds below. Similarly a distinct overlap and unconformity between the lower Siwaliks and the upper nummulitic limestone may be seen in the sections south of Nasak and Harnai.

It is necessary here to mention also the very considerable deposits of recent conglomerates, grits and sandstone which mostly in the form of enormous fans occupy such large tracts in the "trough." They form terraces and fans gently sloping down from the high hills which bound the "trough" along its northern margin and have now been deeply cut into and eroded by

Recent.

the present streams which drain the valleys. They form a thick covering over the great trough-like depression, and are eroded into V-shaped valleys by the existing drainage, which frequently exposes the much-contorted eocene beds below.

I did not observe any disturbance of these recent beds, such as is seen near the entrances of the Bolan, near the Nari gorge and along the eastern slopes of the Sulaiman range.

III—SECTIONS.

Near the Chappar Rift.

Between Dirgi station on the North-Western Railway and the Chappar Rift the ground is most unfavourable for the geologist. The lower nummulitic limestone forms a very fine example of an anticlinal in the Chappar range, which is conformably overlaid by the green sandstones and shales of the middle eocene; between the Chappar Rift and Dirgi the actual contact is not seen, but south-east of the latter station, beds of the middle eocene may be observed in natural contact with the lower limestone, and this contact is conformable. Similarly north-west of the Chappar, much-crushed beds of the middle eocene subdivision rest evidently conformably on the limestone, but the hill-sides are far too much obscured by debris and slipped masses of rock to furnish clear sections. This part of the middle eocene is a continuation of the Mudgorge beds of this subdivision, and may be traced to the station of that name without interruption.

Dirgi.

The sections west and north-west of Dirgi are perfectly normal, but the disturbance is so enormous, that I did not attempt even to study the beds in detail. Coal-seams occur, and they might possibly be found to be part of one or at most two seams, but by faulting and folding the semblance of a number of seams has been produced.

Disturbance of strata.

The middle eocene beds, so conspicuous for their olive green to grey colour, with brown sandstones near the upper part are overlaid conformably by white or light grey limestone with *nummulites* and other fossils of the upper eocene, which again is overlaid by the Siwalik formations. The latter form the uppermost scarp of the range. The average dip of the whole sequence of beds is at an angle of 40° to 45° to south-west. The great disburbance which the beds have suffered is not only due to the natural folding process, which has affected all the strata in Baluchistán, and which in the first instance is probably the result of the lateral contraction of the area once occupied by the beds; it is also influenced to a very large degree by the chemical and other processes which have followed the wrinkling of the strata into mountain masses. Foremost amongst these processes is the change which these beds undergo, through the conversion of the anhydrite nodules and veins so common in the middle eocene, into gypsum, and the subsequent dissolving out of the latter by percolating water. The first leads to an expansion of the mineral and consequent distortion of the strata containing it; the latter creates cavities and leads to the slips which have altered the face of the hills. What with the distortion of these beds, which is bound to bring about minor wrinkles and folds where there is no great thickness of beds overlying and protecting the gypsiferous middle eocene subdivision, and the slips which must necessarily occur, where the angle of the scarps is considerable, the disturbance which has affected the surface of the middle eocene is immense, and it is not frequently possible to make out the true sequence of beds. Undoubtedly secondary folding, and even apparent unconformities between the subdivisions of the eocene, which are formed of such varying rocks, have been produced and may be traced in the valley above Dirgi; such can, in fact, be seen along the whole length of the "trough."

Mr. Jones on Dirgi.

The following notes were made on the Dirgi neighbourhood by Mr. E. J. Jones of the Geological Survey of India:—

"Ascending a stream, which comes down the hill side above Dirgi (north-west of it) one passes over a great thickness of the gray or olive green sandy shales, alternating with light green sandstones, which north-west of the station are seen to dip 50° S.W. A little further on (W. 10° N. from the station) there are some coal-seams, the dip being 70° S.W. near the base of the section, lessening to 30° S.W. near the top.

The section is in descending order:—

Description of beds.	Thickness. ft.	in.
Dull pink shales of great thickness with green conglomeratic sandstone	2	0
Coal-seam	1	0
Shale	0	9
Coal	0	5
Shale	0	5
Coal	0	5
Shale	8	0
Coal	0	1
Shale	3	0
Coal	0	6
Fine-grained sandstone and shales, partly concealed, but about	20	0
Coarse soft sandstone, locally conglomeratic	17	0
Fine-grained sandstone	6	0
Shales	11	0
Coal	0	1
Grey carbonaceous shales	0	4
Good coal	0	3
Shales	0	8
Coal	0	6
Pyritous shales	0	9
Greenish do.	4	7
Carbonaceous shales	0	3
Great thickness of green shales	...	...

Above this section sandstones and shales are seen to continue some distance, with few thin seams of coal (none of over 1 inch in thickness). Further up still, there is a small coal-seam in shales dipping 40° S.S.W., but it is very friable; it may be traced for about ½ mile along the outcrop, when it is covered up by the talus. Immediately below this coal the sandstone contains numerous small bivalves. For some 70 to 100 feet sandstone and shales alternate, and they contain at several horizons thin seams of coal or carbonaceous matter. This series is overlaid by shaly beds of very prominent red, green and light grey colours. In a stream-bed south of Dirgi, near the station, the shales and sandstones dip 40° S.W., beyond which they roll a good deal, and finally dip 30° N.W., near which point I saw a carbonaceous band in the shales. Much disturbed beds follow with some coaly inclosures, overlaid by the highly coloured clay shales seen in the former section which in turn are overlaid by nummulitic limestone.[1]

Between Dirgi station and the railway bridge below, there are numerous exposures of thin seams of coaly matter in the shales; they are much disturbed and their dip varies all round the compass.

Close to the end of the railway bridge, on the right bank of the river, the dip is 40° N.W., whilst nearer the hill they dip about the same angle to south-east.

[1] The Upper Nummulitic limestone.

There is an outcrop of coal on the south side of the Uzdap Sháh anticlinal S.W. from the railway bridge; it is very poor and leafy and does not improve in lower depth. Two seams of coal can be distinguished about 50 feet apart, but the highly coloured clay-shales have slipped down from above, partly covering up the section. They appear now as if both underlying and overlying the coal series.

Mr. Jones on Hákim Khán.

Near Ka'la Hákim Khán, about 1 mile from the railway, coal traces may be seen along the face of the hill for about ¼ mile, though partially covered up by slips.

The following sections are taken from actual exposures and from the headings which have been driven into the hill-side to prove the coal [1]:—

Near the centre of exposure; No. 9 heading.	ft.	in.	At the bottom of the heading 23' from the surface.	ft.	in.	Bottom of No. 6 heading.	ft.	in.
1. Sandstone	2	...						
2. Dull green clay	3							
3. Sandstone	32	...						
4. Clay and shales	12	...	4 *Coal*	...	2			
5. Coloured shales	1	6	5.	...	7	5. Shales	...	...
6. *Coal*	...	6	6.	...	7	6. Leafy *coal*	...	8
7. Brown clay	...	3	7.	...	1	7. Shaly parting	...	1
8. *Coal*		...	8.	1	10	8. Good coal	...	11
9. Brown shales	1	...	9.	...	1	9. Shales	...	10
10. *Coal* with partings	...	10	10.	...	8	10. *Coal*	1	2
11. Friable sandstone	...	7						
12. Light coloured sandstone	8	3						
13. Shaly sandstone	6	...						
14. Shales with sandstone partings	11	...				The whole dipping 55°.		
15. Shales and shaly sandstone	84	...						

At the south-east end the section is at the bottom of the heading; dip 30° S.W.

Description of beds.	Thickness. ft.	in.
4. Clay shales	...	...
4*a*. *Coal* with a thin parting of shales	...	5
5. Shales	...	½
6. *Coal*	...	11
7. { Brown shales	...	9
7. { Carbonaceous shales	...	5
8 *Coal*	...	10
9. Brown shales	...	6
10. Good *coal*	1	...
11. Sandstone	...	...

The section in another heading close to No. 9 is dipping 55° to S.W., and is as follows in descending order:—

Description of beds.	Thickness. ft.	in.
4 to 5 { Grey shales	...	...
4 to 5 { Carbonaceous shales	...	5
4 to 5 { Grey shales	...	6
6. *Coal*	1	4
7. Coaly shales	...	4
8. *Coal*	1	5
9. Clay shales	...	1
10. *Coal*	...	9
11. Sandstone	...	...

[1] Mr. Jones does not mention it, but I assume that the section is a descending one.

Section north-west of No. 9 heading dipping S. 20° W.

Description of beds.	Thickness. ft.	in.
Grey shales	...	...
Carbonaceous shales	...	8
Grey do.	...	6
Coal	...	5
Carbonaceous shales	...	2
Coal	...	9
Carbonaceous shales	...	1½
Alum do.	...	3
Coal	...	3
Carbonaceous shales	...	2
Coal	...	10
Shales	...	3
Coal	...	11
Sandstone	...	...

Khóst Sections.

More important are the sections across the Khóst valley, both as regards the geology which is clearer, and also because some of the best seams of coal of the eocene division of Baluchistán are found there and are being mined.

About 2 miles north-west of Khóst station, and almost opposite Buzgai Rága, a much-disturbed section is *in situ*; the base of the hill slope, which forms the right (south-west) side of the valley, consists of green sandstone and shaly beds characteristic of the middle eocene. The dip is steep to south-west. They are overlaid by shaly greyish brown sandstone, concretionary, showing at places concentric structure. About half-way up the hill side brownish grey sandstone with calcareous layers appears, which is the typical rock of the middle of this subdivision of the eocene. Towards the base of this sandstone series, three considerable thicknesses of sandstone are alternating with shales; the former are about 20′ thick each, and are equidistant from each other. The two lower horizons of shales are traversed by fissures and joints filled with gypsum, and this mineral forms flakes and nests throughout the formation. The shales between the three sandstone horizons contain several poor seams of coal, very irregular in thickness, and it appears from some abandoned workings that they frequently thin out very rapidly. The best and steadiest seam or group of seams is near the upper part of the second sandstone horizon and is descending:—

Description of beds.	Thickness. ft.	in.
Shales	...	...
Coal	...	½
Sandstone	...	4
Coal	...	3½
Carbonaceous shales	...	6
Coal	...	9
Carbonaceous shales	...	8
Coal	...	3
Calcareous shales	...	4
Sandstone	...	...

This is the Khóst coal horizon, which further south-east improves greatly. The dip is steady, 40° to south-west.

The hill-side is greatly obscured by debris and slipped masses, besides which some minor faults evidently repeat the section, for as I ascended I found, after a small thickness of shales, the same series of sandstone repeated, which passes into a considerable thickness of coloured shales, and above it follow some 150 to 200 feet of brown to olive coloured sandstone on which rest conformably the grey fossiliferous upper nummulitic limestones; which again are overlaid by the grey, and further on by the purplish red sandstones of the Siwaliks.

Higher up a fault which runs parallel to the strike of the hill range, cuts off the section and the upper portion of the upper nummulitic limestone with the great mass of the Siwaliks is repeated.

Mr. Jones on Khóst.

Mr. Jones had also examined this last section, and has found several repetitions of it caused by local slips and faulting; he says that "there have been two distinct landslips on the face of the hill, so that the coal-seams are repeated three times, thus giving the idea of a large number of seams. The section according to him is as follows:—

Description of beds.	Thickness. ft.	in.
1. Variously coloured clay shales	...	...
2. Dark-greenish blue shales	...	...
3. *Coal* with shales (mostly the latter)	6	...
4. Shales	40	...
5. Good, bright *coal*	1	...
6 Shales	12	...
7. *Coal*	...	9
8. Shales	70	...
9. Sandstone	10	...
10. Shales	3	...
11. Carbonaceous shales	1	6
12. Shales with a *coal*-seam, 1" thick	10	...
13. Sandstone	10	...
14. Carbonaceous shales	...	2
15. Shales with calcareous concretions	1	...
16. Pale-coloured shales	...	
17. Shales with two *coal* partings of 5" each	2	2
18. Shales	10	..
19. *Coal*	...	3
20. Shales	60	...
21. Sandstone	10	...
22. Shales	20	...
23. Sandstone	9	...

Below this are seen the variously coloured clay shales which have been let down by a fault, and the whole section is repeated.

The ground immediately to the south of the Dabak section (and W.S.W. of Buzgai Raga) is very similar to the area last described. Very little of the beds is seen *in situ*, owing to the numerous minor faults, and the enormous mass of debris which covers the hill-sides. The climbing of the latter is exceedingly easy, though rough, but very little is seen of the lower and middle parts of the section. I could distinguish, though not so clearly, the three sandstone zones alternating with green arenaceous shales, which latter seem to be in greater thickness in this section. They are traversed by a network of veins of gypsum, and there is much surface disintegration and bulging out of the shales in consequence.

The sandstone beds both below and above the coal-seams are full of organic remains; plant-impressions, stalks and carbonaceous matter, besides a great number—whole nests in fact—of a species of *unio*, thus clearly showing the fresh-water origin of the horizon.

The upper portion of the gentle slopes which are composed of these sandstones, and the shaly beds above them, is almost entirely covered up by the debris from the upper nummulitic limestone, which forms a distinct cliff, a precipitous scarp facing northwards. It is composed of a light-coloured limestone full of fossils, *corals*, *foraminiferæ*, *gasteropods* and *bivalves*. This upper eocene subdivision forms the highest part of the crest and part of the dip-slope, which descends down the other side of the range. It appears to be about 150 to 200', thick, but it is most probable that this does not represent the entire thickness, as it has no doubt been extensively denuded before the lower Siwaliks were deposited on it.

Above this upper nummulitic limestone follows the ferruginous grit with chert nodules, and irregular layers of impure limestone chiefly made up of rolled *nummulites* from the limestone below, and this is overlaid by grey grits (with fossil bones) and greenish grey sandstone of the lower Siwaliks. The great hill-mass (7,810') west of the ridge is made up of the purplish red and brown sandstones of the Siwaliks. The dip of the upper nummulitic limestone, which is the same as that of the beds below, where not locally disturbed, is 33° S.W.

A very curious concretionary limestone grit, which weathers a dark rust colour, forms a small thickness between the upper nummulitic limestone and the coal-horizon below, but I have not met with this bed in the sections further south-west.

South of the Khóst Rest-House.

The hill-side south of the rest-house at Khóst shows a similar section to those further to the north-west of it, but the coal-bearing horizon is better developed. There seem to be four distinct horizons of greenish grey sandstone, which contain numerous *unio* and some plant-impressions which are alternating with green shales, in the lowermost horizon of which the workable coal-seams occur.

Above this sandstone and shale series follow highly coloured, pink and greenish clays and arenaceous beds with sandstone partings.

The sandstone and shales series with coal-seams does not exceed 350' in thickness apparently, whilst the highly coloured clays and shales above may be about 500', but that is only a rough estimate, as the numerous slips and small faults put a correct measurement quite out of the question.

The highest beds of the section are, as in the former cases, sandstone and grits which are conformably overlaid by the richly fossiliferous upper nummulitic limestone.

About 2 miles south-east of the Khóst station this limestone is overlaid by the grey sandstone of the lower Siwaliks, which have yielded some rather good and well-preserved fossils in the grits near their base; the upper beds are, as already seen in the sections north-west of Khóst, formed by the purplish red mottled sandstone and shales, also containing bone fragments, but they are less well preserved than those found in the lower beds. Together this Siwalik series forms high and steep scarps along the entire crest of the range south of Khóst, presenting dip-slopes towards the south-west on the other side.

South of Khóst Station.

Almost due south of Khóst station the face of the cliff is much faulted, but several large and intact blocks have slipped down on the north slope, which are now mined for coal, and which so far have yielded the best fuel. There are two series of mines separated by a tongue of debris which occupies a shallow valley between spurs of middle eocene. The spur on the north-west side of this tongue of debris shows about the same section as the hill-side south-west of Buzgai Raga; the lowest beds which are exposed—in fact the middle horizon of the middle nummulitic—consist of greenish-grey sandstones, with reddish grits and sandy beds. They pass into highly coloured clays and shales with gypsum, which are cverlaid conformably by the fossiliferous upper nummulitic limestone. The chief coal-horizon is found in the sandstones and shales below, and I believe that there is only one good seam, consisting of a very steady bed of about 2 feet of coal, with a parting of gypsiferous clay shale of varying width. Above and below occur insignificant seams, generally only of a few inches in thickness, which frequently are found to thin out rapidly, and then generally pass into a ferruginous layer, which sometimes shows some thin partings of leafy coal. The dip varies from 40 to 45° S.W. and S., and the workings are all on to that seam. There are several minor faults which have repeated some of the beds several times over, which makes this subdivision of the eocene appear to be of much greater thickness than it really is.

Siwaliks near Khóst.

The upper nummulitic limestone, which forms a conspicuous light-coloured band along the hill-side, is overlaid by the ferruginous and chert beds with concretions (pisolitic) of clay iron ore. This passes into a ferruginous conglomerate, which locally becomes a coarse grit; it is overlaid by and interstratified with grey Siwalik sandstone. The grits often form patches in the sandstone which contain fossils,—fragments of bones and teeth in excellent preservation. The total thickness of the grey sandstone with the grits below can scarcely be more than 300 feet.

The highest part of the range is formed by reddish purple and rust-coloured sandstones and shales, also containing fossil bones, which rest conformably on the lower beds, but are of much greater thickness. I estimated the thickness south of Khóst at not less than 800 to 1,000′, but this does not represent the total development of the lower Siwaliks, which is enormous. The dip is about 40° S.W. and S.

The Khóst collieries which are south-east of the tongue of debris mentioned, are situated in a wedge of the middle nummulitic which has been let down by a system of parallel faults. Indeed, this has been proved not only by the features on the surface which are somewhat obscured, but by the fact that in several of the workings it has been found that the coal suddenly nips out,—owing no doubt to having been crushed against a fault plane.

Ali Khán.

The range on the right side of the valley shows much disturbance between Khóst and the gorge south-west of Ombo. A series of small faults showing no special feature, save that they are directed generally from south-east to north-west, have let down the hill-side in steps, which gradually bring the upper nummulitic limestone down to the level of the river (see plate I, fig. 1), which is the case south-west of Ombo. The result is that the otherwise normal section of the middle nummulitic has been repeated several times, and mining is rendered much more difficult thereby; several apparently fine outcrops of coal may be seen along the hill-side, one south of Ali Khán being specially remarkable owing to the fact that the local disturbance which the beds have suffered have resulted in a most intricate folding of the beds and with them that of the coal-seam, which being closely folded and dove-tailed, measures at one place not less than 14 feet, the actual and original seam with its centre parting of shales being not more than a little over two feet.

About 2½ miles south-east of Ali Khán the beds sweep round the scarp of the range and up the low pass of Spar Báz leading to Shangal, where another small fault may conveniently be observed,—this one of south-west to north-east strike. Considerable crushing may be observed eastwards of the fault, and the upper nummulitic, which forms a good landmark in the section, is seen to form the lowermost rock in the river-bed. The entire crest of the range is formed by the lower Siwaliks, the grey sandstone with the purplish red sandstone and shales above. The continuation of the section downwards must be looked for north of the range, amongst the low hills and the undulating country which form the base of the trough and immediately west of Ombo, the watershed between the Khóst and Ombo rivers. The greater part of the valley is covered by the enormous fans which descend from the Khaliphát range, but recent denudation has worn them into long strips and has formed long V-shaped channels in the great thickness of gravels and recent sandstone which compose the fans. Further away from the hills, in the low reaches between Khóst and Púnga, the middle nummulitics are exposed in patches surrounded by recent deposits, and are found to be extensively folded, crushed and dipping in every direction. Thin coal-seams are found in these beds, but they are far too much disturbed to be of any great economic importance; where seams of this kind are seen, they can and often are followed up by native contractors, but in such disturbed areas scientific mining is altogether out of the question.

Patches of such rocks are seen here and there in the deeply eroded channels which are formed in the fans, and north and north-east of Khóst some thin coal-seams are seen in the green shales and sandstones of the middle nummulitics.

Mr. Jones has examined the Khóst sections and in his MS. report has given the following section which is exposed in the eastern Khóst ravine, just below the variously coloured shales which overlay the main coal-horizon of Khóst:—

Description of strata.	Thickness. ft.	in.
1. Hard brown sandstone	20	0
2. Light green shales	3	10
3. Deep red shales	3	3
4. Green shales	47	11
5. Brown sandstone with shaly partings	5	0
6. Grey clays	3	0
7. Calcareous sandstone (near the top of which are 9" of carbonaceous shales, thinning out rapidly)	10	0
8. Shales	8	0
9. Soft brown sandstone with partings of shales	12	0
10. Very light green shales, arenaceous near base	40	0
11. Shaly sandstone with clay nodules and partings of shales, pass into (10)	29	0
12. Alternation of greenish grey arenaceous shales and sandstone	30	0
13. Carbonaceous layer	0	1½
14. Dark shales	1	4
15. Parting of ferruginous shales	0	4
16. Dark shales	0	11
17. Light green clay shales	17	5
18. Coaly shales	1	0
9. Bluish green shales	2	0

	Description of beds.	Thickness. ft.	in.
20.	Calcareous brown sandstone	7	0
21.	Greenish shales	23	0
22.	Sandstone, fine-grained	11	0
23.	Greenish shales	4	2
24.	Carbonaceous layer	0	1½
25.	Dark brown limestone	0	2
26.	*Coal*	1	0
27.	Greenish shales with purplish patches	3	7½
28.	*Coal*	1	0
29.	Brown decomposed pyritous shales	0	2
30.	Carbonaceous layer	0	2
31.	Variously coloured purple, green and brown shales	7	0
32.	*Coal* (upper seam)	1	1
33.	Clay shales (pyritous)	0	6½
34.	*Coal* (lower seam)	1	2
35.	Clay shales, similar to (33) with coaly matter	0	4½
36.	Bluish grey shales, carbonaceous	0	10½
37.	Pyritous greenish brown shales	8	0
38.	Fine-grained brown sandstone with partings of shale	86	0
39.	Dark coloured shales	24	0
40.	Sandstone	2	0
41.	Light greenish grey shales	68	0
42.	Shaly sandstone, passing into (41)	2	0
43.	Arenaceous shales passing into (42)	35	0
44.	Sandstone with partings of shales	77	0
45.	Calcareous layer	0	6
46.	Thin-bedded sandstone	4	0
47.	Bluish green shales	102	0
48.	Shaly sandstone	10	0
49.	Greenish shales with calcite veins	56	0
50.	Alternation of shaly sandstone and shales	35	0
51.	Greenish sandstone	7	0
52.	Alternation of dark arenaceous shales and sandstone	89	0
53.	Shaly sandstone with partings of shales	29	0
54.	Arenaceous green shales	21	0
55.	Alternation of sandstone beds and dark shales	107	0
56.	Green shales	56	0
57.	Sandstone with partings of shales	20	0
58.	Greenish gray shales	50	0
59.	Sandstone	15	0

The recent deposits of the river interrupt the section here, but at places the sandstone and shales may be seen to underlie the recent gravels.

Háji Kats.

North of Khóst and near Háji Káts there is a thin seam of coal in the shales which dips 30° to north. It shows a good deal of crushing, is about 4" in thickness, and is traversed by calcite veins.

Sháhrág area.

The sections of the eocene division which are exposed between Harnai and Sháhrág are perhaps the best in this valley. As shown in pl. 1, figs 2, 3 and 4, the sections do not consist of simply one normally ascending sequence of the eocene and Siwaliks, but we may there observe several folds of considerable size. These folds to a large extent have helped to determine the topographical contour of the country, and, indeed, we see all along the north slope of the chain of hills which form the south-eastern continuation of the Khóst range, a series of lower hill ranges, running parallel with the former. They are formed of crushed folds of middle nummulitic beds with Siwaliks. North-west and west of Sháhrág these folds disappear beneath the recent conglomerates, and only here and there much-denuded remains of the middle nummulitics show as patches, overlaid or surrounded by the recent formation.

The section south-west of Sháhrág is a continuation of the Ombo sequence of beds. Near the defile south-west of the latter place, the upper nummulitic limestone is seen actually at the level of the river, with the Siwaliks overlying it. From that point the upper nummulitic limestone is seen to ascend and sweep round the contour of the hill-mass south of Sháhrág; the middle eocene shales and sandstone, which near Ombo are covered up by the river gravels, form a section below the upper nummulitic limestone, gradually widening as I followed it up eastwards. The coal-horizon which is found about half way up the middle eocene, must, therefore, have been covered up by recent deposits south-west and south of Ombo, and as near as can be they should be *in situ* at the base of the hill, due south of Sháhrág. A boring at the base of the hill-side south of Ombo or south of Sháhrág ought in both cases to reach the coal within a very short depth; near the latter locality the coal should be nearer the surface than at the former.

The Púnga stream passes from north to south through a broad belt of eocene beds, the exposures of which are interrupted for considerable distances by the sub-recent and recent conglomerates which are locally of great thickness. But enough is seen of the beds to be able to say that all that part of the eocene, which lies north of the defile 3½ miles south of Púnga, is greatly disturbed,—so much so, indeed, that it would be impossible to follow up every one of the numerous minor folds into which the strata of the middle eocene have been twisted. In its main features, the section one or two miles east of this stream is simple enough; it consists of a great synclinal which occupies the ground between the railway line and the stream which feeds the Siáh Dád river on its left (or east) side, followed south by an anticlinal, or more correctly speaking what was once an anticlinal, the arch having been completely denuded away. South of that the eocene beds and the overlying Siwaliks dip south or south-west (see. pl. 1, fig. 2).

Considering this section in detail the structure is slightly more complicated; the synclinal south of Púnga is not much disturbed, and that chiefly near its eastern termination (west of Nasak), but the denuded anticlinal south of it is immensely crushed. Where the upper nummulitic limestone with the great thickness of Siwaliks above normally overlays the middle eocene shales and sandstone, the latter show little disturbance, except imediately near the surface; but where these upper beds have been denuded away, as is the case within the area of the anticlinal, there the middle eocene, full as they are of gypsum in veins and nests, have undergone an extraordinary amount of local folding and disturbance. Not only have they been crushed and compressed into folds owing to the expansion, following the absorption of water by the anhydrite below the surface, but the latter having been converted into gypsum, is gradually dissolved out by the action of water, and so extensive landslips are seen all over the surface of this undulating country. The entire area shown on the map south-east of Sháhrág and coloured as middle eocene has been thus affected, and is therefore useless for measuring the section, or for economic (mining) purposes.

In many of the side streams of the Siáh Dád river, parts of the same section is repeated many times, and probably some twenty or thirty coal-seams could be recorded, which all of them turn out to represent different folds of, perhaps, at the most, two good-sized seams. In a side stream which joins the Siáh Dád from the right (west),—coming from Sháhrág in fact,—very good examples of folds, both synclinal and anticlinal ones, may be observed,—proved to be such, not only by the constant repetition of the same bed (notably one, a calcareous sandstone with *turritella*), but there are also several distinct folds seen in the bed of the stream. To measure the section by the ordinary means, *i.e.*, with a measuring tape, would have been absolutely useless; I had to do my best to arrive at an approximate measurement of the section by surveying the steeper slope (see pl. 2) of the upper nummulitic and the middle eocene exposed on the scarp of the southern range.

The *lowest* beds are nowhere sufficiently well exposed to allow a correct measurement, but I think my estimate of their thickness will be found to be approximately correct. The following is the section shown on the hill-side, on the east or left side of the Tangi (defile) in descending order:—

Divisions.	Subdivisions.	Description of beds.	Thickness.
Pliocene and Upper miocene	Lower Siwaliks	(12) Sandstones and earthy shales, generally of purplish grey to red colour; often mottled brown and grey.	
		(11) Grey sandstone of true Siwalik type, gritty irregular beds with fossil bones.	
		(10) Grits, conglomerates and chert breccia.	
Eocene	Upper Nummulitic	(9) Massive greyish and white limestones with fossils . . .	250
		(8) Greenish and yellow olive-coloured shales, sometimes light grey, alternating with light grey concretionary limestone full of fossils	75
		(7) Sandstone, shales and conglomerate, weathering black, made up chiefly of pebbles of lower nummulitic limestone. Chert nodules amongst them . .	150
	Middle Nummulitic	(6) Bright coloured shales, red and greenish white, with calcareous sandstones, weathering a deep brick colour	200
		(5) Brown sandstone, weathers brick colour, with limestone beds, which are full of bivalves . . .	60

Divisions.	Subdivisions.	Description of beds.	Thickness
		(4) Greenish brown sandstone alternating with bright green and grey shales with veins and nests of gypsum	30
		(3) Shales, sandstone and two coal-seams	220
Eocene . .	Middle Nummulitic .	(2) Alternation of grey shales and sandstone with beds of shell limestone near base of series; thin partings of leafy coal .	150
		(1) Green sandstone and shales; gypsum, base not exposed. Thickness possibly	800
		Total Thickness of middle and upper eocene	1,935

These beds dip about 55° south, but there is a good deal of rolling, and some of the beds are raised up to an angle of from 70° to 80°.

Fossils are rare and badly preserved in the middle nummulitic beds of Sháhrág, excepting in thin calcareous sandstone beds in the series (2) and (5), which are full of well-preserved *Gasteropods*, amongst which there are a number of genera; also bivalves are met with, which form thick layers composed entirely of the shells of one species only.

In a sandstone horizon immediately above the coal-seams of the series (3) occur large numbers of a species of *unio*, often forming regular nests.

The coal-seams are very few in number, and seldom exceed a few inches in thickness, and often turn out to be nothing else but carbonaceous shales; only two seams appear to be good enough to repay regular mining operations. They occur rather high up in series (3), and are both of about the same thickness, varying from 2 feet to 2 feet 3 inches with thin clay partings. It is possible that they may turn out to be one and the same seam, simply repeated at very short distances by faulting, but it is very difficult to pronounce a decided opinion on the subject, the hill-side being too much obscured by debris.

They are close together, and form a horizon which may be followed for a long distance both south-eastwards and in a west and north-west direction. At present some contractors obtain a certain amount of good coal from shallow workings, but I understand that the North-Western Railway intends to work these seams in a more systematic manner. The uppermost beds of the middle nummulitic subdivision, which are of considerable thickness, do not contain coal-seams, but are chiefly remarkable for the considerable amount of gypsum which occurs in veins and nests.

Upper nummulitics.

The boundary between this subdivision and the upper nummulitics is not very distinct at Sháhrág. A sandstone series with conglomerates seems to define the base of the latter; but excepting this, the two subdivisions pass from one into the other gradually, as the bright coloured clays and shales show which also occur with and above the sandstone. Higher up limestone beds appear and gradually replace the sandstone; they are full of fossils, amongst which an enormous number of *nummulites* of several species are remarkable. Where the rock is weathered, the ground is simply covered by the weathered-out *nummulites*, so that frequently, and for long distances, one walks on nothing but these *foraminiferæ*. In the upper portion of this series ochre-coloured to olive green shales are intercalated, but are not thick enough to be noticed from afar off. Fossils seem scarcer in them than in the limestone beds adjoining. A very predominant rock in this subdivision is the nodular limestone, which I first noticed in the Bolán in 1880,[1] but which is found both in the lower nummulitic limestone and in this subdivision, varying from each other but very slightly.

Siwaliks.

Immediately above the upper nummulitic limestone and with bedding parallel with that of the latter, follow the lower Siwalik strata. The ferruginous breccia (10) at the base also occurs here, locally associated with grits and a bed of chert nodules, above which follow the grits (with teeth and bones) and grey sandstones (11) of the common lower Siwalik type. These pass gradually into the red and greyish purple sandstones and shales (12), and both together form the precipitous scarp which constitutes the main mass of this range. From the crest of the latter one may view ridge on ridge formed of the lower Siwalik sandstones, all dipping south-west, with a dip-slope in that direction and a scarp turned to the north-east. Most probably these sandstones do not represent a continuous sequence of strata, but a series of parallel faults combined with the dovetailing (scaly structure) so commonly seen where sedimentary deposits have been squeezed into narrow strips, have produced the peculiar contour of these hills, and have given the lower Siwaliks the semblance of an enormous thickness of beds.

Other sections near Sháhrág.

There are no great changes seen in the sections further south-south-east, and certainly the scarp shows the same sequence of beds, and that in a fairly normal,—*i.e.*, little disturbed—position, and even if the outcrop of coal (quite close to the small ravine which runs into the main stream) is not always seen, being covered up by debris, still the coal is there, and will be found either by sinking a shaft down on it, or, if a low enough spot can be found, by driving a level into the hill-side below the coal horizon.

North-west and immediately adjoining the described section, the beds are more disturbed. Near the point where the path from Sháhrág descends into the river close to the Tangi, the middle nummulitic beds are exposed on both sides of a small spur; a coal-seam of about 2′ 3″ is *in situ*, and crosses the spur almost at a right angle. A number of thin partings of shale divides the seam into beds of coal not more than 6″ to 7″ each. The dip is very steep to the south, but what there is of coal can of course be taken out easily enough, and, in fact, when I visited the spot it was being removed by a native contractor.

Up the hill slope which stretches west and north-west from near the Tangi, a similar section is seen as described above; it seems a good deal disturbed near the surface, but it is probable that the sequence of beds will be found to be normal at some

[1] Mem. Vol. XVIII, p. 30.

depth below the exposure. The coal horizon runs all along this hill-slope near its base; the only indication of it near the surface consists of two thin seams, respectively 6 and 7 inches thick, divided by a sandstone parting of 1½ foot thickness, the whole enclosed within a series of shales and thin sandstone beds. Gypsum is found throughout the shales and even in the coal-seams. Immediately above this horizon is an impure calcareous sandstone containing many well-preserved *gasteropod* genera represented by numerous species, whilst a sandstone immediately below contains *unio* which form whole banks and shell-beds.

North of this hill-slope and in the Siáh Dád stream itself nothing but very highly disturbed beds are seen, dipping almost in every direction; in fact the friable shales and sandstones of the middle nummulitics have been crushed and disturbed wherever the superincumbent strata have been removed by denudation. Seen from the hill south of Sháhrág, which commands a fine view of the section south of Púnga (see pl. 1, fig. 2.), the structure appears to be plain enough.

Section south of Púnga.

Immediately south of Púnga rises a low range, which extends far to the south-east, only broken through by the Nasak and Harnai streams; this range consists of a shallow synclinal of middle and upper nummulitics and is capped by lower Siwalik sandstone. Denudation has excavated deep ravines into this range, and here and there reduced it to very narrow dimensions indeed, as for instance near Harnai. It is best seen near Púnga, where it is a conspicuous range, south of which may be seen a much-disturbed sequence of the middle nummulitics which dip north and south near the Púnga synclinal and the "Sháhrág" section respectively (see fig. 2.). This disturbed area is the site of an anticlinal, the arch of which has been denuded; at the present moment this anticlinal, the general features of which are partly preserved, has been replaced by a number of smaller and crushed folds, consisting of the shales and sandstones of the middle nummulitics.

In such a highly disturbed area it is only natural that we should meet with numerous exposures of coal-seams, some even of encouraging thickness, as the coal horizon near the middle of this sequence of beds has been repeated many times over through folding and faulting. That this is so, is proved by the structure of the beds exposed in the deeply eroded stream-beds, where numerous secondary folds may be observed. Frequently there are most encouraging coal-exposures met with within these folds, and surface workings have been commenced. I need scarcely mention, that as long as there are coal outcrops, like Khóst or Sháhrág (near the Tangi) left, it could not pay to mine for coal in disturbed localities, such as those in the low hills south of the Púnga synclinal. Where good-sized seams crop out, and can be reached without difficulty, native contractors may be allowed to take out the valuable mineral, but regular mining operations should be confined to such localities as we find 2¼ miles south-east of Sháhrág station.

As already shown, the hill-range south of Púnga is formed by a simple synclinal; the main mass of the range is no doubt made up of Siwalik sandstones, but near the base of it the eocene beds crop out. The southern slope of the range is affected by a good deal of minor disturbance merging into the crushed anticlinal alluded to already, but the northern slope is a normal sequence of beds, all dipping about 25° south.

Close to the highest point of the ascent between Sháhrág and Nasak, called Púnga Ghát, is a burial-place, not far south of which the upper nummulitic limestone is *in situ*, forming a scarp facing north. This exposure of limestone may be traced along the whole face of the cliff in both directions; westwards it is seen to follow the contour of the hill range, and is continuous with the band of limestone which crops out below the Siwaliks along the southern slope of the synclinal In the Nasak direction it follows strictly the contour of the range, where it forms a steep scarp south of the railway line to beyond Harnai; this scarp is continuous but for the gap created by the Nasak stream which has eroded a defile through the range. The strata forming this range dip steadily south-west at an angle of 25° to 45°. The limestone scarp is overlaid by the lower Siwaliks. West and below the upper nummulitic limestone (7 to 9) I observed that the bright coloured clays and green shales and sandstones of the middle nummulitic subdivision form the undercliff between the Púnga Ghát and Nasak.

Near the former locality itself nothing is seen of the beds which underlie the upper nummulitic linestone, but much-distorted beds of the middle nummulitic are *in situ* and form the low hills, which protrude from the sub-recent conglomerates and fan deposits which stretch away to the foot of the Wangi and Khaliphát ranges. The beds which I observed in these isolated hills are much disturbed, but can easily be recognized as the green shales and sandstones of the middle nummulitics. In some places fossils (chiefly *gasteropoda* and *oyster* banks) are common, and here and there thin coal-seams and carbonaceous layers are found in the series. Mr. Jones describes a few seams from the hills north-east of Sháhrág, which, if less disturbed, would no doubt be valuable. As they are, they are only fit to be worked by natives in native manner.

Coal below Púnga.

Mr. R. D. Oldham has already suggested, without specifying any particular spot, that a boring in the Púnga Ghát would reach the coal horizon. I may add to this, that almost any spot near the Púnga Ghát might be selected, were it decided to attempt such a boring, and the only difference in sites would consist in the depth at which the coal horizon of Sháhrág would be struck. A boring about 100 yards south of the gangmen's house on the ghát ought to meet the coal-seams about 700′ below the surface. This depth would lessen as one moves the bore-hole northwards, but on the other hand the possible chances of finding the middle nummulitics much disturbed further away from the hill-slope would lessen the certainty of finding the coal-seams.

Ragani.

West of Púnga Ghát a steep ravine leads down into the Ragani stream valley. The ghát itself—*i.e.*, the highest part of it—is formed by the recent and sub-recent conglomerates, which in this ravine are seen to be of great thickness. They generally show quite horizontal bedding, and of course cover up unconformably the beds of the middle nummulitics; the latter have been exposed in the Ragani stream, a tributary of the Nasak river.

On the right side of the valley the scarp of the range is composed of the upper nummulitic limestones as already related, below which the crushed beds of the middle nummulitic shales and sandstones crop up. Near where the path from Púnga Ghát reaches the Ragani valley, very little is seen of the green shales, etc., beyond some exposures of crushed beds of it beneath the sub-recent conglomerates, but further on, near Ragani itself, the middle of the subdivision is *in situ* with its coal horizon. There appear to be about five seams divided by partings of clay shales, the total thickness of coal and shales not exceeding 6 to 7 feet. Very irregular the seams seem to be, for some of them may be seen to thin out and to pass into dark grey shales within the distance of a few feet. It looks a most unpromising seam to work, but it might be further explored by either boring south of it or by driving a level into the hill-side below the outcrop of the coal; the latter, however, is so near the bottom of the valley that not much of the seam could be worked without interference from groundwater. The dip of the coal-seam and accompanying beds is about 40° south-west.

The bright-coloured shales and clays with sandstone beds (6) overlie the coal series of Ragani, above which the upper nummulitic limestone rests conformably.

The same shales and clays, deep red and greenish grey with bluish bands, are *in situ* on the left side of the Ragani valley, north-west of the village; they are mostly covered up and obscured by the sub-recent conglomerates. But enough of them is seen to warrant the assumption that the whole of the middle nummulitics will be found to be greatly disturbed below the fan deposits, and that the fragments of seams which are met with in the crushed sections of the Ragani valley would be worthless for purposes of regular mining, although some of them might be good enough to be dug out by native miners.

Section west of Nasak.

A section drawn at a right angle across the ranges between Ragani and Nasak (see pl. 1, fig. 3) reveals a structure very similar to that of the section south of Púnga Ghát. There is first a synclinal fold,—the south-eastern prolongation of the Púnga Ghát synclinal, only with this difference, that here it widens considerably, and excepting that they are much cut up by denuding streams, the beds appear to be less disturbed than south of Púnga Ghát.

The Siwalik synclinal is rather more than two miles wide, and near its southern flank, where the beds dip north-east (the point of observation is 3½ miles west of the village of Gachin), the contact between the lower Siwaliks (brown grits) and the upper nummulitic limestone beneath is most distinctly unconformable. The Siwaliks dip about 50° to 55° north-east, whereas the limestone below is vertical or nearly so, its dip decreasing further south, until a north-easterly dip has set in. Of course the unconformity between these two divisions may be an apparent one only, and the divergence of dip be explained by the enormous compression and disturbance which the area has suffered, but the examination of the section further south shows clearly that there is a great unçonformity between the two series of strata, as indeed one might suppose that such must occur when a fresh-water deposit follows a purely marine one.

A very fair section is obtained on this line about 2½ miles south-west of Nasak, where a small stream has cut through the beds south of the synclinal. The beds between the upper nummulitics and the normal sequence of strata on the southern or main range, are practically an anticlinal, the dip being north-east and south-west respectively, but as is the case south-east of Sháhrág, so also here, the upper part of the anticlinal having been denuded, the middle nummulitic shales, etc., which form the greater part of the section have been exposed to chemical and mechanical action, and thus we see them now puckered and folded in a most complicated manner. There is a good deal of recent debris, which obscures the section at places, but leaving unnoticed the numerous minor disturbances, inversions and faults, I could observe not less than two, perhaps three, distinct folds within the belt of middle nummulitics.

The upper nummulitic limestone is of the same thickness as along the scarp near Ragani, and overlies a series of soft alum shales with sandstone partings, which may be of about 600 to 800 feet in thickness. They pass conformably into a horizon of shales and sandstones, which contains coal-seams. I noticed two coal-seams besides one or two carbonaceous layers. The upper coal-seam is about 1' to to 1' 2" in thickness, whilst the lower coal horizon appears to be a continuation of the one worked at Khóst and Sháhrág. It consists of two seams of 1' 8" and 4" of good coal, divided by a shaly parting of 1' to 1' 6". The beds are much disturbed and crushed, whilst the dip of the seams is nearly vertical, and the whole series is traversed by numerous gypsum veins.

These seams occur near the base of the valley which runs parallel to the strike of the anticlinal. Close to the coal seams, apparently *above* them, occur shales and calcareous sandstone beds, full of *gasteropods*, which horizon was also observed south-east of Sháhrág. From the base of this valley to the crest of the range south of it the section is again an ascending one. Sandstone shales and above it the greyish white and pink clay shales of the Sháhrág section may be observed to gradually pass into a great thickness of beds which belong to the upper nummulitic subdivision It is an alternation of light coloured grey limestone, full of *nummulites* and other fossils alternating with yellowish green shales. Many of the limestone beds possess the peculiar nodular structure already often noticed, and with the latter occur numerous chert concretions full of *foraminiferæ*. This development of the upper nummulitics is lithologically precisely the same as that of the "Kirthar" limestone of Sukkur and Rohri, and evidently belongs to the upper portion of this subdivision, which is fully represented in the present section, but has been denuded away in the neighbourhood of Khóst and Sháhrág. This being so, explains the unconformity of the lower Siwaliks over the eocene seen further north-east in the same section; the former rest upon different strata of the upper eocene in different localities, and we may, therefore, assume that a considerable erosion of the upper nummulitics has taken place in early Siwalik times.

The entire thickness of the upper nummulitic limestone with shales cannot be less in this section than from 1,200 to 1,500 feet. They form the somewhat steep slope of the main range along the southern flank of the section, and are overlaid by the typical grits and chert conglomerate with grey sandstone of the lower Siwaliks followed by a great thickness of red sandstone.

Scarp between Nasak and Harnai.

As already stated elsewhere, the upper nummulitic limestone forms the scarp south-east of Nasak as far as Harnai. South-east of Nasak Station the road passes over a low pass, and through a cutting in recent conglomerate. Immediately east of it the road (and also the railway line) crosses a low saddle formed by an anticlinal of middle nummulitic shales and green sandstones (with traces of coal-seams), flanked on each side by upper nummulitic limestone. Some short distance further to south-east, coal-seams are *in situ* near the road-side; they consist of a number of thin seams of leafy coal with many partings. The total thickness of coal available cannot be more than about 2' 6", but it is so much divided by shaly partings that it is quite worthless. This sequence of grey friable shales, clays, and coal-seams forms together a series, about 15 feet thick, which dips 25° to 30° south-south-east and is underlaid by brown sandstone. The hill-side is too much obscured by debris to afford opportunities for a closer examination, but I estimate the thickness of the middle nummulitic subdivision which lies above this coal horizon at about 600' to 700', and is then conformably overlaid by upper nummulitic limestone. About 2¼ miles south-east of Nasak Station the Harnai stream makes a sharp bend to the north-east, and near it the coal (in very poor leafy seams) occurs again in the bed of the stream itself. From this point I traced it along the scarp on the right side of the valley, gradually rising to a higher level; it dips 28° south. Above the coal-seams brown ochreous sandstone with impure clay nodules occurs, which has furnished some marine fossils, mostly small bivalves. Below the horizon with coal, I noticed a bed of grey shell limestone, patchy with red ferruginous stains, full of bivalves (valves generally open). The section above the coal to the upper nummulitic limestone is highly disturbed, but presents no special features to be noticed.

The Harnai Section.

The section from Harnai to the spur of the Torghar—*i.e.*, from north-east to south-west—is, as may be supposed, very similar to the section west of Gachin already described. It crosses a synclinal (see pl. 1, fig. 4 and pl. 3), passes then through a much-disturbed anticlinal, and becomes an ascending section again until the Siwalik sandstones of the Torghar spur are reached.

South of Harnai the scarp of the range already described shows a very fair section from the upper nummulitic limestone to the lower portion of the middle eocene. It has a sharp crest with a fine dip-slope of 25° south to south-south-west. The main features of the sequence of beds are in descending order as follows:—

Upper nummulitic.—Considerable thickness of dark grey to reddish limestone with *echinoderms, bivalves* and *nummulites* throughout, the same facies seen also at Púnga Ghát, Khóst, etc. It cannot be more than 180' to 200' thick and forms a steep scarp facing north, with a dip-slope of 25° to south.

Immediately below this limestone are sandstone beds of a rather strange character; they are dark brownish grey and resemble the Siwaliks. Throughout its thickness ferruginous concretions occur, which weather out in irregular-sized nodules. In this sandstone, but seldom in the highest beds of it, occur sub-angular fragments of chert. They are formed both in layers and singly.

Below this thickness of sandstone is a bed of brown ochre-coloured calcareous rock, which also contains numerous sub-angular fragments of chert, being in fact partially made up of them; locally it could be called a breccia. It is of no great thickness and passes below into sandstone; it is dark grey to reddish in colour, and resembles somewhat the red Siwalik sandstone, but is more gritty. Near the base of this series is a conglomerate, which is made up of chert nodules and limestone pebbles, cemented together by grey sandstone. Though differing in some respects from beds in the upper nummulitics, it must be recognized as the lowest series of the latter (see series 7 of the Sháhrág section). The conglomerate indicates an unconformity, but neither at Sháhrág nor here could I see any divergence in the dip between the conglomerate beds and the shales of the middle nummulitic below.

Middle nummulitic.— Below the above, I observed the green and whitish grey and pink coloured shales with sandstone partings which seem to constitute a very constant horizon of this subdivision.

Below these are gypsiferous shales, generally of greenish colour, with green and brown sandstone and clay beds. In the lower strata of this series a few thin seams of coal occur. The dip is 28° south-east, and as this block of beds is not much disturbed, the coal might be extracted with a fair chance of success. The most promising seam is about 2 feet 6 inches in thickness, but with a parting running along its centre. The coal could be got at by a tunnel at or near the base of the range in the same manner as at Khóst, but probably there would not be so much of it available as at the latter locality, for the present outcrop itself is not far above the base of the range. Below the coal horizon, green to brown sandstone and shales crop out, the lowest beds of which are not seen.

South of the crest of the range, the section is, as indicated in fig. 4, a synclinal of upper nummulitic limestone which incloses crushed beds of Siwaliks. The latter show conformity along their northern boundary, but overlap denuded beds of upper nummulitics along the southern flank of the synclinal. The base beds of the Siwaliks are strongly developed; the ferruginous grits and chert bed are seen on both sides of the narrow valley, and associated with the lowest beds of the grey sandstone overlying them. I noticed again the typical grits with bones.

Near the unconformable contact of the Siwaliks and nummulitic limestone, I noticed once more the peculiar deposit immediately above the base beds of the Siwaliks,—namely, a calcareous irregular band, made up almost entirely of rolled *nummulites* and fragments of the same,—all no doubt derived from the upper nummulitic limestone. This deposit is irregular in thickness, but in some places is most conspicuous from afar off, owing to its dark brown colour.

Following this section further south, and crossing the southern arm of the synclinal, I observed the upper nummulitic limestone composing the same, which dips at an angle of some 50° to 60° below the Siwaliks, and forms a steep scarp, which faces south. The descent into the valley beyond leads over the upturned beds of the upper nummulitic limestones, sandstones and conglomerates,—finally over much-crushed beds of the middle eocene with carbonaceous layers, but no coal as far as I could see. It is quite possible that the coal thins out in these sections, as it undoubtedly does immediately west of the Harnai seams, which pass laterally into a ferruginous grit with carbonaceous layers. Near the base of the valley I observed shales with numerous fossils, chiefly *gasteropods*, which is probably the same horizon seen further north-west in the Sháhrág section.

The undulating valley, which is a continuation of the Sháhrág-Gachin anticlinal, shows a very disturbed structure, and it appears most probable that there are several secondary folds and reversions within this valley, of which I give a diagrammatic rendering in pl. 1, fig. 4.

Above these folds and forming the hill-slope of the spur of the Torghar which faces northwards, there is a fine, and I believe very extensive, section of the upper nummulitics *in situ*. The base beds are formed of limestones and nodular limestone beds with light greenish shales, such as are seen also in the sections north-west of this one. Higher up come sandstones and green grits, with sandstone beds of very altered and Flysch-like character which I have not met with within the upper nummulitic subdivision in Baluchistán before. The whole is once more overlaid by nummulitic limestone on which the Siwaliks rest in normal order. The green grits and sandstones might possibly represent the lowest beds of the upper nummulitics, and they resemble somewhat the beds of that subdivision met with in the Sháhrág section, and the sequence of eocene immediately south of Harnai. Some of the sandstone beds in this section show concentric weathering, very similar to the shales and sandstone of Flysch type which I noticed in the hills between Cherát in the Peshawar district, where they are also associated with eocene beds.

Gachin Sections.

The sections further north-west, near the group of villages of Gachin, are very similar to those of Harnai; they simply form continuations of the diagrammatic section, fig. 4, particularly as regards the south-western portion of it.

Structure of hills north of Harnai.

In previous paragraphs in this paper I have mentioned that the range of the Chappar, which stretches to the east as the Khaliphát mountains and beyond, is made up chiefly of beds belonging to the lower mummulitic limestone, which form a simple anticlinal, much cut into by eroding streams, but on the whole showing its structure perfectly. The green shales and sandstones of the middle eocene overlie this limestone conformably, though along the margin of this range this feature can scarcely be observed; first, the middle nummulitics have generally been covered up by sub-recent conglomerates and fan deposits as shown on the map, and secondly, because where an actual contact is visible, it is usually a disturbed one, because the softer shales and sandstones have naturally suffered much more than the compact limestones of the lower nummulitic, when the whole area was compressed into folds, and also because aided by denudation and other causes, the shales, etc., of the middle nummulitic have followed the laws of gravity and slipping off the highly incline-anticlinal, are now seen collected in a mass of complicated folds at the base of the latter. It is, therefore, easily explained why little can be learned by studying the contact of the two subdivisions of the eocene along the base of this range. South and in front of the eastern prolongation of the Khaliphát ránge, and between the Punga river, and east of the Wám Tangi, another and very distinct anticlinal extends, in structure precisely the same as that of the more northern one. Along the greater part of its southern margin it is flanked by fans and sub-recent conglomerates, whilst in the synclinal between the two anticlinals middle eocene beds are seen to overlie the lower nummulitic limestone (see pl. 1, fig 2).

Details.

I examined first the south-eastern and eastern termination of the range. Between it and Sháhrág several low hills and isolated ranges stand out conspicuously from the gently sloping plain, which is formed of the fan deposits already mentioned. They are merely remains left of the numerous folds into which the middle nummulitics have been laid. I found the strata composing them dip irregularly in all directions; coal-seams appear in the mass of shales and green sandstones, but the bedding is far too much disturbed to permit their being regularly mined for.

Near the western termination of the southern anticlinal and about 1½ miles south-west of Wangi, a mass of shales and sandstones belonging to the lower beds of the middle nummulitic form a low range close to the anticlinal, and there the conformable position of the beds over the limestone may be seen. They consist almost entirely of a series of friable olive green shales with a few partings of calcareous sandstone. The two villages of Wangi are situated close to the mouth of a defile of that name, which not only cuts through the limestone anticlinal, but also deeply down into the sub-recent gravels and fan deposits, which latter form magnificent, almost vertical-faced cliffs, several hundred feet high. At Wangi it is clearly seen that the range really consists of two anticlinal folds, which further east merge into one only. The stream which runs through the northern Wangi, defile rises in the neighbourhood of Ziarat in the Khaliphát anticlinal, where it forms deep ravines, cuts through the Wangi defile, and flowing south has eroded a narrow and vertical-sided channel through the limestone, afterwards continuing its erosion of the fans south of the range, where it becomes the Nasak river. It affords an illustration of a river which could not have scooped out the defile through the anticlinal whilst the latter was formed; the sub-recent gravels south of the "Tangi" are absolutely undisturbed, and yet have been cut into by the river, the defile through it being an absolute continuation of that which passes through the limestone,—with vertical sides and sharply defined course.

The upper beds which form the anticlinal are dark coloured *crinoid* and *coral* limestone, in which numerous fossil traces appear; *nummulites* are common. The sequence of beds is generally the same as the one observed in the Chappar rift, but fossil traces become scarcer as one descends in the section. In the upper portion of it, beds of nodular limestone are frequent, of the kind seen also in the Chappar rift; this is a recurring lithological feature, and beds of this kind are not only seen in this subdivision, but also in the upper nummulitic, where I first noticed them.

The lower beds seen in the Tangi are perhaps more flaggy in character, or at all events, many flaggy layers occur within the dark limestone, but I saw no *shales*. Before reaching the north end of the defile, the beds descend rapidly towards the north, completing the anticlinal. The dip is 60° north and the beds of limestone finally disappear below the horizontal sub-recent conglomerates.

The synclinal between the two limestone anticlinals is divided into two drainages. The western one escapes east of Peri through the Wangi defile, whilst the eastern one breaks through the Wám Tangi. The western valley (of Peri) is mostly filled by sub-recent deposits and fans; there are traces only of the midde eocene shales near the northern margin of the valley. Near Shavzgi the ground rises, and a low pass leads into the Wám drainage; the middle nummulitic green shales and sandstone (with coal traces) are seen to form the pass and occupy the greater part of the synclinal valley on the other side, only patches of sub-recent deposits obscuring the beds, which are highly disturbed and crushed.

The Wám river breaks through the anticlinal of limestone and affords a very good section. The latter is seen to form a simple arch, minor disturbances and local faults excepted; the upper beds are dark limestone, full of minute organic remains, and some well-preserved *nummulites*. Broken, the rock shows no kind of organic structure. In the upper part of the limestone series, nodular beds are common, similar to those of the more western Wángi defile. In the solid limestone beds I observed good examples of cleavage, and the whole mass of this subdivision of the eocene is jointed throughout.

Belemnite beds.

Near the centre of the Tangi and close to the base of the arch, I noticed a band of thin-bedded red and pinkish limestone, below which the beds become flaggy and alternate with shales and marls of light green colour; the lower horizon of it is a fine olive-green marl with the usual conchoidal structure which reminds me of some of the upper cretaceous horizons which I have seen in Baluchistán.

This I take to be Mr. Oldham's *belemnite* horizon: indeed the latter occupies the same relative position in the more eastern Miráb Tangi according to him and seems lithologically very similar. I have not been lucky enough to find fossils in these shales.

CONCLUDING REMARKS.

It only remains to add a few words on the economic value of the area. This, of course, consists in the large amount of coal which is available in the more or less constant horizon of the middle nummulitic subdivision. Most of the outcrops have either been worked or are sufficiently tested to prove the usefulness of the coal as regards quality and the limited thickness of the seams, and it is certain that even after the complete exhaustion of the Khóst collieries there will be a very large amount of coal left in other sections of the field. I will not enter here into the composition of the coal; this has been done already[1] by other observers. Mr. Jones has also attempted to compute the quantity of coal available, but he has certainly much under-estimated the latter. The fact is, no estimate, even approximately correct can possibly be arrived at, which would be of the least practical use. The whole basin of the "trough," including the entire hill-range which bounds it along the southern rim, with probably a large area south of it, is part of the field and contains seams of coal. If only the Khóst seams are taken as examples and the amount of coal calculated on the thickness of these seams and the area of the basin, no doubt a fairly accurate idea of the amount of coal *present* in these strata would result; but that is not the amount actually available. The greater portion of the basin is broken up by faults, folds, and some of it has been carried away by denudation, so that only a small proportion of the total coal is available for mining purposes, and of these portions the exact limits are not known. In the above paper I have given a description of the distribution of the seams, and also indicated in outlines which I consider the most promising localities for opening works, after Khóst is exhausted or nearing that stage.

Amongst the best of these localities is the cliff, 3½ miles south-east of Sháhrág Station, with the area immediately adjoining it. This will undoubtedly offer as good chances as did the Khóst workings, and the locality is near enough, the line of railway to be worked cheaply. Next to Sháhrág in importance, I consider the cliff between Púnga Ghát and Harnai; there the seams are good, but the outcrops are too low down the hill-side, to allow the same process of mining to be adopted as at Khóst and Sháhrág. The workings would be soon below the level of the ground-water, and therefore pumping would have to be resorted to, which would increase the cost of the output considerably.

Still more difficult to work, on account of the underground-water, would be mines established on the Púnga Ghát, or north of the river near Ali Khán, were it decided to bore in these localities for coal, which most probably would be met with not far below the present surface.

[1] *Records, Vol. XXII, Pt. 3, p. 140.*

Notes *on the* Geology *of a part of the* TENASSERIM VALLEY *with special reference to the* TENDAU-KAMAPYING Coal-field; *by* P. N. BOSE, B.Sc., F.G.S., *Officiating Superintendent, Geological Survey of India.* (With two Maps [1].)

SECTION I.—PREVIOUS OBSERVERS.

Mergui has probably been visited by more geologists than any other part of Burma. The earliest explorer was Dr. Helfer, whose second report (the only one I have had an opportunity of seeing) was printed in 1839.[2] It contains an account of an overland journey from Moulmein to Mergui.

Dr. Helfer, 1838.

With regard to the coal in the Mergui district, Dr. Helfer observed several outcrops of it above Tirok Chhangh in the Great Tenasserim Valley. He observes, however, and rightly, that none of them "promised to be of practical use, the quality being either inferior, of considerable specific gravity, intermixed with numerous iron pyrites, or the seams very inconsiderable."[3]

Dr. Helfer was, however, very enthusiastic about his find of coal in the Little Tenasserim Valley, about five days' journey above the town of Tenasserim. He thought it combined all the desiderata required "respecting quality, quantity, and easy access." He considered this coal to be destined to supply the whole of India. It is to be observed that he was not aware of the Tendau-Kamapying coal, the subject of our exploration last season.

The next report is that of Captain Tremenheere, which is dated August 1841.[4] Though dealing chiefly with tin, it incidentally mentions the coal mine near Tendau. The Tendau-coal would, therefore, appear to have been discovered some time between 1838 and 1841.

Tremenheere, 1841.

Captain Tremenheere also speaks of extensive beds of "manganese ore" between Therabwin and Tagu. The ore was, however, subsequently found to be akin to graphite in composition, and was called Tremenheerite by Piddington.

Dr. Oldham paid a visit in 1855 and submitted a comprehensive report[5] on the coal and tin of the Mergui district. He describes the deserted coal mines at Tendau which had been worked twelve years previously and notices the occurence of excellent coal north of Tendau at Heinlat and Kamapying.

Oldham, 1855.

On the Little Tenasserim, Dr. Oldham found that the fine descriptions given of the coal there by Dr. Helfer were quite unsupported by facts. He says that "out of a bed or beds which on the surface look like a bed of coal of more than 4 feet

[1] The boundaries of the coal area in Map have been laid down by my colleague, Mr. P. N. Datta, Assistant Superintendent, Geological Survey. The topographical features in Map 2 have been compiled from the old map of Lieut. Bagge and from tracings courteously furnished by the officers of the Survey of India of their last season's work as it was in progress. This map is therefore of an entirely provisional character. The patch of granite which has been mapped in south-west of the village of Tenasserim is from information.

[2] Reprinted at the Government Central Press, Calcutta 1875.

[3] *Op. cit.*, p. 36.

[4] Reprinted in "Geological Papers on Burma," p. 350.

[5] Reprinted in "Geological Papers on Burma," p. 375.

thick, there is in reality not more than 18 inches, frequently much less, of good coal, and this not in a continuous deposit but in irregular patches." [1]

Theobald, 1855.

Mr. Theobald appears to have accompanied Dr. Oldham. He was sent to examine some coal which had been reported by Dr. Helfer to occur above the great rapids of the Tenasserim. He found that it occurs in small nodular strings, not more than an inch in thickness, and by no means continuous, having therefore no practical value whatever.

Fryar, 1871.

In 1871, Mr. Mark Fryar, a Mining Engineer, was engaged by the Burma Government to report on the mineraliferous localities of the Tenasserim division. He has a short reference in his report to the coal at Tendau. He managed to dig from the mud and water of the river a sufficient amount of coal to make a large fire, and from the way in which it burnt, he thought that if required as a fuel on the coal-field or within a short distance of it, the coal would prove to be very valuable.[2]

Hughes, 1889-92.

The prospecting operations under Mr. T. W. H. Hughes in the Mergui district had special reference to tin. During the season 1891-92, however, the coal on the Htiphanko at Kamapying was explored.[3]

SECTION II.—GEOGRAPHY.

1. *The Tenasserim river.*—The Tendau-Kamapying coal-field is situated in the valley of the Great Tenasserim river, which has its source in the Tavoy district. After running nearly north and south for about 200 miles (measured in a straight line) it joins the Little Tenasserim at the old town of Tenasserim. Thence the river takes a westerly to north-westerly course, and divides into two important channels. The main channel to which the name of the river is restricted flows in a general north-westerly direction, and has its debouchure near the town of Mergui. The other channel running nearly south to north and falling into the sea at Kyuk Phya is called after this village. Both of these channels are navigable without any serious difficulty at all times of the year for vessels drawing about 6 feet of water as far as Banlaw, a distance by the main channel of about 50 miles. The influence of the tides is felt as far at this place, though the rise of water during the lowest neap is very slight. The highest spring-tide reaches about 14 miles further north, as far as Therabwin.

The river was found to be at its lowest from the middle of February to the middle of March. Even then, however, I succeeded with careful piloting in taking the launch *Ataran*, drawing about 3 feet of water, as far as Therabwin during high spring-tide. Above Therabwin the river is full of shallows and rapids, and is navigable only for vessels of small draught between December and March.

Watersheds.—On either side of the Great Tenasserim (between its source and the town of Tenasserim) there is a hill-range running parallel to it,—that is, in a general north-south direction. It is observable, that the principal physical features of the Tenasserim division—the chief rivers and hill-ranges and the coast line—all

[1] "Geological Papers on Burma," p. 389.
[2] "Geological Papers on Burma," p. 419.
[3] Records, G. S. I., Vol. XXVI, pt. 1.

take this direction, which coincides with that of the dominant strike of the rocks constituting the country.

Of the two hill-ranges just mentioned, that to the east of the river forms the boundary between Siam on one side and the districts of Tavoy and Mergui on the other. It forms a well-marked watershed; the rivers rising from it on the Siam side flow into the Gulf of Siam, and those on the Tavoy-Mergui side run into the Mergui Archipelago. The hill-range to the west of the river forms a minor watershed,—the streams which have their source in it on the east side falling into the Great Tenasserim. Neither of the ranges rises to any very great heights, within the district of Mergui no peak being known higher than 2,500 feet.

3. The Great Tenasserim Valley.—The valley between the two ranges just mentioned is what may be called the Upper Tenasserim Valley. The Tendau-Kamapying coal-field is situated in this valley.

Alluvial flats.

The main ranges on either side of the river send out spurs in all directions, which give the valley a hilly character. There is, however, usually a variable stretch of alluvial flat just bordering the river.

Population.

The entire valley is very thinly peopled. The district of Mergui is greatly under-populated. The density of population per square mile according to the last census is 9·44. In the serial order graded by density, it occupies the thirty-third place, having only three districts below it in the whole of Burma.[1]

The Upper Tenasserim Valley is one of the least dense parts in the district. The population diminishes as we go up the valley. Within the coal-area, from Tendau to Kamapying, measuring about 30 square miles, there are probably not more than 50 houses with 250 souls.

Climate.

The mean annual rainfall of the town of Mergui is 183·7.[2] The rainfall of the Upper Tenasserim Valley will not be less than this figure. We had fine weather for two months and a half only, from the beginning of January to the middle of March. This fineness also is to be qualified. The whole valley used to be enveloped in mist till 9 or 10 o'clock in the morning. During the five months we stayed in the valley (December to April), I doubt if there were as many bright mornings. From the middle of March rain began to fall, and not unoften in heavy showers and accompanied by strong gales.

History.

Tenasserim, which gives its name to the southernmost administrative division of British Burma, was a large and important city when the country was in Siamese possession. It has now dwindled into a small village with probably not more than 400 inhabitants. It was founded by the Siamese in 1373 A.D. In 1759 the Tenasserim Valley was taken from the Siamese by the Burmese King Alom Pra. After the Burmese conquest, the Siamese, who were the principal occupants of the valley, deserted it and went over to Siam. The country has not yet recovered from the effects of that depopulation. It became British territory in 1855.

[1] Report on the Census of Burma (1891), p. 15.

[2] Report on the Census of Burma (1891), p. 7.

SECTION III.—GEOLOGICAL SKETCH.

1. Moulmein Group.

(*a*) Lithology.

Variously coloured clay rocks and sandstones in different degrees of mixture and of alteration form the predominant constituents of this group. There is one kind of clay rock which being dark and compact simulates the appearance of basalt. There is another kind of a lighter colour in which fragments of felspar and of granite being interpersed give it partly the appearance and character of tuff. Conglomerate is rare. I met with it in only one place, on the island just opposite Mergui, where it is developed in massive beds. There are a few bands of limestone of a highly crystalline character. It occurs in highly precipitous, jagged, bare ridges which form a most attractive feature in the scenery of the country. In these ridges occur caves[1] of various dimensions. Some I measured on the Great Tenasserim and the Lenya rivers were from 50 to 150 feet in breadth, and 60 to 250 feet in length.

There are also bands of carbonaceous shales with occasionally thin and variable seams of much-crushed, lustrous, graphitic-looking coal. These shales sometimes occur in close proximity to the limestone, as at Therabwin. At one locality above the great rapids of the Tenasserim I found the shales in superposition on the limestone.

The carbonaceous shales just mentioned are very widely distributed. They occur at various places in the Upper and Lower Tenasserim Valley—at Therabwin, Bankyot, Tagu, Thaket, Marton, etc. They are also known in the districts of Tavoy and Amherst, considerable tracts of which are constituted by the group under description.

(*b*) Disturbance.

The prevailing strike varies between a few degrees on either side of north and south. The dips are rather high, being seldom lower than 45° and sometimes as high as 80°. The beds are often found to be contorted. In the Upper Tenasserim Valley, on the west side of the river the dips chiefly point westward, and on the east side they were mostly found directed eastward, so that the main Tenasserim Valley would appear to lie along a denuded anticline.

(*c*) Age.

The only rock in the group which has yielded fossils is the limestone. It being highly crystalline, the fossils cannot be extracted without great difficulty. After some search in the neighbourhood of Therabwin I succeeded in getting together a small collection. It consists of the following well-marked carboniferous forms which have been determined by Dr. Noetling, the Palæontologist of the Survey:—

Schwagerina' blanfordi, sp. Nov.
Lonsaleia sdalinaria, Waag. and Wentz. sp. indet.
Lithostrotion, sp. Nov.

[1] It may be mentioned that thick deposits of the excrementa of bats cover the floors of these caves, and the stuff may be, and to a small extent is, utilised.

Aræpora, cf. *ramosa*, Waag. and Wentz.
Polypora, cf. *biarmica*, Keyserl.
Productus, cf. *sumatrensis*, F. Rœmer.
Athyris sp.
Spirifer sp.
Bellerophon sp.
Pleurotomaria, aff. *durga*, Waag.
Murchisonia sp.

Dr. Oldham, who called the group under consideration after the town of Moulmein, met with a similar assemblage of fossils in the limestone at the well-known caves near that place.

There can be no doubt of the carboniferous age of the Moulmein group, on the supposition, of course, that the limestone from which the above fossils have been obtained is an integral portion of it. I must say that I have scarcely any doubt on this point, though the evidence is not quite so conclusive as might be desirable.

2 *The Tendau Group.*

(*a*) Area and Lithology.

It occupies an area of about 30 square miles between Tendau and Kamapying, and is important as the group in which the workable coal of the district occurs.

Towards the base of the group occur shales and sandstones. The latter are medium-grained and reddish coloured, and were noticed to underlie the shales at the Chá Mitwe stream (near Tendau), the only place where the base of the group is well exhibited.

Shales.

The shales are variously coloured from greyish white to black, the darker colours being indicative of the proximity of coal which will be described in detail in the next section. They were encountered only on the western side of the river; and there, too, were not continuously traceable. Being of economic importance they have been roughly indicated on the map by a deeper shade of the colour appropriated to the group. The shales thin out to the east and appear ultimately to disappear altogether in that direction, as they do not reappear on the eastern side of the synclina basin.

Conglomerates.

Superposed on the shales are found conglomerates with interbedded sandstones and shales. The conglomerates are coarse, sometimes extremely so, the constituent pebbles measuring a foot or so in diameter. The pebbles are never well rolled, sometimes indeed they preserve their angularity to such an extent that the rock has more the appearance of a breccia, than that of a conglomerate. Amongst the pebbles are those of hard, compact clay-rocks belonging to the Moulmein group. The matrix of the conglomerate is more of a clayey than of a sandy nature. The sandstones interbedded with the conglomerates are massive, soft, and false-bedded.

(*b*) Disturbance.

The Tendau beds have been disturbed so as to form a syncline, those on the western side of the river dipping eastward, and those on the eastern side dipping in the reverse direction.

The strike in the northernmost part of the area is in a north-east—south-west direction. But it changes on the Heinlat stream, whence to Tendau it maintains a north-north-west—south-south-east direction, which is nearly the same as that of the strike of the "Moulmein" beds. It is remarkable how the disturbing forces, whatever they may have been, have continued to act in the same direction during so many ages. The dips are scarcely ever lower than 20° and are never higher than 40°; 30° may be taken to be the average dip.

(*c*) Age and Mode of deposition.

Uncomformable relation to the Moulmein group.

The Tendau beds rest uncomformably on the denuded edges of the Moulmein strata. At the boundary on the western side of the river the latter invariably dip westward, but on the eastern side they usually dip eastward. Besides, the dips of the younger group are not so high as those of the older.

Age.

The Tendau group is, therefore, evidently younger than the Moulmein. Some plant-fossils (mostly Dicotyledenous) and some fish-remains have been obtained from the shales belonging to the former group. Their exact determination, however, is a matter of the greatest difficulty. All that can be said is, that the age in all probability is tertiary.

The deposits of shallow-water origin.

That the deposits under notice were of shallow-water origin is abundantly apparent from the false bedding of the sandstones, and the great predominance and excessively coarse character of the breccia conglomerates. The Tendau-Kamapying beds extend for only about a mile or so on either side of the Tenasserim, and the length of the area occupied by them does not exceed 15 miles. There can be scarcely any doubt that they were laid down in a lake-like expansion of the then Tenasserim Valley, the physical configuration of the ground at the time of their deposition being much the same as at present. The material of the deposits was derived from the disintegration of the hills which still bound them in.

3. Alluvium.

The alluvial deposits in the Upper Tenasserim Valley consist of clay or loam resting upon sandy and gravelly beds. The former is usually coloured brownish and its thickness varies from 10 to about 40 feet. But the exact thickness of the latter could not be ascertained. A few borings were let down in the alluvial ground near Therabwin. But after passing through the loam, as soon as the rods came to the sandy and gravelly strata, the progress was slow and ultimately *nil*, or even negative. Sand and gravel filled up the hole as fast as it was made, or even faster, as they sometimes came up with some force, somewhat in the manner of an artesian spring. The same difficulty was experienced with borings and diggings at Tendau and at Kamapying. Boring after boring, and pit after pit, had to be given up, as with the appliances at our command scarcely any progress could be made through the troublesome sands.

The alluvial clay is more or less ferruginous and is at places cemented into a lateritic rock. Its vesicular character was in some cases found due to the agency of burrowing animals. Laterite due to the alteration of older rocks is also found.

Both kinds of lateritic rocks abound in the valley, though they are nowhere of any great thickness.

The alluvial deposits are found to dip, though at very small angles. They would thus appear to have been slightly disturbed in recent times.

SECTION IV.—THE TENDAU-KAMAPYING COAL IN ITS ECONOMIC BEARINGS.

1. Extent of the Coal.

Coal of two ages.

From the last section it is clear that there is coal of two different ages in the Tenasserim Valley, one belonging to the Moulmein (carboniferous) group, and the other to the Tendau-Kamapying group, which is in all probability of tertiary age.

The carboniferous coal worthless.

The former coal is the more widely distributed of the two. It has repeatedly raised delusive hopes of workable fuel from the time of Dr. Helfer, when attention was first directed to the mineral resources of the Tenasserim division, until the time of Mr. Hughes, when they were exploited by a large staff of explorers. During the present exploration the coal was subjected to thorough and systematic search, borings and diggings being made in several promising localities in the vicinity of Therabwin. In every case, however, it was found to be economically useless. It occurs only as thin lenticular strings or pockets seldom more than 2 or 3 inches in thickness, largely mixed up with nodular white quartz, and containing a considerable percentage of ash. Often it scarcely deserves the name of coal, the shaly element predominates to such an extent. From an examination of the exposed outcrops of it, and from the results of the trial borings and diggings, I can say with some confidence that no workable coal is to be expected in the Moulmien group, at least in the Tenasserim division. This is a curious result considering that it is of carboniferous age, and the workable coal in Europe is mostly of that age.

The younger coal alone workable.

The workable coal is limited to the Tendau-Kamapying group, which is probably of tertiary age. The group covers an area of thirty square miles in the Tenasserim Valley. Within this area the coal has been met with only on the western side of the Tenasserim river. It has never been found on the eastern side: and there are considerations which make its occurrence there very unlikely.

Occurs on the western side of the Tenasserim river.

At Chá Mitwe (Tendau).

On the western side of the Tenasserim river the coal was experimentally worked in 1843 for a year or so at a place called Chá Mitwe (Burmese for coal) in the village of Tendau. The old workings are situated at a distance of a little over three quarters of a mile from the Great Tenasserim river by the side of a small stream which, formerly known as Thatay-Chhaung, changed its name to Chá Mitwe since the working of the coal on its banks.

Old working.

The coal had been extracted by open adits sunk on its dip for a distance of a few yards along this stream; shafts also had been sunk along the strike for a distance of a few hundred yards north and south of the stream. One of these (at a distance of 250 feet south of the point where adits had been sunk) struck coal at a depth of about 65 feet, but none of it was raised, the works having been abandoned shortly after the sinking of the shafts.

The coal in the Chá Mitwe stream has a total thickness of 7 feet 2 inches including three partings of shales, and of 6 feet 8 inches excluding these.

Thickness of the coal in the Chá Mitwe stream.

The Tendau-Kamapying strata at the deserted workings have an inclination of about 30° E.N.E. Southward they are mostly concealed by alluvium as far as the Yángse Chhaung, in which there are good exposures, but presenting no indications of the existence of coal, so that it must have died out in the intervening ground. In this ground several boring sites were selected along strike-line calculated from the direction of dip in the Chá Mitwe stream. One of the borings at a distance of a quarter of a mile south of this stream gave the following section:—

The coal traced thence southwards.

	Feet.
Alluvium	28
Brownish shale	17
Black shale	2
Coal	8
Shale	7

The coal in this section very likely includes thin partings of shale, so that its thickness is approximately the same as at the deserted workings by the Chá Mitwe stream. The coal must continue for a short distance further south, but it dies out somewhere north of the Yángse Chhaung, for in that stream no indication of it was observed by Mr. Datta.

Less than a mile and a quarter north of the Chá Mitwe stream there is a small stream covered by impenetrable jungle and specially infested by leeches, which is known as Bochypo-chhaung. It was carefully explored by Mr. Datta, but not a trace of the Tendau-Kamapying rock was visible, being hidden by alluvial deposits. A boring was tried at a site chosen on the strike, which, as seen by the Tenasserim close by is N. 20° W.—S 20° E. The rod after passing through the alluvium got down to conglomerates, progress through which was extremely slow. The boring had ultimately to be given up and another site was selected. Here, however, after the rod had gone down to nearly 70 feet without meeting coal or the shale accompanying it a bolt fell into the hole, which seriously obstructed progress; and this boring too was in the end abandoned.

Traced northward.

North of the Bochypo-chhaung there is no indication of coal or of the shales with which it is associated until we reach the Heinlat stream, which is situated in the village of Kamapying. About a mile (measured in a straight line) from the junction of that stream with the Tenasserim river there is an outcrop of brownish shales resembling those in association with which coal is found elsewhere in the Tendau-Kamapying area. The shales, however, are only some 3 feet or so in thickness and rest upon massive-bedded arenaceous clay rocks without a trace of coal. Proceeding a couple of miles along the strike north-westward, there occurs in the same stream at a distance of three quarters of a mile to the west of the Tenasserim river a splendid seam of coal which at one point is no less than 23 feet in thickness. The coal was traced by close diggings and borings for a distance of about one hundred yards.

The Heinlat, Kamapying.

The following section was revealed at boring No. i:—

	Feet.	Inches.
Alluvium	2	0
Hard blackish shale	2	6
Coal (with very thin partings of shale)	28	6
Hard grey shale	2	6

About 84 feet south of this along the strike, a pit (ii) gave the following section:—

	Feet.	Inches.
Dark grey and blackish shale	3	0
Black shales with thin coal	2	6
Coal	18	0
Grey shale	7	0

Twenty-nine feet S. 5° E. from the last along the strike, a pit and boring (iii) disclosed the following section:—

	Feet.	Inches.
Decomposed brownish shale	1	6
Coal mostly shaly	2	6
Black carbonaceous shale	1	5
Coal	4	0
Black carbonaceous shale	0	9
Coal	0	9
Shaly Coal	3	0
Black shale	9	4
Shaly Coal	6	6
Yellowish brown shale	3	6

Thirty-three feet S. 5° E. from the last along the strike, the following section was obtained in pit (iv):—

	Feet.	Inches.
Decomposed shales	2	0
Alternations of brownish grey and black shales	5	4
Coal	0	9
Greyish black shales	3	3
" hard shales	2	2

Further south, some pits and borings were sunk, none of which disclosed any coal.

North of boring (i), some pits and borings were undertaken, in most of which the difficulty of passing through the sandy alluvium within the time and means at our disposal, and, in the case of pits, also of baling out water which appeared at only 3 to 8 feet under the surface, was found nearly insuperable. The two following, however, successfully reached down to coal. One boring at a distance of 130 feet N. 10° W. of boring (i) gave the following result:—

	Feet.	Inches.
Alluvium	9	0
Dark coloured shales	1	0
Hard black shales	4	0
Black shale with thin coal	0	6
Coal		

One pit 25 feet from the last, across the strike, exposed the following section :—

	Feet.
Reddish loam	12
Sand and gravel	4
Coal	2

(bottom not reached).

From these two sections and boring (i), it would appear that the coal here is at least 13 feet in thickness.

About three quarters of a mile further north on the Htiphanko, the following section was exposed by digging during the season 1891-92 [1] :—

	Feet.	Inches.
Coal	0	10
Shale	2	0
Coal	2	3
Shale	3	0
Coal	4	6

2 *Quantity of the Coal.*

At Kamapying.

From the sections given above it is evident that the coal on the Heinlat thins out and ultimately disappears rather suddenly in the southern direction. There may be some faulting between the pits (iii) and (iv). But even if there were, the impoverishment of the seam in the southern direction is plainly shown by (iii), in which within a distance of 30 feet the 18-feet bed of pure coal has already suffered marked deterioration. The coal may reappear, but from what is seen on the Heinlat close to its junction with the Tenasserim, it may be confidently asserted that it will not be of any thickness.

Northwards there is reason to believe that the coal continues, though with diminishing thickness, as far as the Htiphanko.

We shall be on the safe side if we assume the longitudinal extent of the coal at Kamapying to be only three quarters of a mile, which is very nearly the distance between the coal on the Heinlat and that on the Htiphanko. The dip in the Heinlat is 40°. But this is exceptionally high, and I think we shall be quite within the mark if we take 35° to be the average dip.

The workable depth to which the coal could be worked in such a part may be taken to be 300 feet. For such a depth the horizontal extension of the coal in the direction of the dip would be some 400 feet.

The average thickness of the workable coal, between the Heinlat and the Htiphanko, may be confidently taken to be 15 feet.

With these data, the total amount of coal at Kamapying would be found to be about 890,000 tons, taking 100 cubic feet of coal to be equivalent to only three tons.

As there is some doubt about the extension of the coal in the direction of dip to any long distance, it would probably be safer to assume it to extend for only

[1] Report on the Prospecting Operations, Mergui District, season 1891-92, p. 2. "Records, Geological Survey of India," Vol. XXVI, Part 1.

about 300 feet to the eastward, within which limit the coal could be worked at a vertical depth not exceeding 200 feet. On this assumption the total amount of available coal at Kamapying would be about 600,000 tons.

At Tendau.

At Tendau, the coal probably extends along the strike for about a mile and a half. Taking its mean thickness to be only 4 feet, the dip 30°, and the maximum vertical depth to which it could be worked 300 feet, the total amount of coal is found to be about 554,083 tons. If, on considerations stated in the preceding paragraph, the vertical depth be reduced to 200 feet, which would assume a horizontal extension of the coal in the direction of dip of about 340 feet, there would be about 380,000 tons.

3. *Quality.*

Assays.

The coal by the Heinlat stream is the best, the analysis of an average sample in the Survey Laboratory giving the following result:—

Moisture	16·40
Volatile matter	35·08
Fixed carbon	44·24
Ash	4·28

The coal cakes, though not strongly, and the ash is light buff.

The following is the result of analysis of a sample of coal from the Htiphanko stream explored during the season 1891-92:—

Moisture	11·34
Volatile matter	36·40
Fixed carbon	43·27
Ash	8·99

Sinters slightly, ash reddish brown.

Compared with Indian coal.

In the following table the coal is compared with some of the best known Indian coals:—

	Fixed carbon.	Moisture.	Volatile matter.	Ash.
Karharbari (average)[1]	63·66	...	24·01	12·33
Raniganj (good specimen)	51·80	...	37·50	10·70
Upper Assam[2] (Makum)	60·00	...	36·2	3·8
Heinlat (Kamapying)	44·24	16·40	35·08	4·28

As regards the percentage of ash the Heinlat coal compares very favourably with that of Makum, and is far superior to that of Raniganj and Karharhari. It contains, however, less carbon. It is a splendid steam coal, and, as it cakes, it would be well suited for smelting purposes also.

[1] Manual of the Geology of India, Vol. III, page 80.
[2] Manual of the Geology of India, Vol. III, page 103.

Pyrites in the Tendau coal.

The Htiphanko coal does not cake; and it, as well as the Tendau coal, especially the latter, contains iron pyrites which is supposed to render it liable to spontaneous combustion. The experimental working of the Tendau coal, fifty years ago, was given up chiefly on account of the presence of this objectionable element. The Heinlat coal, however, was found to contain very little of the pyrites.

Heinlat coal the best.

As regards thickness and quality, the Heinlat coal is by far the best in the whole coal-field. How far it maintains its thickness and quality in the direction of the Htiphanko it is difficult to say. On the Htiphanko it is found in an attenuated and somewhat deteriorated condition. It may, however, be safely asserted that half the estimated available coal[1] at Kamapying is of the Heinlat type.

The coal comes out in good blocks. A few tons of it were extracted from the Heinlat bed last season and tried in the launch *Ataran*. The engine-driver preferred it to any other coal he had used before. For steaming purposes it is above the average of Indian coals.

4. Mining Expenses.

High dip but no crushing.

The rather high dip of the coal is a somewhat objectionable feature about it and would make its extraction more expensive than in Bengal, where the coal has a very easy dip. The strata, however, are nowhere crushed or contorted. The shales above the coal will afford a firm roof, so that there might be no necessity for timbering.

Labour.

Labour would have to be imported from India. Our Indian coolies were paid R10 per month. For a permanency the rate would be lower. Besides, the agricultural possibilities of the area, which is at present greatly under-populated, are great; and those members of the miners' families who are not engaged in mining would find agriculture a very profitable pursuit. A colony of Indian miners from West Bengal would change the face of the country; and I have no doubt the district authorities will offer advantageous terms for their settlement.

Maximum outlay.

Taking into consideration the two unfavourable circumstances about the mining of the Tendau-Kamapying coal, *viz.*, high dip and high cost of labour, the following estimate[2] made by Mr. Hughes last year of the probable charges for one ton of coal at the pit on an output of 10,000 tons a year may be accepted as a maximum outlay:—

	R	*a.*
Labour	2	8
Stores	1	0
Establishment and supervision	1	0
Haulage and contingencies	1	0
Royalty	0	4
	5	12

[1] That is, about 300,000 tons according to the lower estimate.

[2] Report on the Prospecting Operations, season 1891-92, page 3. "Records," Geological Survey of India," Vol. XXVI, Part 1.

Dr. Oldham also estimated the cost of the coal at the pit's mouth at about R5 per ton.

5. *Transit.*

(*a*) Water-carriage.

Carriage from the pits to the river.

The coal at Tendau as well as at Kamapying is situated about three quarters of a mile from the Great Tenasserim river; and the country between being tolerably level, a cart-road, or preferably tramway, could easily be constructed.

At Kamapying there are some bad rapids below which it would be advisable to take the coal if it has to be carried by water. The distance is only about two miles, over pretty level ground.

Bamboo rafts.

When the Tendau coal was experimentally worked in 1843, it was sent down to Mergui in bamboo rafts. Bamboo being plentiful in the area, the plan commends itself as economical, as the bamboos, after the rafts had been disburdened of their coal, would sell at a pretty high price at Mergui.

Objections to their use in systematic working.

However, though rafts might do for experimental working for a season or so, they would be quite unsuited for systematic working. In the first place, the gain in expense, which accrues from their use, is to a large extent counterbalanced by the loss in time. The coal I extracted at Kamapying was sent down the river by rafts as far as Banlaw, a distance of about 36 miles. They took nearly five days to reach that place, whereas boats would scarcely take two. Secondly, the coal would be partially soaked in salt water in its passage below Teraphon. Thirdly, though bamboos are plentiful, they would not meet the demand caused by a systematic working of the coal. Fourthly, even if they did meet the demand, the market at Mergui being glutted, their selling price would utimately become almost nominal.

Barges preferred.

If the coal be worked, and if it be conveyed by water, the best plan would be to have shallow-draught barges which could be towed down from Banlaw throughout the year, and from Therabwin during the greater part of it. As there is an abundance of good wood in the forests of the Tenasserim valley, the construction of boats would be a matter of no great expense.

(*b*) Land-carriage.

As the course of the Tenasserim between the coal-field and the port of Mergui is a most circuitous one, and as the river nearly as far down as Banlaw is full of shallows and rapids, offering serious obstructions to navigation, the idea of a railway has been broached. One of the objects of my exploration was to indicate the direction which such a railway would most advantageously take.

Only one track from the coal-field.

There is a track in the southern portion of the coal-field which leads from Chá Mitwe (Tendau) to Therabwin, crossing a spur at a place where it has a height of about 1,350 feet above the level of the surrounding country. There is no other track in the coal area. Even going from one village to another, one must go by water.

Track from Therabwin to Htombyo.

There are two fair weather tracks from Therabwin which are resorted to especially by cattle-dealers from Mergui and Tavoy. The best known of these is the one to Htombyo. It crosses the main hill range west of Therabwin at a point not more than 600 feet above the sea-level. The length of the track from Therabwin to Htombyo (in a straight line) is about 18 miles. The ground it traverses is comparatively easy. But the Kamapying coal would have to be brought down to Therabwin. The distance between the two places is not great, being only about 12 miles, but two hills would have to be crossed, one at a height of some 1,300 feet above the level of the adjacent country. The total length of the railway from Kamapying to Htombyo would be about 30 miles. But large sea-going vessels cannot come up to Htombyo; so, the coal would have to be carried thence to Mergui in cargo boats or shallow draught steamers to be shipped to Penang or Rangoon, there being hardly any local demand.

Objections to it.

Track from Therabwin to Tanyet.

The same objection on the score of transhipment which always adds to the cost of transit holds in the case of the track from Therabwin to Tanyet, which has the additional disadvantages of being a little longer and of crossing a difficult mountainous country.

Track from Powat to Kyuh Phya.

North of the coal-field there is a track from Powat (8 miles north of Kamapying) to Kyuk Phya, a port accessible to large sea-going vessels. But the country between Kamapying and Powat is difficult, and for the purpose of carrying the coal the track will probably be found to be useless.

Suggested line.

If it be found advisable to have a railway at all, I would suggest a direct one from Kampaying to Kyukphya. The nature of the intervening country is not known at present, except that it is a trackless, unbroken jungle. But I do not expect it will be a very difficult one. The distance between Kamapying and Kyukphya is about the same as that between Kamapying and Htombyo. But Kyukphya being by the sea-side and having a good harbour, the suggested route, besides being shorter by the distance between Htombyo and Mergui, would save one transhipment.

Cost of transit.

It is difficult to estimate the cost of transit. If the coal be carried by water, as, in case of its being worked, it will very likely have to be for some time at least, the carriage from the pits at Kamapying to the river side below the rapids would be very little if a short tramway be constructed. Thence to Mergui if there be a service of specially constructed shallow draught cargo boats towed by launches from Therabwin or Banlaw, the cost of transit would not, I think, exceed R2 per ton.

6. Other mineral resources.

(*a*) Iron.

Lateritic ores in the valley.

In the course of the coal exploration, attention was also directed to the other mineral resources of the valley besides coal. Lateritic iron ores are widely distributed in the valley; but they are superficial deposits and do not, as a rule, appear to be rich.

One sample analysed in the Survey Laboratory was found to contain 36·06 per cent. of iron. Another sample from Therabwin contains 50·49 per cent. of iron.

But these samples are of exceptionally good quality. The general run of the ores is far inferior to them, and I do not think their quantity or quality is such as to afford scope for an industry on a commercial scale.

At Maha Champa.

Close to the mouth of the Tenasserim, however, 6 miles to the west of Mergui, at a place called Maha Champa (at the southern extremity of the Kola Gyun Island) I came upon extensive deposits of iron ore. It, too, is of a lateritic character, being the result of the alteration of argillaceous schists belonging to a group of rocks older than the "Moulmein" to which the name of "Mergui" has been applied by Dr. Oldham ("Geological Papers on Burma," p. 377). The ores cover at least one square mile of ground; and though from its nature it cannot go down more than a few feet below the surface, what there is exposed appeared to me practically inexhaustible. The quality is not very good. But the quantity would make up for this deficiency. A mixture of several samples (good and bad) was found to contain, by assay in the Survey Laboratory, 36·8 per cent. of iron.* An assay of a rather picked sample showed 37·58 per cent.

Field for an iron industry.

The boats which would carry down coal to Mergui could take up the iron ore to the coal-field, so that its carriage would but entail little additional expense. If the boats did not carry the ore, they would mostly have to go back empty to the coal-field, which would be very uneconomical. Should the coal be worked, I would advise a fair trial of the Maha Champa iron ores. The Heinlat coal has been found to cake; and there is splendid flux at Therabwin, as will be shewn presently. At present the demand for coal in the Tenasserim division is confined to a few steamers plying along the coast. They have been hitherto mostly using wood. But a tax has been recently imposed upon fire-wood which will have the effect of raising its price probably so high as to make the substitution of fair-priced coal desirable. But even then, the local demand will never be sufficient to support a properly worked mine. It would mostly have to be shipped off to Rangoon or Penang. In the event of iron works being started on the coal-field or close to it they would absorb a good quantity of the coal, and thus reduce the dependence on the distant markets of Penang and Rangoon.

I must say, however, that the local demand for iron is surprisingly small. Almost the only articles which the people want it for are knives and axes. They generally do without ploughs, and when they have any, iron does not enter into any part of their construction. They seldom use any cooking utensils made of iron. Wood is so abundant that it will continue to be used for beams, railings, etc., for a long time to come. There is not a single blacksmith in the district outside the town of Mergui. But the requirements of the different districts constituting the Tenasserim division will be considerable, and what is not taken up by them would probably be more profitably exported to Rangoon and Penang than coal.

* The iron ores in the neighbourhood of Barakar, which are used in the works at that place contain from 24·24 to 49·63 per cent. of iron, so that the average percentage is about the same as that contained in the Maha Champa ores. (See Manual of the Geology of India, Vol. III, page 370.)

(*b*) Limestone.

The limestone ridges in the vicinity of Therabwin would supply excellent flux. A sample of the limestone has been analysed in the Survey Laboratory with the following result:—

Insoluble in dilute H. Cl.	13·40
Oxide of iron and alumina	0·61
Carbonate of lime	85·85
Carbonate of magnesia (by difference)	0·14
	100·00

If iron works be started, I think Therabwin would be a good site for them. It is quite close to the coal-field; shallow-draught launches can come up to it throughout the year; and it has a large extent of flat ground suitable for a settlement.

(*c*) Tin.

Tin was formerly worked for at the following places in the vall ey of the Great Tenasserim:—

(1) Tendau (close to the coal-field) at the head-waters of a stream of the same name.
(2) Tagu, near the source of a stream of the same name.
(3) Myengyee, about 6 miles N. N.-W. of Tenasserim.
(4) Marton—There are numerous old pits along the foot of a range of granitic hills north-east of the village.
(5) Zoe, about 8 miles N. N.-W. of Marton.

There are also several localities in the Little Tenasserim valley where tin was worked of old. At present tin workings are confined to a place called Thebawlik, about 18 miles to the west of Tenasserim. For information regarding these and several of the deserted workings in the Great Tenasserim valley I would refer to the reports of the prospecting operations under Mr. Hughes published by the Government of Burma.

(*d*) Gold.

It is still washed for on a very small scale in the Tenasserim river at the old town of Tenasserim. I mention its occurrence more with a view to make the list of the mineral resources of the Tenasserim valley complete than to raise hopes of remunerative exploitation.

7. Summary.

The results of the coal-exploration embodied in the present report may be summarized as follows:—

(1) There is, in the Mergui district, coal of two distinct ages, carboniferous and tertiary.
(2) The carboniferous coal is far more widely distributed than the tertiary, but is economically worthless.
(3) The tertiary coal occurs at two localities—Chá Mitwe (Tendau) and Kamapying, both situated on the right, or western, bank of the river

Tenasserim. There is hardly any chance of the coal being found on the eastern side of the river.

(4) The available quantity of coal at Kamapying is *at least* 600,000 tons, and at Chá Mitwe *at least* 380,000 tons.*

(5) For steaming purposes the coal is far above the average of Indian coals.

(6) The coal on the Heinlat at Kamapying is the most promising in the whole field. It is very thick, cakes though not strongly, and is almost free from iron pyrites, the presence of which in some abundance in the Tendau and the Htiphanko coal detracts from its value. There are at least 300,000 tons of the Heinlat type of coal at Kamapying.

(7) Having regard to the high dip of the coal and the difficulty of getting labour locally, the expense of working the coal on a fairly commercial scale would amount to about R5 per ton.

(8) The cost of transit to Mergui would amount to about R2 per ton, if the coal be carried in specially constructed shallow-draught barges towed by stern-wheel launches from Therabwin or Banlaw.

(9) If a railway be constructed the best alignment would, I am inclined to think, be from Kamapying, where we have the best coal, to the port of Kyukphya, which is accessible to large sea-going vessels. The distance is about 28 miles.

(10) The presence of extensive deposits of iron ore at the southern extremity of the Kola Gyun Island, 6 miles west of Mergui, and the occurrence of excellent limestone at Therabwin are circumstances highly favourable to the working of the coal, as an iron-industry would locally absorb a good quantity of it.

On a Magnetite *from the* Madras Presidency containing Manganese *and* Alumina, *by* T. H HOLLAND, A.R.C.S., F.G.S., *Geological Survey of India.*

Amongst a number of manganese ores recently received from the Kodúr mines, south of Chipparupale, Vizagapatam district, Madras Presidency, a specimen labelled "braunite" attracted my attention from its resemblance to magnetite. I found it to be strongly magnetic, exhibiting distinct polarity; and it had also the lustre, hardness and colour of magnetite, but gave a distinctly reddish brown streak. The specimen was composed of a mass of granules, each about ¼ inch across, and limited by faces which were apparently the result of mutual interference during the growth of adjacent crystals.

* These figures preclude the possibility of mining in the Tendau-Kamapying field on such a large scale as that on which some of the Indian mines are worked. The annual output of several of these exceeds forty thousand tons.

A number of crystals gave an average *specific gravity* of 5·045.

Chemical analysis gave the following results:—

Moisture lost below 105° C.	0·14	
Residue insoluble in hydrochloric acid	0·11	
Water lost by ignition	2·18	
Alumina (Al_2O_3)	2·52	
Ferrous oxide (FeO)	26·84	Fe_3O_4, 91·62
Ferric oxide (Fe_2O_3)	64·78	
Manganese oxide (Mn_3O_4)	3·00	
	99·57	

Separate determinations of the iron and manganese gave 66·74 per cent. Fe (equal to 92·16 Fe_3O_4); 2·183 and 2·144 per cent. Mn (equal to 3·03 and 2·98 Mn_3O_4 respectively).

Neglecting the hygroscopic moisture and insoluble matter (both very small), and calculating to 100, we obtain:—

H_2O	2·19
FeO	27·03
MnO	0·94
Al_2O_3	2·54
Fe_3O_4	65·22
Mn_3O_4	2·08
	100·00

Calculating the atomic ratios of these we have—

	$R^{ii}O$	$R_2^{vi}O_3$
Fe	·3754	·4077
Mn	·0132	·0132
Al	...	·0247
H	·12 6	...
	·5102	·4456

The protoxide group thus appears in excess of the sesquioxides, evidently due to calculating the water as a protoxide. The water, therefore, must be regarded, in part at least, as a hydrate of one or more of the bases.

On comparing these results with previously recorded analyses of magnetites, we find that manganese has been found before replacing the iron, either with or without magnesia, but I know of no case in which at the same time alumina replaces the sesquioxide. The nearest approach to the Madras specimen seems to be a mangan-magnetite from Vester Silfberg, described by Mats Weibull. Its specific gravity (5·064) agrees closely with that of the Madras mineral, and, as the author remarks, it is slightly lighter than ordinary magnetite. A chemical analysis by Rudelius gave—

FeO	26·93
MnO	3·80
Fe_2O_3	69·32
	100·05[1]

A variety of magnetite from New Zealand, analysed by Mr. F. J. Cairns, under the direction of Professor A. H. Chester, in 1888, gave 4·98 per cent MgO and 4·82 per cent Mn_3O_4[2]. The Vizagapatam specimen is thus a new variety.

[1] *Min. und. petr. Mittheil.*, vol. VII (1886), pp. 109 and 110.

[2] *Min. Mag.*, vol. VIII (1889), pp. 125 and 126.

On Hislopite (Haughton); *by* THOMAS H. HOLLAND, A.R.C.S., F.G.S., *Geological Survey of India*, (with a plate).

I.—HISTORY AND CHEMICAL COMPOSITION.

In the year 1858, Prof. Haughton proposed the name *Hislopite* for "a remarkable combination of calc-spar and glauconite" found by the Rev. S. Hislop at Nagpur in the Central Provinces.[1] The specimen described presented the crystalline form of calc-spar; was of a brilliant grass-green colour, and effervesced briskly with weak hydrochloric acid, which dissolved its calcareous portion, leaving a beautiful, green, siliceous skeleton described by the author as "glauconite." The original specimen, according to Professor Haughton's analysis, was composed of—

Green siliceous skeleton (glauconite)	16·63
Alumina	0·73
Carbonate of lime	80·79
Carbonate of magnesia	trace.
	98·15

From the description it appears that the substance was found associated with zeolites and other secondary minerals infilling crevices and amygdaloidal cavities in the Deccan lavas, which are known for the variety and beauty of the large crystals of hydrous silicates which they have yielded.

There seems little doubt, also, that "hislopite" is the substance mentioned by Lieutenant-Colonel Sykes in his paper "On a portion of the Dukhun, East Indies," communicated to the Geological Society of London in 1833. Col. Sykes found masses measuring 2 feet across, of a green colour, exhibiting the form of calc-spar *but of lower specific gravity*[2] (*vide infra*, specific gravity, p. 168).

A specimen of calcite recently sent by the Hyderabad (Deccan) Company for determination presented somewhat similar characters to those of hislopite described by Prof. Haughton. Well-developed cleavage rhombs of calcite showed included patches of green material, similar to the green earth which is so common in the amygdules of the Deccan lavas, and which has generally been referred to as *glauconite*. Sections examined under the microscope show a groundmass of calcite, with its characteristic cleavage and occasional *Gleitflächen*, including botryoidal and irregular masses of green earth (glauconite in part); and a colourless mineral, polarising with low colours of the first order, and exhibiting extinctions inclined to all the section-outlines. These, which frequently include portions of the green earth, proved, on separation by means of heavy liquids, to be *heulandite* (see plate).

[1] *Journ., Roy., Dub. Soc.*, vol. II (1858-59), pp. 176 and 177; *Phil. Mag.*, 4th ser., vol. XVII (1859), pp. 16-18.
[2] *Trans. Geol. Soc.*, vol. IV, p. 425.

Two fragments were selected for determination of the carbonic acid. One piece yielded 31·47 per cent. (CO_2) as an average of two closely agreeing results. The second fragment, kindly analysed for me by Mr. J. Cleghorn, of the Public Works Department, gave 30·49 per cent. The average of these two results (30·98) indicates the presence of 70·41 per cent. of lime carbonate, the remainder (29·59 per cent.) being composed of heulandite, green earth and moisture.

The complete analysis of the substance is as follows :—

Specific gravity of the fragment analysed, 2·546[1].

Chemical composition.

Moisture	4·031
Residue insoluble in acetic acid	23·476
Fe_2O_3 and Al_2O_3	0·247
CaO	40·483
CO_2	30·980
	99·217

The iron, alumina and a small portion of the lime are derived from the green earth and heulandite, both of which are slightly attacked even by cold acetic acid. By this decomposition there is a small loss, due principally to the combined water in these hydrated minerals, and which cannot be accounted for by this method of analysis. Hence the total is below 100. A low total, probably from the same cause, may be noted in Prof. Haughton's analysis.

The above results show a much larger proportion of the included minerals than that indicated by Prof. Haughton's analysis. But such variations need not be surprising for three reasons :—(1) The green earth is partially, and the heulandite wholly, decomposable by hydrochloric acid, the solvent which Prof. Haughton used to separate the carbonate of lime from the green siliceous skeleton. Hence the insoluble residue would be less than the total mineral included in the calcite. Even in acetic acid these included minerals are partially soluble. (2) The proportion of heulandite to green earth is variable. (3) The foreign substances are only mechanically included in the calcite, and consequently there is no necessary proportion between the minerals included and the host. This statement is verified by the results recorded below.

Prof. Haughton in a later paper gives the following result of his analysis of

[1] With the chemical analysis of *mixtures* of minerals (as all rocks are) in which the proportion of constituents is variable, it is very important to determine the specific gravity of the *actual fragment analysed*, whatever be its size. In this way a quantitative mineral composition can often be stated with considerable accuracy (*vide Rec.*, *Geol. Sur. Ind.*, vol. xxiv, (1891), pp. 232 and 236). The same remark applies equally to minerals, in which (the spinels for example) isomorphous compounds replace one another to varying degrees. In offering this suggestion I do not imply that the advantage of this proceeding is overlooked by other workers but whilst in many published analyses other details (some none, the less important) are care; fully recorded, the discrepancy between the specific gravity and chemical analysis, which is often so evident, shows that this precaution is still frequently overlooked, with the result that the scientific value of the result is greatly depreciated.

"calc-spar, clouded-like plasma, with pale greenish streaks of a siliceous mineral":—

Carbonate of lime	97·19
Green siliceous mineral	2·81
	100·00

He remarks that "the quantity of colouring mineral was too small for examination, and its percentage much less than that of the Glauconite, which gives its rich green colour to Hislopite [1]."

It would seem from this last remark, and from the fact that on the same page the author refers to the *new minerals* hislopite and hunterite, that he regards the proportion of green siliceous mineral as important, and places specific value on the term *hislopite*. With this in view I examined a specimen of green calc-spar in the Geological Museum, Calcutta, labelled "Hislopite, Nagpur." The analysis showed—

Carbonate of lime	95·385
Moisture, inclusions, etc.	4·615
	100·000

Specific gravity of fragment analysed . . . . . . 2·659

There is thus a great variation in the quantity of material included in the calcite; sometimes the inclusions are greater in quantity and sometimes less than that found in the original specimen of hislopite.

II.—Specific Gravity.

The variation thus found in different specimens is evident to the naked eye in the specimen of green calcite sent by the Deccan Company. But a comparison of the specific gravities of different fragments demonstrates this fact more conclusively, and shows how the inclusions, when occurring in large quantities, give the specimen a lower specific gravity, as was noticed by Colonel Sykes in 1833 (*vide supra*, p. 166). This, of course, is due to the fact that both heulandite and glauconite are lower in specific gravity than calcite:—

Specimen.	Sp. gr.	Carbonate of lime.	Moisture and minerals included (by difference).	Insoluble residue (by experiment).
A. Specimen sent by Hyderabad (Deccan) Company.	2·546	70·41	29·59	23·47[2]
B. Hislopite, original specimen analysed by Haughton.	2·645	80·79	19·21	16·63[3]
C. Specimen labelled "Hislopite, Nagpur," in Geological Museum, Calcutta.	2·659	95·38	4·62	2·340[2]
D. Clear Iceland spar, small fragment cut from A.	2·711	99·12	0·88	...

[1] *Phil. Mag.*, 4th Ser., vol. XXIII (1862), p. 50.
[2] Insoluble in acetic acid.
[3] Insoluble in hydrochloric acid.

Specimen A varies so much in different parts that whilst, as shown, by D, it is in places made up of transparent Iceland spar, in other places the green earth occurs in such quantities that the presence of calcite is only manifested by using acid.

Of this specimen (A) in which the inclusions are well-defined, I have determined the specific gravity of the insoluble residue[1] and find it to be 2·42. Taking the specific gravity of calcite as 2·72, we have:—

Calcite . . .	2·72 × 70·41	=	191·6
Green earth and heulandite	2·42 × 23·47	=	56·8
Moisture (difference) .	1·00 × 6·12	=	6·1
TOTAL .			254·5 = 100 × 2·545

This result agrees thus very closely with 2·546 (the specific gravity of A as determined by experiment) and in this particular case the very close approximation is doubtless accidental; but from analogy of many other examples I should expect agreement to the second decimal point.

III.—MINERALS INCLUDED.

To determine the nature of the included minerals, I dissolved a large fragment in acetic acid and treated the residue with a heavy liquid. The material was by this means divided into three portions:—

(1) The green botryoidal masses.
(2) Compound grains, or crystals of heulandite with *included* green earth.
(3) Clean heulandite crystals.

(1). *The green earth.*—The first portion had a specific gravity of 2·62, which is high for glauconite, but may be accounted for by the numerous apple-green, opaque portions, probably referable to *celadonite.* On account of the composite nature of the material, as shown by the microscope, a quantitative chemical analysis would be of little value. I found, however, that it gave off water on heating, fused before the blowpipe to a black magnetic glass, and was partly decomposable by hydrochloric acid, colouring the acid by the dissolved iron. The first treatment with acid changed the colour of the masses from a pistachio-green to an apple-green colour, which I attribute to celadonite.[2]

(2). *The compound grains.*—Were disregarded.

[1] By Smeeth's method (*Proc. Roy. Dublin Soc.*, Vol. VI (1888), p. 61). I have modified the method by using paraffin instead of vaseline, as the latter substance is of oily consistency in this climate.

[2] *Cf.* Heddle on Celadonite, *Trans. Roy. Soc. Ed.*, vol. XXIX (1879), p. 102. It may be remarked that the percentage of silica, 54·59, obtained by Prof. Haughton from the green siliceous residue of his hislopite agrees very closely with the average of the results given by Prof. Heddle for four specimens of celadonite (54·84); but I would place very little value upon this agreement, for the green earth which I have separated from the calcite is decidedly composite in character, and, unlike celadonite, a large proportion of it is decomposable by hydrochloric acid. Moreover, the heulandite, with which it is associated in the green calc-spar, is decomposable by hydrochloric acid, and would consequently contribute a variable but serious amount of silica to Prof. Haughton's insoluble residue ("Green siliceous skeleton").

(3). *The heulandite crystals.*—The third portion consisted of minute glistening plates, seldom measuring more than 0·25 mm. in any direction, and with a specific gravity of 2·21. Most of the crystals agree in form with those of heulandite given by Artini.[1] They are generally combinations of basal plane (OP), orthodomes ($2\bar{P}\infty$ and $-2\bar{P}\infty$), prism (∞P), and clinopinacoid ($\infty \bar{P}\infty$), (Fig. 2). As the clinopinacoids are in all cases well-developed, the crystals naturally lie on those faces, and so allow of an easy determination of the angles between the basal plane and dome faces by revolving the cross wires of the microscope. The angles obtained in a large number of examples agree very closely with those recorded for undoubted heulandite. They are—

$OP \wedge 2\bar{P}\infty$	116°.	(116° 20′, quoted by Dana).
$2\bar{P}\infty \wedge -2\bar{P}\infty$ . .	130°.	(129° 40′, „ „ „)
$OP \wedge -2\bar{P}\infty$	114°.	(114°, „ „ „)

The crystals between crossed nicols are generally seen to be zoned parallel to the dome faces and basal plane, extinction angles, therefore, show variations from 6° to 12° measured from the line of intersection of prism and clinopinacoid (parallel to vertical axis)[2]. Crystals turned up in viscous Canada balsam with their clinopinacoids perpendicular to the slide show straight extinction. In some cases, when lying on their clinopinacoids, they are seen between crossed nicols to be divided into four sectors, two of which extinguish at the usual angle, whilst the other two exhibit almost straight extinction. This, and the zoning, may be due to intergrowths or successive growths of heulandite with the dimorphous form, epistilbite, or with either of the closely related species mordenite, stilbite, and laumontite. Still, crystals showing undoubted heulandite characters prevail, and the results of Rinne, Hussak, Negri and Artini show some curious variations in the optical properties of this mineral obtained from different localities.

When heated before the blowpipe the crystals swell and fuse to a white enamel. On treatment with hydrochloric acid decomposition takes place rather slowly, the residue of silica retains the perfect outline of the original crystal, but is traversed by irregular cracks, and is isotropic between crossed nicols. If the action of the acid is not too prolonged, cores of undecomposed mineral are left, but showing apparently only irregular shapes.

There seems no reason why other zeolitic minerals of about the same specific gravity should not occur mixed with the heulandite crystals in subordinate proportions.

IV.—SUMMARY.

(1) The handsome crystals of green calcite from the Deccan "traps" contain inclusions which vary greatly in amount and sometimes exceed the host in quantity.

(2) The inclusions consist of—(*a*), a green earth of rather indefinite composition, but consisting in part of material closely resembling that which has been described as celadonite, and (*b*) crystals of heulandite.

(3) There is a variable, but no essential, connection between the proportion of calcite and the minerals which it includes, the specific gravity of any fragment

[1] *Vide* Dana: System of Mineralogy (1892), pp. 574 and 576.

[2] *Cf.* Levy and Lacroix, *Les Minéraux des Roches* (1888), *Heulandite non déformée*, p. 310.

being that of a mixture of the component minerals. Prof. Haughton has described as a "new mineral" (*vide Phil. Mag.*, vol. XXIII (1862), p. 50), a specimen of calcite containing 17·36 per cent. of glauconite, under the name *hislopite.* The name hislopite loses its specific value when the variation of the included so-called glauconite is proved to be so great as the foregoing results show; and still more so when it is found that glauconite is neither the only, nor, indeed, always the most abundant, inclusion in the calcite.

EXPLANATION OF PLATE.

Fig. 1. Section of calcite showing its rhombohedral cleavage with inclusions of botryoidal masses of green earth and clear crystals of heulandite. Inclusions of the green earth in the heulandite are very common. Magnified by 40 diameters.

Fig. 2. Crystal of heulandite lying on its clinopinacoid. Length of crystal between its basal planes 0·25 mm.

$$a = 0P \wedge 2\bar{P}\infty = 116^\circ$$
$$b = 0P \wedge -2\bar{P}\infty = 114^\circ$$
$$c = 2\bar{P}\infty \wedge -2\bar{P}\infty = 130^\circ$$

GEOLOGICAL SURVEY OF INDIA DEPARTMENT.

TRI-MONTHLY NOTES.

No. 17.—ENDING 31ST OCTOBER 1893.

Director's Office, Calcutta, 31st October 1893.

The disposal of officers during the next field season (1893-94) has been arranged as follows :—

SCIENTIFIC.

Baluchistan and N. W. Frontier.

Mr. C. L. Griesbach, C. I. E., Superintendent.
Mr. F. H. Smith, Assistant Superintendent.
Babu Kishen Singh, Sub-Assistant.

Madras.

Mr. C. S. Middlemiss, Deputy Superintendent.
Dr. Warth, do. do.

Burma.

Dr. Fritz Nöetling, Palæontologist.

Rewa State.

Mr. P. N. Bose, Officiating Superintendent.

Central Provinces.

Mr. P. N. Datta, Assistant Superintendent.

Head-quarters and Tours.

The Director.
Mr. T. H. Holland, Assistant Superintendent.
Babu Hira Lal, Sub-Assistant.

ECONOMIC.

Sukkur Experimental Boring.

Mr. T. D. LaTouche, Officiating Superintendent.

Superintendents, Messrs. T. W. Hughes and R. D. Oldham are on sick leave and furlough; and within the last month Mr. Assistant Superintendent W. B Dallas Edwards has also been sent home on sick leave.

The Director was on tour in the Madras Presidency from the beginning of September to the middle of October, when opportunities admitted of a conference with the Government of Madras as to the disposal of a geological officer for further continued survey in the Presidency. It was arranged that Mr. Middlemiss will complete the mineral survey of the Salem District, the western portion of which still remains open to further exploration; and that the occurrence of corundum is to be made the immediate object of inquiry according as this mineral and its associated rocks are studied in the course of survey. In this connection it is also proposed, when the district is finished, to initiate a series of district Mineral Manuals by the issue of one on the Salem District.

Opportunity was taken to examine certain areas of the crystalline rocks, particularly at the Palaveram hill near Madras, in connection with recent petrological observations which had been made by Mr. T. H. Holland while on deputation at different times for the Imperial Institute inquiries into the iron resources of Southern India: and to which reference was made in his paper (Records XXV, pp. 141-45) on the *Iron Ores and Iron Industries of Salem*, and in the Tri-monthly Notes of the same volume. It may be remembered that, in the Annual Report of the Survey for last year, it was stated that :—

"Another noticeable feature amongst the rocks collected in the South of India is the wide prevalence of the mineral hypersthene, and, to a less extent, other members of the pyproxene group. This mineral occurs as a constituent of rocks varying in composition from hypersthene-microcline granite to norite and hypersthene-rock. The very wide area over which Mr. Holland's tour for the collection of specimens and information extended prevented his doing more than a superficial examination of these rocks, but I look upon them as a promising sequel to the petrological results obtained by M. Lacroix on the Salem and Ceylon specimens; and they promise to be only an earnest of what may be expected from a more detailed examination of this complex area. It seems likely that many of the rock-masses which have been provisionally mapped as metamorphic will be found, as Dr. Lawson has shown in the Rainy Lake Region of Canada, to be merely rolled-out laccolites and intrusive bosses—some with a well-defined parallelism of constituents, but passing by imperceptible gradations into true granitic structures."

Since this was written, Mr. Holland has paid two more visits to Madras, the latter in company with the Director, to some of the rock 'massifs' referred to in the closing passages of the above extract, namely the Nilgiris, the Shevaroy Hills, and Palaveram, from the recorded observations in which and the suites of specimens collected, it now seems certain that these masses are really such laccolites and intrusive bosses of igneous rocks as he indicated. These discoveries necessarily involve considerable modification of the views of the earlier surveyors regarding their interpretation of the Nilgiri and Shevaroy rocks as belonging to a great series of very old gneissic or highly metamorphosed sedimentary deposits; although the rocks of the wide plains, stretching away from, and surrounding, those hill groups are still open to such a classification as being a decidedly more foliated and pseudo-bedded series, among which these newly-discovered granites were irrupted. The whole question of the history and constitution of the Madras crystallines is, however, as yet only advanced thus far, and it must wait the results of the further survey, which is now being gradually carried out.

List of assays and examinations made in the Laboratory, Geological Survey of India during the months of August, September and October 1893.

Substance.	For whom.	Result.
1. Specimen of quartz, with iron pyrites and visible gold.	Gillanders, Arbuthnot & Co., Calcutta.	Assayed for gold.
2. Specimens of quartz, from the ancient gold workings (discovered by R. Sewell, I.C.S., Collector of Bellary) near Yeutanhatti, Bellary.	Dr. H. Warth, Officiating Superintendent, Government Central Museum, Madras.	(I) White quartz. Quantity received, 34 lb. Contains no gold. (II) Blue quartz. Quantity received, 33 lb. Contains no gold.
Nodules from the lavender shales between Ratwahi and Jalar, Salt Range.	C. S. Middlemiss, Deputy Superintendent, Geological Survey of India.	= Barytes. sp. gr. 4·43.
A "small sample of stone" for determination.	Balmer Laurie & Co., 103, Clive Street, Calcutta.	= Iron pyrites.
A specimen of stone locally called "Hiranchi," found in the hills at Tehie Ghatia, Kawardha State.	A. S. Womack, I.C. S., Political Agent, Chhattisgarh Feudatories, Raipur, Central Provinces.	= Hematite.
A specimen of "certain stones," found at Manza Sagar, Government estate of Damin-i-Koh.	H. H. Heard, Sub-divisional Officer, Godda.	= Limonite.
A specimen from Badshahr, Persia; found by Mr. Ferrell; supposed to contain gold.	W. Coldstream, I.C.S., Deputy Commissioner, Simla.	= Mica schist; contains no gold; the shining particles being mica, stained with iron.

Notification by the Geological Survey of India during the months of August, September and October 1893, published in the "Gazette of India," *Part II.—Leave.*

Department.	No. of order and date.	Name of officer.	Nature of leave.	With effect from	Date of return.	REMARKS.
Geological Survey Department.	1390, dated 31st August 1893.	P. N. Datta, Assistant Superintendent, Geological Survey.	Privilege	7th September 1893.	...	...

Anuual increments to graded officers sanctioned by the Government of India during August, September and October 1893.

Name of officer.	From	To	With effect from	No. and date of sanction.	REMARKS.
	R	R			
P. N. Datta, Assistant Superintendent, Geological Survey . .	470	500	1st July 1893.	Revenue and Agricultural Department No. $\frac{1880}{158}$, dated 3rd August 1893.	
C. L. Griesbach, Superintendent, Geological Survey. . . .	950	1,000	1st August 1893.	Do. No. $\frac{1927}{167}$, dated 7th August 1893.	
F. H. Smith, Assistant Superintendent, Geological Survey .	380	410	Do.	Do. No. $\frac{1929}{168}$, dated 7th August 1893.	
F. H. Holland, Assistant Superintendent, Geological Survey. .	410	440	1st September 1893.	Do. No. $\frac{2427}{194}$, dated 29th September 1893.	

Notifications by the Government of India during the months of August, September and October 1893, published in the "Gazette of India," *Part I.—Appointment, Confirmation, Promotion, Reversion and Retirement.*

Department.	No. of order and date.	Name of officer.	From	To	Nature of appointment, etc.	With effect from	REMARKS.
Revenue and Agricultural Department.	$\frac{2150}{60}$, Surveys, dated 30th August 1893.	P. N. Bose.	Deputy Superintendent.	Officiating Superintendent.	Acting, temporary.	18th July 1893.	

Postal and Telegraphic Addresses of Officers.

Name of officer.	Postal address.	Nearest Telegraph Office.
T. W. H. HUGHES	On furlough.	
C. L. GRIESBACH . . .	Quetta	Quetta.
R. D. OLDHAM	On furlough.	
P. N. BOSE	Rewa	Rewa.
T. H. D. LATOUCHE	Sukkur. . . .	Sukkur.
C. S. MIDDLEMISS	Madras. . . .	Madras.
W. B. D. EDWARDS	On furlough.	
P. N. DATTA	Nagpur. . . .	Nagpur.
F. NOETLING	Dandot . . .	Dandot.
HIRA LAL.	Calcutta . . .	Calcutta.
KISHEN SINGH	Quetta	Quetta.

DONATIONS TO THE MUSEUM.

FROM 1ST NOVEMBER 1892 TO 31ST JANUARY 1893.

Six specimens of rocks, from Giridih and Asansol.
PRESENTED BY F. G. BROOK-FOX, F.G.S., CHICACOLE, GINGAM DISTRICT.

Specimens of sapphire, garnet, tourmaline, quartz and pyrite, said to come from Spiti. Fossils from Larsa, Lippa Valley; quartz with graphite, quartz with azurite, and quartz crystals, from Gumjang Valley.
PRESENTED BY E. F. LITCHFIELD, ASSISTANT SUPERINTENDENT, FOREST SURVEYS, DEHRA DUN.

Five specimens, consisting of quartz with pyrite, serpentine, etc., from the Andamans.
PRESENTED BY G. BARTON GROVES, DEPUTY POSTMASTER-GENERAL, EASTERN BENGAL, DACCA.

A miscellaneous collection of fossils from the Samana Range, Miranzai.
PRESENTED BY MAJOR F. G. L. MAINWARING, I.S.C., 29TH PUNJAB INFANTRY.

A specimen of galena in quartz, from Bilowra, Pargana Antri, Gwalior State.
PRESENTED BY RAGHUNATH RAO DINKAR, DISTRICT MAGISTRATE, TAWARGHAR STATE, GWALIOR.

Several specimens of minerals and rocks, from Jesalmeer, Bikaneer, Hazaribagh, Birbhum, etc.
PRESENTED BY N. A. BELLETTY, CALCUTTA.

A specimen of copper ore (chalcopyrite and pyrite, with quartz) from the 'Gladstone shaft' Rakha.
PRESENTED BY GILLANDERS ARBUTHNOT & CO., CALCUTTA.

ADDITIONS TO THE LIBRARY.

FROM 1ST OCTOBER TO 31ST DECEMBER 1892.

Titles of Books. *Donors.*

CALLON, *J.*—Lectures on Mining, delivered at the School of Mines, Paris, with Atlas of Plates. 8° Paris, 1876.

COLLINS, *J. H.*—On the origin and development of Ore deposits in the West of England. 8° Pam. Cornwall, 1890.

DAVIES, *D. C.*—A treatise on Metalliferous Minerals and Mining. 8° London, 1892.

FLETCHER, *L.*—The optical Indicatrix and the transmission of Light in Crystals. 8° London, 1892.

Titles of Books. *Donors.*

FUTTERER, *Dr. Karl.*—Die Ammoniten des Mittleren Lias von Oestringen. 8° Pam. Heidelberg, 1890. THE AUTHOR.

" Die Entstehung der Lapisinschen seen. 8° Pam. Berlin, 1892. THE AUTHOR.

" Die "Ganggranite" von Grosssachsen und die Quarzporphyre von Thal Im Thüringer Wald. 8° Pam. Heidelberg, 1892. THE AUTHOR.

" Die Tertiärschichten von Grosssachsen. 8° Pam. Heidelberg, 1890. THE AUTHOR.

GEIKIE, *Sir Archibald.*—Atlas of Physical Geography. 8° Edinburgh, 1892.

HARRISON *J. B.*, and JUKES-BROWNE, *A. J.*—The Geology of Barbados, being an explanation of the Geological map of Barbados prepared by the same authors. 8° Pam. Salisbury, 1890.

HUGHES, *T. W. Hughes.*—Report on the Prospecting Operations, Mergui District, 1891-92. Flsc. Pam. Rangoon, 1892.

" Tin-Mining in Mergui District. Parts II-III. Flsc. Pam. Calcutta and Rangoon, 1890-1891.

HUNTER, *M.*, and ROSENBUSCH, *H.*—Über Monchiquit ein camptonitisches Ganggestein aus der Gefolgschaft der Eläolithsyenite. 8° Pam. Wien, 1890. THE AUTHOR.

ISSEL, *Arturo.*—Liguria Geologica e Preistorica. Vols. I and II, with Atlas. 8° Genova, 1892.

JONES, *Robert H.*—Asbestos. Its properties, occurrence and uses, with some account of the Mines of Italy and Canada. 8° London, 1890.

LOCKYER, *J. Norman.*—The Meteoritic Hypothesis: a statement of the results of a spectroscopic inquiry into the origin of cosmical systems. 8° London, 1890.

MARGERIE, *Emm. De*, et SCHRADER, *Fr.*—Apercu de la Structure Geologique des Pyrénées. 8° Pam. Paris, 1892. THE AUTHOR.

MOREING, *C. Algernon*, and NEAL, *Thomas.*—The New General and Mining Telegraph Code. 8° London, 1891.

MUIR, *M. M. P.*—The Elements of Thermal Chemistry. 8° London, 1885.

NÖETLING, *Dr. Fritz.*—Notes on the Mineral Resources of the Northern Shan States. Flsc. Pam. Rangoon, 1891.

" Report on the Petroleum Industry in Upper Burma. Flsc. Pam. Rangoon, 1892.

Paleontologie Française, 1re série, Animaux Invertebres. Terrains Tertiaries, Eocéne Échinides. Livr. 27. 8° Paris, 1892.

PHILLIPS, *H. J.*—Fuels, solid, liquid, and gaseous, their analysis and aluativon. 8° London, 1892.

POWER, *F. D.*—A pocket-book for Miners and Metallurgists. 8° London, 1892.

Return of Mineral production in India for 1891. Flsc. Pam. Calcutta, 1892. REVENUE AND AGRICULTURAL DEPARTMENT.

SHERBORN, *Charles Davies.*—A Bibliography of the Foraminifera, Recent and Fossil, from 1565—1888, with notes explanatory of some of the rare and little-known publications. 8° London, 1888.

Titles of Books. *Donors.*

SWANK, *J. M.*—History of the Manufacture of Iron in all ages. 2nd edition. 8° Philadelphia, 1892.

TANNER, *H.*—Elementary lessons in the Science of Agricultural practice. 8° London, 1890.

The Scientific American Cyclopedia of Receipts, Notes and Queries. Edited by Albert A. Hopkins. 8° New York, 1892.

TRYON, *G. W.*—Manual of Conchology. Vol. XII, part 53, and 2nd series, Vol. VI, part 29. 8° Philadelphia, 1892.

WOODWARD, *A. S.*, and SHERBORN, *C. D.*—A Catalogue of British Fossil Vertebrata. 8° London, 1892.

WYATT, *F.*—The Phosphates of America. 3rd edition. 8° New York, 1892.

PERIODICALS, SERIALS, ETC.

American Geologist. Vol. X, Nos. 2-3. 8° Minneapolis, 1892.

American Journal of Science. 3rd series, Vol. XLIV, Nos. 261-263. 8° New Haven, 1892.

American Naturalist. Vol. XXVI, Nos. 309-311. 8° Philadelphia, 1892.

Annalen der Physik und Chemie. Neue Folge, Band XLVII, heft 1-3. 8° Leipzig, 1892.

Annals and Magazines of Natural History. Vol. X, Nos. 58-60. 8° London, 1892.

Athenœum. Nos. 3385-3397. 4° London, 1892.

Beiblätter zu den Annalen der Physik und Chemie. Band XVI, Nos. 8-10. 8° Leipzig, 1892.

Chemical News. Vol. LXVI, Nos. 1711-1722. 8° London, 1892.

Colliery Guardian. Vol. LXIV, Nos. 1654-1666. Fol. London, 1892.

Geological Magazine. New series, Decade III, Vol. IX, Nos. 10-11. 8° London, 1892.

Indian Engineering. Vol. XII, Nos. 13-25. Flsc. Calcutta, 1892. PAT. DOYLE.

Iron. Vol. XL, Nos. 1026-1037. Fol. London, 1892.

Mining Journal. Vol. LXII, Nos. 2976-2988. Fol. London, 1892.

Natural Science. Vol. I, Nos. 7-8. 8° London and New York, 1892.

Nature. Vol. XLVI, No. 1193 to Vol. XLVII, No. 1205. 8° London, 1892.

Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie. Band II, heft 1-2. 8° Stuttgart, 1892.

Oil and Colourman's Journal. Vol. XIII, Nos. 146-148. 4° London, 1892.

Palæontographica. Band XXXIX, lief. 2-3. 4° Stuttgart, 1892.

Palæontologische Abhandlungen. Neue Folge, Band II, heft. 1. 4° Jena, 1892.

Petermann's Geographischer Mittheilungen. Band XXXVIII, Nos. 9-11. 4° Gotha, 1892. THE EDITOR.

Scientific American. Vol. LXVII, Nos. 9-21. Fol. New York, 1892.

Scientific American. Supplement. Vol. XXXIV, Nos. 869-881. Fol. New York, 1892.

Titles of Books. *Donors.*

The Indian Engineer. Vol. XIII, No. 285, to Vol. XIV, No. 297. Flsc. Calcutta, 1892.
J. MacIntyre.

GOVERNMENT SELECTIONS, REPORTS, Etc.

Bombay.—Brief Sketch of the Meteorology of the Bombay Presidency in 1891-92. Flsc. Bombay, 1892,
Meteorological Reporter, Bombay.

Bombay.—Selections from the Records of the Bombay Government. New Series, Nos. 259 and 261-262. Flsc. Bombay, 1892. Bombay Government.

India.—History of Services of Officers holding gazetted appointments in the Home, Foreign, Revenue and Agricultural, and Legislative Departments, corrected to 1st July 1892. 8° Calcutta, 1892.
Government of India.

„ List of Civil Officers holding gazetted appointments under the Government of India in the Home, Legislative, Foreign, and Revenue and Agricultural Departments, corrected to 1st July 1892. 8° Calcutta, 1892.
Government of India.

„ List of Officers in the Survey Departments, and in the Offices of the Meteorological Reporter to the Government of India, Trustees, Indian Museum, Reporter on Economic Products, and Director, Botanical Department, Northern India, corrected to 1st July 1892. 8° Calcutta, 1892.
Government of India.

„ Quarterly Indian Army List. New Series, No. 14. 8° Calcutta, 1892.
Government of India.

„ Selections from the Records of the Government of India in the Foreign Department. Nos. 289, 292 and 294. Flsc. Calcutta, 1892.
Government of India.

„ Monthly Weather Review for May and June 1892. 4° Calcutta, 1892.
Meteorological Reporter to Government of India.

„ Rainfall Data of India for 1891. Flsc. Calcutta, 1892.
Meteorological Reporter to Government of India.

„ Register of original observations, reduced and corrected, May 1892. 4° Calcutta, 1892.
Meteorological Reporter to Government of India.

„ Report on the administration of the Meteorological Department of the Government of India in 1891-92. 4° Calcutta, 1892.
Meteorological Reporter to Government of India.

TRANSACTIONS, PROCEEDINGS, ETC., OF SOCIETIES, SURVEYS, ETC.

Batavia.—Nederlandsch-Indisch Plakaatboek, 1602-1811. Deel 10. 8° Batavia, 1892.
Batavian Society.

„ Notulen van het Bataviaasch Genootschap van kunsten en Wetenschappen Deel XXX, Afl. 2. 8° Batavia, 1892. Batavian Society.

Titles of Books. *Donors.*

BATAVIA.—Tijdschrift voor Indische Taal—Land-en Volkenkunde. Deel XXXV, Afl. 3—4. 8° Batavia, 1892. BATAVIAN SOCIETY.

BERLIN.—Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin, 1891. 4° Berlin, 1892. THE ACADEMY.

„ Jahrbuch der Königlich Preussischen Geologischen Landesanstalt und Bergakademie für 1890. 8° Berlin, 1892. THE ACADEMY.

„ Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaten. Nos. I to XXV. 8° Berlin, 1892. THE ACADEMY.

„ Zeitschrift der Deutschen Geologischen Gesellschaft. Band XLIV, heft 2. 8° Berlin, 1892. THE SOCIETY.

BOLOGNA.—Memorie della R. Accademia délle Scienze dell' Istituto di Bologna. Série V, Tome 1. 4° Bologna, 1891, THE ACADEMY.

BOMBAY.—Journal of the Bombay Natural History Society, Vol. VII, No. 2. 8° Bombay, 1892. THE SOCIETY.

BRISBANE.—Annual Report of the Trustees of the Queensland Museum for 1891. 8° Brisbane, 1892. THE MUSEUM.

BRISBANE.—Proceedings and Transactions of the Queensland Branch of the Royal Geographical Society of Australia. Vol. VII, part 2. 8° Brisbane, 1892. THE SOCIETY.

BRUSSELS.—Bulletin de la Société Royale Belge de Geógraphie. Année XV, No. 4. 8° Bruxelles, 1892. THE SOCIETY.

BUDAPEST.—Fóldtani Közlöny. Kotet XXI, füzet 4-12. 8° Budapest, 1892. HUNGARIAN GEOLOGICAL INSTITUTE.

„ Mittheilungen aus dem Jahrbuche der Kön. Ungarischen Geologischen Anstalt. Band IX, heft 6. 8° Budapest, 1892. HUNGARIAN GEOLOGICAL INSTITUTE.

„ Természetrajzi Füzetek. Vol. XV, No. 3. 8° Budapest, 1892. THE HUNGARIAN NATIONAL MUSEUM.

CALCUTTA.—Epigraphia Indica of the Archæological Survey of India. Vol. II, part 11. 4° Calcutta, 1892. GOVERNMENT OF INDIA.

„ List of the Batrachia in the Indian Museum, Calcutta, by W. L. Sclater. 8° London, 1892. THE MUSEUM.

„ Proceedings of the Asiatic Society of Bengal. Nos. 6-8. 8° Calcutta, 1892. THE SOCIETY.

„ Report of the Calcutta Public Library for 1891-92, with appendices. 8° Pam. Calcutta, 1892. THE LIBRARY.

„ Survey of India Department Notes for August to October 1892. Flsc. Calcutta, 1892. SURVEY OF INDIA DEPARTMENT.

CAMBRIDGE.—Annual Report of the Library Syndicate of the Cambridge University for the year ending 31st December 1891. 4° Cambridge, 1892. THE UNIVERSITY.

„ Proceedings of the Cambridge Philosophical Society. Vol. VII, part 6. 8° Cambridge, 1892. THE SOCIETY.

„ Transactions of the Cambridge Philosophical Society. Vol. XV, part 3. 4° Cambridge, 1892. THE SOCIETY.

Titles of Books. *Donors.*

CANADA.—Journal and Proceedings of the Hamilton Association. Parts 7-8. 8° Canada, 1891-1892. THE ASSOCIATION.

CASSEL.—Mittheilungen aus dem Kœniglichen Mineralogisch-geologischen und Præhistorischen Museum in Dresden. Heft 11. 4° Cassel, 1892. THE MUSEUM.

CINCINNATI.—Journal of the Cincinnati Society of Natural History. Vol. XV, No. 1. 8° Cincinnati, 1892. THE SOCIETY.

COPENHAGEN.—Fortegnelse over de af det Kongelige Danske Videnskabernes Selskabs Arbejder, 1742-1891. Kobenhavn, 1892. THE ACADEMY.

DEHRA DUN.—Spirit-Levelled Heights. No. 6, Bombay Presidency. 8° Dehra Dun, 1892. GREAT TRIGONOMETRICAL SURVEY OF INDIA.

„ Synopsis of the Results of the Operations of the Great Trigonometrical Survey of India. Vol. XXVII. 4° Dehra Dun, 1892. GREAT TRIGONOMETRICAL SURVEY OF INDIA.

DRESDEN.—Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gesellschaft Isis in Dresden. Jahrg., 1892, January to June. 8° Dresden, 1892. ISIS SOCIETY.

DUBLIN.—Report of the Director of the Science and Art Museum, Dublin, for the year ending 31st December 1891. 8° Pam. Dublin, 1892. THE MUSEUM.

„ Scientific Proceedings of the Royal Dublin Society. Vol. VII., pts. 3-4. 8° Dublin, 1892. THE SOCIETY.

„ Scientific Transactions of the Royal Dublin Society. Vol. IV., Nos. 9-13. 4° Dublin, 1892. THE SOCIETY.

„ Transactions of the Royal Irish Academy. Vol. XXX., pts. 1-2 4° Dublin, 1892. THE ACADEMY.

EDINBURGH.—Scottish Geographical Magazine. Vol. VIII, Nos. 9-11. 8° Edinburgh, 1892. SCOTTISH GEOGRAPHICAL SOCIETY.

FRANKFORT.—Abhandlungen von der Senckenbergischen Naturforschenden Gesellschaft. Band XVII., heft 1-2. 4° Frankfort-a-M., 1892.

HALLE.—Katalog der Bibliothek der Kaiserlichen Leopoldinisch-Carolinischen Deutschen Akademie der Naturforscher. Lief 3. 8° Halle, 1891. THE ACADEMY.

„ Leopoldina. Heft XXVII. 4° Halle, 1891. THE ACADEMY.

„ Nova Acta Academiæ Cæsareæ Leopoldino-Carolinæ Germanicæ Naturæ Curiosorum. Vols. LV and LVI. 4° Halle, 1891. THE ACADEMY.

HARRISBURG.—Geological Survey of Pennsylvania. Atlas Southern Anthracite Field. Parts IV, B.-A. A.; V, A. A. and VI. A. A. 8° Harrisburg, 1891. GEOLOGICAL SURVEY, PENNSYLVANIA.

LAUSANNE.—Bulletin de la Société Vaudoise des Sciences Naturelles. 3me serie, Vol. XXVIII, No. 107. 8° Lausaune, 1892. THE SOCIETY.

LEIDE.—Annales de l'Ecole Polytechnique de Delft. Tome VII, liv. 2-4. 4° Leide, 1892. L'ECOLE POLYTECH. DELFT.

LONDON.—Journal of the Chemical Society. Nos. 358-360. 8° London, 1892.

„ Journal of the Iron and Steel Institute. No. 1. 8° London, 1892. THE INSTITUTE.

Titles of Books. *Donors.*

LONDON.—Journal of the Society of Arts. Vol. XL, No. 2077, to Vol. XLI, No. 2089. 8° London, 1892. THE SOCIETY.

" Philosophical Transactions of the Royal Society. Vol. 182, A and B, with list of Fellows. 4° London, 1891. THE SOCIETY.

" Proceedings of the Royal Society. Vol. LI., No. 313. 8° London, 1892. THE SOCIETY.

" Proceedings of the Royal Geographical Society. New Series, Vol. XIV, Nos. 8-9. 8° London, 1892. THE SOCIETY.

" Proceedings of the Zoological Society of London. Part 3. 8° London, 1892. THE SOCIETY.

" Quarterly Journal of the Geological Society. Vol. XLVIII, No. 192, with list of Fellows. 8° London, 1892. THE SOCIETY.

MADRID.—Boletin de la Sociedad Geografica de Madrid. Tome XXXIII, Nos. 1-3. 8° Madrid, 1892. THE SOCIETY.

MANCHESTER.—Memoirs and Proceedings of the Manchester Literary and Philosophical Society. 4th series, Vol. V., No 2. 8° Manchester, 1892. THE SOCIETY.

" Transactions of the Manchester Geological Society. Vol. XXII, part 1. 8° Manchester, 1892. THE SOCIETY.

MELBOURNE.—Proceedings of the Royal Society of Victoria. New Series, Vol. IV, part 1. 8° Melbourne, 1892. THE SOCIETY.

" Special Reports of the Department of Mines, Victoria, issued under the authority of the Minister of Mines. Flsc. Melbourne, 1892. DEPARTMENT OF MINES, VICTORIA.

" Transactions of the Geological Society of Australia, Vol. I, part 6. 8° Melbourne, 1892. THE SOCIETY.

MOSCOW.—Bulletin de la Société Impériale des Naturalistes. No. 2. 8° Moscou, 1892. THE SOCIETY.

NEWCASTLE-UPON-TYNE.—Transactions of the North of England Insitute of Mining and Mechanical Engineers. Vol. XLI, part 4. 8° Newcastle-upon-Tyne, 182. THE INSTITUTE.

PARIS.—Annales des Mines. 9^me^ série, Tome I., livr. 6, and II. livr. 7. 8° Paris, 1892. DEPARTMENT OF MINES, PARIS.

" Bulletin de la Société de Géographie. 7^me^ série, Tome XIII, No. 2. 8° Paris, 1892. THE SOCIETY.

" Bulletin de la Société Geologique de France. 3^me^ série, Tome XIX, No. 13. 8° Paris, 1892. THE SOCIETY.

" Mémoires de la Société Géologique de France. Tome II, fasc. 4, and III., fasc. 1-2. 4° Paris, 1892. THE SOCIETY.

PHILADELPHIA.—Journal of the Franklin Institute. Vol. CXXXIV. Nos. 3-5. 8° Philadelphia, 1892. THE INSTITUTE.

" Proceedings of the American Philosophical Society. Vol. XXX, No. 138. 8° Philadelphia, 1892. THE SOCIETY.

" Transactions of the American Philosophical Society. New Series, Vol. XVII., Parts 1-2. 4° Philadelphia, 1892. THE SOCIETY.

Titles of Books. *Donors.*

PISA.—Atti della Societa Toscana di Scienze Naturali. Processi Verbali. Vol. VIII, pages 85-154. 8° Pisa, 1892. THE SOCIETY.

ROME.—Atti della Reale Accademia dei Lincei. Série V, Rendiconti, Vol. I., Semestre II, fasc. 4-9. 4° Roma, 1892. THE ACADEMY.

„ Bollettino del R. Comitato Geologico d'Italia. Vol. XXII, Nos. 1-4. 8° Roma, 1892. ROYAL GEOLOGICAL COMMISSION, ITALY.

SALEM, MASS.—Bulletin of the Essex Institute. Vol. XXIV., Nos. 4-6. 8° Salem, Mass. 1892. THE INSTITUTE.

SINGAPORE.—Journal of the Straits Branch of the Royal Asiatic Society. No. 24. 8° Singapore, 1892. THE SOCIETY.

ST. PETERSBURGH.—Memoires de L'Académie Impériale des Sciences de St. Petersbourg. Tome XXXVIII., Nos. 9-13. 4° St. Petersbourg, 1892. THE ACADEMY.

SYDNEY.—Proceedings of the Linnean Society of New South Wales. Vol. VII, part 1. 8° Sydney, 1892. THE SOCIETY.

„ Records the Australian Museum. Vol. II, Nos. 2-3. 8° Sydney, 1892. THE MUSEUM.

„ Report of the Trustees of the Australian Museum for the year 1891. Flsc. Sydney, 1892. THE MUSEUM.

„ Records of the Geological Survey of New South Wales. Vol. III., part 1. 8° Sydney, 1892. THE SURVEY.

TURIN.—Atti della R. Accademia delle Scienze di Torino. Vol. XXVII, disp. 12-15. 8° Torino, 1892. THE ACADEMY.

VIENNA.—Denkschriften der Kais. Akademie der Wissenschaften. Band LVIII. 4° Wien, 1891. THE ACADEMY.

„ Jahrbuch der Kais. König. Geologischen Reichsanstalt. Jahrg. 1891. Band XLI, heft 2-3. 8° Wien, 1892. THE INSTITUTE.

„ Sitzungsberichte der Kais. Akademie der Wissenschaften:—

Band C., Abth. I., heft 1-7.
„ C., Abth, IIa., „ 1-7.
„ C., „ IIb., „ 1-7.
„ C., „ III., „ 1-7.

8° Wien, 1891. THE ACADEMY.

„ Verhandlungen der K. K. Geologischen Reichsanstalt. Nos. 6-10. 8° Wien, 1892. THE INSTITUTE.

VENICE.—Atti del Reale Istituto Veneto di Scienze, Lettere ed Arti. Serie VII., Tome III, disp. 4-7. 8° Venezia, 1892. THE INSTITUTE.

WASHINGTON.—Bulletin of the Philosophical Society of Washington. Vol. XI. 8° Washington, 1892. THE SOCIETY.

YOKOHAMA AND TOKIO.—Mittheilurgen der Deutschen Gesellschaft für Natur und Völkerkunde Ostasiens in Tokio.

Band V., heft 50.
„ V., supplement, heft 2-3.

4° Yokohama and Tokio, 1892. THE SOCIETY.

Titles of Books. *Donors.*

YOKOHAMA.—Transactions of the Asiatic Society of Japan. Vol. XX, part. 1, and Supplement, parts. 2, 3 (Section I), and 5. 8° Yokohama, 1892.
THE SOCIETY.

ZÜRICH.—General register der Publikationen der Naturforschenden Gesellschaft in Zürich und Uebersicht ihres Tauschverkehres. 8° Zürich, 1892.
THE SOCIETY.

" Vierteljahrschrift der Naturforschenden Gesellchaft. in Zürich. Jahrg. XXXVII., heft 2. 8° Zurich, 1892. THE SOCIETY.

G. I. C. P. O. -No. 21 D. G. Survey.— 18-3-93.— 620

DONATIONS TO THE MUSEUM.

FROM 1ST FEBRUARY TO 30TH APRIL 1893.

18 specimens of minerals, consisting of Datholite on greenstone, from Bergen Hill, New Jersey; Colemanite with tabular Celestine, from San Bernardino Co., California; Bournonite, from Cornwall; Adamine, from Pamarisa, Laurium, Greece; Galena, from Alston, Cumberland; Topaz, from San Luis, Potosi, Mexico; Witherite with Bromlite, from Fallowfield Mine, Hexam, Northumberland; Anatase, from Binn, Wallis, Switzerland; Melanophlogite, from Girgenti, Sicily; Fluor, from Weardale, Durham; Dyserasite, from Andreasberg, Harz; Phenacite, from Mount Antero, Chaffee Co. Colorado; Chessylite, from Copper Queen Mine, Arizona; Rubellite, from California; Microcline, from Pike's Peak, Colorado; Calcite, from Bigrigg Mine, Egremont, Cumberland; Agate, from Uruguay, South America; and Barytes, from Buckingham Co., Virginia.

PRESENTED BY THE TRUSTEES OF THE BRITISH MUSEUM, LONDON.

Specimens of Bryozoa and Lamelli branches from a well 250 feet below the surface, Poozoondoung, Rangoon.

PRESENTED BY KRUGER & CO., RANGOON.

ADDITIONS TO THE LIBRARY.

FROM 1ST JANUARY TO 31ST MARCH 1893.

Titles of Books. *Donors.*

ALLEN, *Alfred H.*—Commercial Organic Analysis: a treatise on the properties, proximate analytical examination, and modes of assaying the various organic chemicals and products employed in the arts, manufactures medicines, etc., with concise method for the detection and determination of their impurities, adulterations, and products of decomposition, Vol. III, pt. 2. 8° London, 1892.

BRONN'S Klassen und Ordnungen des Their-Reichs. Band III, lief. 2, and IV, lief. 24-27. 8° Leipzig, 1892.

CURZON, *George N.*—Persia and the Persian Question. Vols. I and II. 8° London, 1892.

DANA, *E. S.*—The System of Mineralogy. 6th Edition. 8° Loudon, 1892.

DEICHMÜLLER, *J. V.*—UEBER Gefässe mit Graphit-Maleri aus sächsischen Urnenfeldern. 8° Pam. Dresden, 1890. THE AUTHOR.

HATCH, *F. H.*—Text-Book of Petrology, containing a description of the rock-forming minerals and a synopsis of the chief types of igneous rocks. 8° London, 1892.

HÖFER, *Hans.*—Das Erdöl (Petroleum) und seine Verwandten. 8° Braunschweig, 1888.

IHLSING, *M. C.*—A Manual of Mining. 8° Newyork, 1892.

JOHNSTON, *H. H.*—The Kilima-Njaro Expedition. 8° London, 1886.

LYMAN, *Benjamin Smith.*—Shippen and Wetherill Tract, with a geological and topographical map. 8° Pam. Philadelphia, 1893. THE AUTHOR.

Titles of Books. *Donors.*

Paléontologie Française, 1re série, Animaux Invertebrés. Terrains Tertiaries, Éocéne Échinides. Livr. 28. 8° Paris, 1892.

STEFANESCU, *Prof. Gregorie.*—On the existence of the Dinotherius in Roumania. 8° Pam. Roumania, 1891. THE AUTHOR.

STRIPPELMANN, *Leo.*—Die Petroleum-Industrie Oesterreich-Deutschlands. Abth. I-III. 8° Leipzig, 1878-1879.

TOULA, *Prof. Dr. Franz.*—Neure Erfahrungen Uber den Geognostischen Aufbau der, Erdoberfläche. 8° Pam. Wien, No date. THE AUTHOR.

TRYON, *George W.*—Manual of Conchology. Vol. XII, part 54, and 2nd series, Vol. VI, part 30. 8° Philadelphia, 1892.

WALLACE, *Alfred Russel.*—The Geographical distribution of animals, Vols. I-II. 8° London, 1876.

WATT, *George.*—A Dictionary of the Economic Products of India, Vol. VI, Part 1. 8° Calcutta, 1892. GOVERNMENT OF INDIA.

ZITTEL, *Karl A.*—Handbuch der Palæontologie. Band IV, Abth. I, lief 1. 8° München, 1892.

PERIODICALS, SERIALS, ETC.

American Geologist. Vol. X, Nos. 4-5, 8° Minneapolis, 1892.

American Journal of Science. 3rd series, Vol. XLIV, No. 264 to XLV, No. 267. 8° New Haven, 1892-1893.

American Naturalist. Vol. XXVI, No. 312, to XXVII, No. 314. 8° Philadelphia, 1892-1893.

Annalen der Physik und Chemie. Neue Folge, Band XLVII, heft 4, and XLVIII, heft 1-2. 8° Leipzig, 1892-1893.

Annals and Magazine of Natural History. 6th series, Vol. XI, Nos. 61-63. 8° London, 1893.

Athenæum. Nos. 3398-3411. 4° London, 1892-1893.

Beiblätter zu den Annalen der Physik und Chemie. Band XVI, Nos. 11-12, and XVII, Nos. 1-2. 8° Leipzig, 1892-1893.

Beiblätter zu den Annalen der Physik und Chemie. Namenregister zum 1-15. Bande (1877-1891). 8° Leipzig, 1893.

Chemical News. Vol. LXVI, No. 1723 to LXVII, No. 1737. 4° London, 1892-1893.

Colliery Guardian. Vol LXIV, No. 1667 to LXV No. 1680. Fol. London, 1892-1893.

Geographische Abhandlungen. Band V, heft 1-2. 8° Wien, 1891.

Geological Magazine. New series, Decade III, Vol. IX, No. 12, and X, Nos. 1-3. 8° London, 1892-1893.

Indian Engineering. Vol. XII, Nos. 26-27, and XIII, Nos. 1-12; and Index to Vol. XII. Flsc. Calcutta, 1892-1893. PAT DOYLE.

Iron. Vol. XL, No. 1038 to XLI, No. 1052. Fol. London, 1892-1893.

London, Edinburgh and Dublin Philosophical Magazine, and Journal of Science. 5th series, Vol. XXXV, Nos. 212-214. 8° London, 1893.

Mining Journal. Vol. LXII, No. 2989 to LXIII, No. 3002. Fol. London, 1892-1893.

Natural Science. Vol. I, No. 9, to II, No. 11. 8° London and New York, 1892-1893.

Nature. Vol. XLVII, Nos. 1206-1219. 4° London, 1892-1893.

Titles of Books. *Donors.*

Neues Jahrbuch für Mineralogie, Geologie, und Palaeontologie. Band II, heft. 3 (1892). and Band I, heft 1 (1893). 8° Stuttgart, 1892-1893. THE EDITOR.

Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie. Beilage-Band VIII, heft 2. 8° Stuttgart, 1892.

Oil and Colourman's Journal. Vol. XIV, Nos. 149-151. 4° London, 1893.

Palæontographica. Band XXXIX, lief. 4-6. 4° Stuttgart, 1892.

Petermann's Geographischer Mittheilungen. Band XXXVIII, No. 12, and XXXIX, Nos. 1-2. 4° Gotha, 1892-1893. THE EDITOR.

Scientific American. Vol. LXVII, Nos. 22-27, and LXVIII, Nos. 1-8. Fol. New York, 1892-1893.

Scientific American. Supplement, Vol. XXXIV, No. 882 to XXXV, No. 895. Fol. New York, 1892-1893.

The Indian Engineer. Vol. XIV, No. 298 to XV, No. 311. Fol. Calcutta, 1892-1893. J. MC INTYRE.

The "Pioneer." New series, 1st edition, Vol. XCIII, Nos. 9925-10001. Fol. Allahabad, 1893.

Tschermak's Mineralogische und Petrographische Mittheilungen. Neue Folge., Band XII, heft. 6. 8° Wien, 1892.

Zoological Record. Vol. XXVIII, 1891. 8° London, 1892.

GOVERNMENT SELECTIONS, REPORTS, ETC.

ASSAM.—Report on the Administration of the Province of Assam for the year 1891-92. Flsc., Shillong, 1892. CHIEF COMMISSIONER OF ASSAM.

BENGAL.—Report on the Administration of Bengal for 1891-92. Flsc. Calcutta, 1892. GOVERNMENT OF BENGAL.

BOMBAY.—Report on the Administration of the Bombay Presidency for the year 1891-92. Flsc. Bombay, 1892. BOMBAY GOVERNMENT.

" Selections from the Records of the Bombay Government. New series, Nos. 254, 260 and 264. Flsc. Bombay, 1892. BOMBAY GOVERNMENT.

BURMA.—Report on the Administration of Burma during 1891-92. Flsc. Rangoon, 1892. CHIEF COMMISSIONER OF BURMA.

CENTRAL PROVINCES.—Report on the Administration of the Central Provinces for the year 1891-92. Flsc. Nagpur, 1892. CHIEF COMMISSIONER, CENTRAL PROVINCES.

HYDERABAD.—Report on the Administration of Hyderabad Assigned Districts for 1891-92. Flsc. Hyderabad, 1892. RESIDENT, HYDERABAD.

INDIA.—Administration Report on the Railways in India for 1891-92. Part II. Flsc., Calcutta, 1892 GOVERNMENT OF INDIA.

INDIA.—Census of India, 1891.

Vols. I-II.—Assam.

" VI.—Berar, or the Hyderabad Assigned Districts.

" VII-VIII.—Bombay and its Feudatories, Parts 1-2.

" IX-X.—Burma, Parts, 1-2.

" XIX-XXI.—The Punjab and its Feudatories, Parts 1-3.

" XXVI.—Rajputana, Parts 1-2.

Flsc. Shillong, Calcutta, Bombay, and Rangoon, 1892. REVENUE AND AGRICULTURAL DEPARTMENT.

Titles of Books. *Donors.*

INDIA.—India Weather Review, Annual Summary, 1891. 4° Calcutta, 1892.
METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA.

„ Monthly Weather Review, July to October 1892. 4° Calcutta, 1892-1893.
METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA.

„ Indian Meteorological Memoirs. Vol. V, Part 2. 4° Calcutta, 1892.
METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA.

„ Quarterly Indian Army List. New Series, No. 14. 8° Calcutta, 1893.
GOVERNMENT OF INDIA.

„ Register of Original Observations, reduced and corrected, June to October 1892. 4° Calcutta, 1892.
METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA.

MADRAS.—A Collection of Treaties, Engagements and other papers of importance relating to British affairs in Malabar. Edited with notes by W. Logan. 2nd Edition. 8° Madras, 1891. MADRAS GOVERNMENT.

„ Annual Administration Report of the Forest Department, Madras Presidency, for the year 1891-92. Flsc., Madras, 1892.
MADRAS GOVERNMENT.

„ Report on the Administration of the Madras Presidency during 1891-92. Flsc., Madras, 1892. MADRAS GOVERNMENT.

PUNJAB.—Final Report of the Revised Settlement of the Jullundur District in the Punjab. By W. E. Purser, B. C. S. Flsc. Lahore, 1892.
PUNJAB GOVERNMENT.

„ Report on the Administration of the Punjab and its Dependencies for 1891-92. Flsc. Lahore, 1892. PUNJAB GOVERNMENT.

TRANSACTIONS, PROCEEDINGS, ETC., OF SOCIETIES, SURVEYS, ETC.

ADELAIDE.—Transactions of the Royal Society of South Australia. Vol. XV., pt. 2, and, XVI, pt. 1. 8° Adelaide, 1892. THE SOCIETY.

BALTIMORE.—Johns Hopkins University Circulars. Vol. XII, Nos 101-103. 4° Baltimore, 1892-1893. JOHNS HOPKINS UNIVERSITY.

BATAVIA.—Notulen van het Bataviaasch Genootschap van Kunsten en Wetenschappen. Deel XXX, Afl. 3-4 8° Batavia, 1892-1893. BATAVIAN SOCIETY.

„ Tijdschrift voor Indische Taal-Land-en Volkenkunde. Deel XXXV, afl. 5-6, and XXXVI, afl. 2-3 8° Batavia, 1892-1893. BATAVIAN SOCIETY.

BELFAST.—Report and Proceedings of the Belfast Natural History and Philosophical Society for the Session 1891-92. 8° Belfast, 1893. THE SOCIETY.

BERLIN.—Sitzungsberichte der König. Preuss. Akad. der Wissenschaften. Nos. 26—40, 8° Berlin, 1892. THE ACADEMY.

„ Zeitschrift der Deutschen Geologischen Gesellschaft. Band XLIV, heft 3. 8° Berlin, 1892. THE SOCIETY.

BOMBAY.—Journal of the Bombay Natural History Society. Vol. VII, No. 3. 8° Bombay, 1892. THE SOCIETY.

BOSTON.—Proceedings of the American Academy of Arts and Sciences. New Series, Vol. XVII. 8° Boston, 1891. THE ACADEMY.

Titles of Books. *Donors.*

BUENOS AIRES.—Boletin de la Academia Nacional de Ciencias en Cordoba. Tomo X., No. 4, and XI, No. 4. 8° Buenos Aires, 1889-1890. THE ACADEMY.

CALCUTTA.—Epigraphia Indica of the Archæological Survey of India, Vol. II, part 12. 4° Calcutta, 1893. GOVERNMENT OF INDIA.

„ Journal of the Asiatic Society of Bengal. New series, Vol. LXI., Part I, No. 3, and LXI, Part II, No. 3 8° Calcutta, 1892-1893. THE SOCIETY.

„ Proceedings of the Asiatic Society of Bengal. No. 9. 8° Calcutta, 1892. THE SOCIETY.

„ Records of the Geological Survey of India. Vol. XXV, pt. 4. 8° Calcutta, 1892. GEOLOGICAL SURVEY OF INDIA.

„ Survey of India Department Notes for November 1892 to February 1893 Flsc. Calcutta, 1892-1893. SURVEY OF INDIA DEPARTMENT.

CAMBRIDGE, MASS.—Annual Report of the Curator of the Museum of Comparative Zoölogy for 1891-92. 8° Cambridge, Mass., 1892. THE MUSEUM.

„ Bulletin of the Museum of Comparative Zoölogy. Vol. XXIII, Nos. 4-5. 8° Cambridge, Mass., 1892. THE MUSEUM.

CASSEL.—Mittheilungen aus dem Kœniglichen Mineralogisch-Geologischen und Præ-Historischen Museum in Dresden. Heft. 10. 4° Cassel, 1892. THE MUSEUM.

CINCINNATI.—Journal of the Cincinnati Society of Natural History. Vol. XV, No. 2. 8° Cincinnati, 1892. THE SOCIETY.

COLOMBO.—Journal of the Ceylon Branch of the Royal Asiatic Society. Vol. XI, No. 39. 8° Colombo, 1892.

DEHRA DUN.—Synopsis of the results of the operations of the Great Trigonometrical Survey of India. Vols. XXVIII and XXX. 4° Dehra Dum, 1892. GREAT TRIGONOMETRICAL SURVEY OF INDIA.

DUBLIN.—Proceedings of the Royal Irish Academy, 3rd series, Vol. II, No. 3. 8° Dublin, 1892. THE ACADEMY.

„ Transactions of the Royal Irish Academy. Vol. XXX, pts. 3-4. 4° Dublin, 1892-1893. THE ACADEMY.

EDINBURGH.—Proceedings of the Royal Society of Edinburgh. Vol. XVIII. 8° Edinburgh, 1892. THE SOCIETY.

„ Transactions of the Royal Society of Edinburgh. Vol. XXXVI, Parts II, No. 9 to III, No. 23. 4° Edinburgh, 1891-1892. THE SOCIETY.

„ Scottish Geographical Magazine. Vol. VIII, No. 12, and Index; and IX, Nos. 1-5. 8° Edinburgh, 1892-1893. SCOTTISH GEOGRAPHICAL SOCIETY.

FRANKFORT.—Abhandlungen von der Senckenbergischen Naturforschenden Gesellschaft. Band XVIII, heft 1. 4° Frankfort-a-m., 1892.

FREIBURG.—Berichte der Naturforschenden Gesellschaft zu Freiburg. Band VI, heft 1-4. 8° Freiburg, 1891-1892. THE SOCIETY.

GLASGOW.—Proceedings of the Philosophical Society of Glasgow. Vol. XXIII, and Index to Vols. I-XX. 8° Glasgow, 1892. THE SOCIETY.

GÖTTINGEN.—Abhandlungen der Konig. Gesellschaft der Wissenschaften zu Göttingen. Band XXXVIII. 4° Göttingen, 1892. THE SOCIETY.

Titles of Books. *Donors.*

LAUSANNE.—Bulletin de la Société Vaudoise des Sciences Naturelles. 3me série, Vol. XXVIII, No. 108. 8° Lausanne, 1892. THE SOCIETY.

Liège.—Annales de la Societe Géologique de Belgique. Tome XVIII, livr 3, and XIX, livr 4. 8° Liège, 1891-1892. THE SOCIETY.

LISBON.—Communicacoes da Commissao dos Trabalhos Geologicos de Portugal. Tome II, fasc. 2. 8° Lisboa, 1892. THE COMMISSION.

LIVERPOOL.—Proceedings of the Liverpool Geological Society. Vol. VI, pt. 4. 8° Liverpool, 1892. THE SOCIETY.

LONDON.—First Report of the Royal Commission on explosions from coal dust in Mines; with Minutes of evidence and Appendices. Flsc. London, 1891. REVENUE AND AGRICULTURAL DEPT.

" Journal of the Chemical Society. Nos. 361-362: and Supplementary number containing Title-pages, Contents, and Indexes to Vols. LXI-LXII. 8° London, 1892-1893.

" Journal of the Society of Arts. Vol. XLI, Nos. 2090-2103. 8° London, 1892-1893. THE SOCIETY.

" Proceedings of the Royal Geographical Society. New series, Vol. XIV, Nos. 10-12. 8° London, 1892. THE SOCIETY.

" The Geographical Journal, including the Proceedings of the Royal Geographical Society. Vol. I, Nos. 1-3. 8° London, 1893. THE SOCIETY.

" Proceedings of the Royal Society. Vol. LI, No. 314 to LII, No. 316. 8° London, 1892. THE SOCIETY.

" Quarterly Journal of the Geological Society. Vol. XLIX, No. 193. 8° London, 1893. THE SOCIETY.

" Special Volume of Proceedings of the Iron and Steel Institute in America in 1890. 8° London, 1890. THE INSTITUTE.

MANCHESTER.—Memoirs and Proceedings of the Manchester Literary and Philosophical Society. 4 series, Vol. VI. 8° Manchester, 1892. THE SOCIETY.

" Transactions of the Manchester Geological Society. Vol. XII, pts. 2-3. 8° Manchester, 1892. THE SOCIETY.

MILANO.—Atti della Societa Italiana di Scienze Naturaii. Vol. XXXIV, fasc. 1. 8° Milano, 1892. THE SOCIETY.

MONTREAL.—Proceedings and Transactions of the Royal Society of Canada for the year 1891. Vol. IX. 4° Montreal, 1892. THE SOCIETY.

NAPLES.—Rendiconto dell' Accademia delle Scienze Fisiche e Matematiche. 2a série, Vol. VI, fasc. 7-12, and VII, fasc. 1-2. 4° Napoli, 1892-1893. THE ACADEMY.

NEWCASTLE-UPON-TYNE.—Transactions of the North of England Institute of Mining and Mechanical Engineers. Vol. XXIX, pt. 3; XL, pt. 5; and XLI, pt. 5. 8° Newcastle-upon-Tyne, 1892. THE INSTITUTE.

NEW YORK.—Annals of the New York Academy of Sciences. Vol. VI, Nos. 1—6. 8° New York, 1891-1892. THE ACADEMY.

" Transactions of the New York Academy of Sciences. Vol. X, Nos. 7-8; and XI, Nos. 1-5. 8° New York, 1891. THE ACADEMY.

PARIS.—Annales des Mines. 9me série, Tome II, livr. 8-11. 8° Paris, 1892. DEPARTMENT OF MINES, PARIS.

" Annuaire Géologique Universel. Tome VIII, fasc. 2. 8° Paris, 1892. THE EDITOR.

Titles of Books. *Donors.*

PARIS.—Bullitin de la Société de Géographie. 7^me^ série, Tome XIII, No. 3 8° Paris 1892. THE SOCIETY.,

„ Bulletin de la Société Géologique de France. 3^me^ série, Tome XIX, No. 12, and XX, No. 2 8° Paris, 1892. THE SOCIETY.

„ Comptes Rendus des Séances de la Société de Géographie. Nos. 15-18 (1892), and Nos. 1-4 (1893). 8° Paris, 1892-1893. THE SOCIETY.

„ Rapport Sur le Congrés Geologique de Washington. Par Emm. de Margerie. 8° Paris, 1892. THE AUTHOR.

PHILADELPHIA.—Journal of the Franklin Institute. Vol. CXXXIV, No. 6, and CXXXV, Nos. 1-2. 8° Philadelphia, 1892-1893. THE INSTITUTE.

PISA.—Atti della Societa Toscana di Scienze Naturali. Processi Verbali. Vol. VIII, pp. 157-176. 8° Pisa, 1892. THE SOCIETY.

ROME.—Atti della R. Accademia dei Lincei. Serie IV, Mémorie, Vol. VI. 4° Roma, 1890. THE ACADEMY.

„ Atti della Reale Accademia dei Lincei. Rendiconti, Série V, Semestre II, Vol. I, fasc. 10-12, with Index: and Semestre I, Vol. II, fasc. 1-3. 8° Roma, 1892-1893. THE ACADEMY.

„ R. Ufficio Geologico. Mémorie descrittive della Carta Geologica d'Italia. Vol. VIII. 8° Roma, 1893. GEOLOGICAL SURVEY OF ITALY.

SALEM, MASS.—Proceedings of the American Association for the Advancement of Science, Vol. XL 8° Salem, Mass., 1892. THE ASSOCIATION.

SYDNEY.—Australian Museum, Sydney. Catalogue No. 16 of Australian Mammals, with introductory notes on general Mammalogy, by J. D. Ogilby. 8° Sydney, 1893. THE MUSEUM.

„ Records of the Australian Museum. Vol. II, No. 4. 8° Sydney, 1893. THE MUSEUM,

„ Memoirs of the Geological Survey of New South Wales. Palæontology No. 5, Part II. 4° Sydney, 1892. THE SURVEY.

„ Records of the Geological Survey of New South Wales. Vol. III, pt. 2. 4° Sydney, 1892. THE SURVEY.

„ Proceedings of the Linnean Society of New South Wales. 2° series, Vol. VII, pt. 2. 8° Sydney, 1892. THE SOCIETY,

TURIN.—Atti della R. Accademia delle Scienze di Torino. Vol. XXVIII, disp. 1-3. 8° Torino, 1892-93. THE ACADEMY.

„ Memoire della Reale Accademia delle Scienze di Torino. 2ª serie, Tomo XLII. 4° Torino, 1892. THE ACADEMY.

„ Osservazioni Meteorologiche fatte nell' anno 1891 Au' Osservatorio della R. Universita di Torino. 8° Torino, 1892. THE UNIVERSITY.

VIENNA.—Abhandlungen der K. K. Geologischen Reichsanstalt. Band XVII, heft 1-2. 4° Wien, 1892. THE INSTITUTE.

„ Annalen des K. K. Naturhistorischen Hof-Museums. Band VI, Nos. 3-4, and VII, Nos. 1-2 8° Wien. 1891-1892. THE MUSEUM.

„ Jahrbuch der Kais. König. Geologischen Reichsanstalt. Jahrgang, 1892. Band XLII, heft 1. 8° Wien, 1892. THE INSTITUTE.

„ Verhandlungen der K. K. Geologischen Reichsanstalt. Nos. 11-16. 8° Wien, 1892. THE INSTITUTE.

WASHINGTON.—Department of the Interior. United States Geological Survey. Mineral Resources of the United States for the Calendar years 1889 and 1890. 8° Washington, 1892.
UNITED STATES GEOLOGICAL SURVEY.

Titles of Books. *Donors.*

WASHINGTON.—Report of the Director of the United States Mint for the fiscal year ending 30th June 1892. 8° Washington, 1892.
UNITED STATES MINT.

„ Smithsonian Contributions to Knowledge. Vol. XXVIII. 4° Washington, 1892.
THE INSTITUTE.

WELLINGTON.—Report on the Mining Industry of New Zealand, 1892. Flsc. Wellington 1892.
MINING DEPARTMENT, NEW ZEALAND.

YOKOHAMA.—Transactions of the Asiatic Society of Japan. Vol. XX, Supplement, part 1, and XX, pt. 2. 8° Yokohama, 1892-1893.
THE SOCIETY.

MAPS.

PARIS.—Carte Géologique de taillee de la France. Sheets, 13, 32, 72, 83, 94, 114, 145, and 176. Maps, Paris, 1891-1892.
GEOLOGICAL SURVEY, FRANCE.

WASHINGTON.—United States Relief Map, published under authority of J. W. Powell, Director, United States Geological Survey. Map, Washington. No date.
UNITED STATES GEOLOGICAL SURVEY.

G. I. C. P. O.—No. 1 D. G. Survey.—3-6-93.—620.

DONATIONS TO THE MUSEUM.

FROM 1ST MAY TO 31ST JULY 1893.

Nine specimens of minerals from Eckak Village, Chota Nagpore.

PRESENTED BY M. ANDERSON, CALCUTTA.

One specimen of "Stone with the first glacial stride observed in the Carboniferous Boulder bed near Brauxton, New South Wales."

PRESENTED BY R. D. OLDHAM, GEOLOGICAL SURVEY OF INDIA.

One specimen of Elæolite-Syenite, from Junagadh, Kathiawar.

PRESENTED BY J. W. EVANS, D.Sc., L.L.B., F.G.S., JUNAGADH.

Fifty specimens of rocks and minerals from the Madras Presidency.

PRESENTED BY F. G. BROOK-FOX, F.G.S., CHICACOLE, GANJAM DISTRICT.

ADDITIONS TO THE LIBRARY.

FROM 1ST APRIL TO 30TH JUNE 1893.

Titles of Books. *Donors.*

BRONN'S Klassen und Ordnungen des Thier-Reichs. Band IV, lief. 28-30; and VI, Abth. IV, lief. 42-43. 8° Leipzig, 1893.

BROWN, *H. Y. L.*—Report on country in the neighbourhood of Lake Eyre, South Australia. Flsc. Pam. Adelaide, 1892.

THE AUTHOR.

FRITSCH, *Dr. Ant.*—Fauna der Gaskohle und der Kalksteine der Permformation Böhmens. Band III., heft 2. 4° Prag, 1893.

KLEIN, *Dr. H. J.*—Jahrbuch der Astronomie und Geophysik. III. Jahrgang, 1892. 8° Leipzig, 1893.

MARCOU, *Jules.*—A little more light on the United States Geological Survey. 8° Pam. Cambridge, Mass, 1892.

THE AUTHOR.

MARCOU, *Jules.*—On the classification of the Dyas, Trias, and Jura in North-West Texas. 8° Pam. Cambridge, Mass, 1892.

THE AUTHOR.

MARCOU, *Jules.*—Second supplement to "Mapoteca Geologica Americana," 1752-1881. 8° Pam. Cambridge, Mass, 1893.

THE AUTHOR.

NICHOLLS, *H. A. Alford.*—A Text-Book of Tropical Agriculture, with illustrations. 8° London, 1892.

NOETLING, *Dr. Fritz.*—Notes on the Mineral Resources of Upper Burma. Flsc. Pam. Rangoon, 1893. BURMA GOVERNMENT.

Palæontologie Française, 1re série, Animaux Invertebres. Terrains Tertiaires, Éocéne Échinides. Liv. 29. 8° Paris, 1893.

Titles of Books. *Donors.*

PENCK, *Professor Dr. A.*—The construction of a map of the world on a scale of 1 : 1,000,000 (from the Geographical Journal for March 1893). 8° Pam. London, 1893. THE AUTHOR.

TROSCHEL, *Dr. F. H.*—Das Gebiss der Schnecken zur Begrundüng Einer Naturlichen Classification. Band II, lief. 8. 4° Berlin, 1893.

WATT, *Dr. George.*—Dictionary of the Economic Products of India, Vol. VI, part 2. 8° Calcutta, 1893. GOVERNMENT OF INDIA.

PERIODICALS, SERIALS, ETC.

American Journal of Science. Vol. XLV, Nos. 268-270. 8° New Haven, 1893.

American Naturalist. Vol. XXVII, Nos. 315-317. 8° Philadelphia, 1893.

Annalen der Physik und Chemie. Neue Folge, Band XLVIII, heft 3-4, and XLIX, heft 1-2. 8° Leipzig, 1893.

Annals and Magazine of Natural History. Vol. XI, Nos. 64-66. 8° London, 1893.

Athenæum. Nos. 3412-3424. 4° London, 1893.

Beiblätter zu den Annalen der Physik und Chemie. Band XVII, Nos. 3-4. 8° Leipzig, 1893

Chemical News. Vol. LXVII, Nos. 1738-1750. 4° London, 1893.

Colliery Guardian. Vol. LXV, Nos. 1681-1693. Fol. London, 1893.

Geological Magazine. New series, Decade III, Vol. X, Nos. 4-6. 8° London, 1893.

Indian Engineering. Vol. XII, No. 22, and XIII, Nos. 13-25. Flsc. Calcutta, 1893. PAT. DOYLE.

Iron. Vol. XLI, Nos. 1053-1065. Fol. London, 1893.

London, Edinburgh, and Dublin Philosophical Magazine, and Journal of Science. 5th series, Vol. XXXIII, No. 200 to XXXIV, No. 211; and XXXV, Nos. 215-217. 8° London, 1892-1893.

Mining Journal. Vol. LXIII, Nos. 3003-3015. Fol. London, 1893.

Natural Science. Vol. II, No. 12. 8° London and New York, 1893.

Nature. Vol. XLVII, No. 1220 to XLVIII, No. 1232. 4° London, 1893.

Neues Jahrbuch für Mineralogie, Geologie und Palaeontolcgie. Band I, heft. 2-3. 8° Stuttgart, 1893.

Oil and Colourman's Journal. Vol. XIV, Nos. 152-154. 4° London, 1893.

Palæontographica, Band XL, lief. 1-2. 4° Stuttgart, 1893.

Petermann's Geographischer Mittheilungen. Band XXXIX, Nos. 4-5, and XL, No. 3. 4° Gotha, 1893. THE EDITOR.

Scientific American. Vol. LXVIII, Nos. 9-21. Fol. New York, 1893.

Scientific American. Supplement. Vol. XXXV, Nos. 896-908. Fol. New York, 1893.

The Indian Engineer. Vol. XVI, Nos. 312-324. Fol. Calcutta, 1893. J. MACINTYRE.

The "Pioneer." New series, 1st Edition, Vol. XCIV, Nos. 10002-10077. Fol. Allahabad, 1893. SUPDT. OF STATIONERY.

Zeitschrift für Krystallographie und Mineralogie. By P. Groth. Band XXI, heft. 3-4. 8° Leipzig, 1893.

GOVERNMENT SELECTIONS, REPORTS, ETC.

Titles of Books, *Donors.*

BENGAL.—Notes on the District of Gaya, by G. A. Grierson. 8° Calcutta, 1893.
REV. AND AGRIC. DEPARTMENT.

BOMBAY.—Selections from the Records of the Bombay Government. New Series, Nos. 263, 265 and 266. Flsc. Bombay, 1892-1893.
BOMBAY GOVERNMENT.

INDIA.—Census of India, 1891. Vol. XI, Part I, and XII, Part II. The Central Provinces and Feudatories. Flsc. Calcutta, 1893.
REV. AND AGRIC. DEPARTMENT.

„ General Report on the Operations of the Survey of India Department for 1891-92. Flsc. Calcutta, 1893. SURVEY OF INDIA DEPARTMENT.

„ List of Officers in the Survey and other Departments subordinate to the Government of India in the Revenue and Agricultural Department, corrected to January 1893. 8° Calcutta, 1893.
REV. AND AGRIC. DEPARTMENT.

„ Meteorological Observations recorded at seven stations in India, in the year 1892, corrected and reduced. 4° Calcutta, 1893.
METEOROLOGICAL REPORTER TO GOVT. OF INDIA.

„ Monthly Weather Review, November 1892 to January 1893. 4° Calcutta, 1893.
METEOROLOGICAL REPORTER TO GOVT. OF INDIA.

„ Register of Original Observations, reduced and corrected, November 1892 to January 1893. 4° Calcutta, 1893.
METEOROLOGICAL REPORTER TO GOVT. OF INDIA.

„ Quarterly Indian Army List. New series, No, 15. 8° Calcutta, 1893.
GOVERNMENT OF INDIA.

PUNJAB.—Gazetteer of the Hissar District, 1892. 8° Lahore 1893.
PUNJAB GOVERNMENT.

„ Gazetteer of the Karnal District, 1890. 8° Lahore, 1892.
PUNJAB GOVERNMENT.

TRANSACTIONS, PROCEEDINGS, ETC., OF SOCIETIES, SURVEYS, ETC.

BALLARAT.—Annual Report of the Ballarat School of Mines, Industries and Science, for 1892. 8° Ballarat, 1893. THE SCHOOL OF MINES.

BALTIMORE.—American Journal of Mathematics. Vol. XIV, Nos. 2-3. 4° Baltimore, 1892. JOHNS HOPKINS UNIVERSITY.

„ Johns Hopkins University Circulars. Vol. XII, Nos. 104-105. 4° Baltimore, 1893. JOHNS HOPKINS UNIVERSITY.

BOMBAY.—Journal of the Bombay Natural History Society. Vol. VII, No. 4. 8° Bombay, 1893. THE SOCIETY.

BOSTON.—Memoirs of the Boston Society of Natural History. Vol. IV, No. 10. 4° Boston, 1892. THE SOCIETY.

„ Proceedings of the Boston Society of Natural History. Vol. XXV, parts 3-4. 8° Boston, 1892. THE SOCIETY.

Titles of Books. *Donors.*

BUDAPEST.—Termeszetrajzi Füzetek. Vol. XV, No. 4. 8° Budapest, 1893.
THE HUNGARIAN NATIONAL MUSEUM.

CAEN.—Bulletin de la Société Linnéenne de Normandie. 4me serie, Vol. VI, fasc. 4. 8° Caen, 1892. THE SOCIETY.

„ Mémoires de la Société Linnéenne de Normandie. Vol. XVII, fasc. 1. 4° Caen, 1892. THE SOCIETY.

CALCUTTA.—Journal of the Asiatic Society of Bengal.
Vol. LX, Part I, No. 3 (1891).
„ LXI, Part I, extra number (1892); and No. 4 (1893); and Part II, Nos. 1-3 (1893).
„ LXII, Part I, No. 1; Part II, No. 1; and Part III, No. 1 (1893). 8° Calcutta, 1891-1893. THE SOCIETY.

„ Proceedings of the Asiatic Society of Bengal. Nos. 2 and 10 (1892); and Nos. 1-5 (1893). 8° Calcutta, 1892-1893. THE SOCIETY.

„ Records of the Geological Survey of India. Vol. XXVI, parts 1-2. 8° Calcutta, 1893. GEOLOGICAL SURVEY OF INDIA.

„ Survey of India Department Notes for March to May 1893. Flsc. Calcutta. 1893. SURVEY OF INDIA DEPARTMENT.

CAMBRIDGE.—Proceedings of the Cambridge Philosophical Society. Vol. VIII, part 1. 8° Cambridge, 1893. THE SOCIETY.

„ Twenty-seventh Annual Report of the Museums and Lecture Rooms Syndicate, Cambridge University, for the year 1892. 4° Cambridge, 1893. THE UNIVERSITY.

CAMBRIDGE, MASS.—Bulletin of the Museum of Comparative Zoölogy. Vol. XVI, Nos. 11-12; XXIII, No. 6; and XXIV, Nos. 1-3. 8° Cambridge, Mass, 1893. THE MUSEUM.

COPENHAGEN.—Mémoires de l'Académie Royale des Sciences et des Lettres de Denemark. 6me série, Tome VI. No. 3, and VII, No. 6. 4° Kjobenhavn, 1892. THE ACADEMY.

„ Oversigt over det Kongelige Danske Videnskabernes Selskabs Forhandlinger og dets Medlemmers Arbejder i Aaret, 1892, No. 2. 8° Kjobenhavn, 1892. THE ACADEMY.

DRESDEN.—Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gesellschaft Isis in Dresden. Jahrg. 1892, July to December. 8° Dresden, 1893. ISIS SOCIETY.

EDINBURGH.—Scottish Geographical Magazine. Vol. IX, Nos. 4-6. 8° Edinburgh, 1893. SCOTTISH GEOGRAPHICAL SOCIETY.

GENEVE.—Mémoires de la Société de Physique. Supplementary Centenairy Volume. 4° Genéve, 1891. THE SOCIETY.

KONIGSBERG.—Führer durch die Geologischen Sammlungen des Provinzial museums der Physikalisch-Oekonomischen Gesellschaft zu Königsberg. 8° Königsberg, 1892. THE SOCIETY.

LAUSANNE.—Bulletin de la Société Vaudoise des Sciences Naturelles. 3me serie, Vol. XXVIII, No. 109. 8° Lausanne, 1892. THE SOCIETY.

LILLE.—Mémoires de la Société Géologique du Nord. Vol. III. 4° Lille, 1889.
THE SOCIETY.

Titles of Books. *Donors.*

LISBON.—Direction des Travaux Géologiques du Portugal. Description de la Faune Jurassique du Portugal. Mollusques Lamellibranches par Paul Choffat. Livr 1. 4° Lisbonne, 1893. THE COMMISSION.

LONDON.—Journal of the Chemical Society. Nos. 364-366. 8° London, 1893.

" Journal of the Society of Arts. Vol. XLI, Nos. 2104-2116. 8° London, 1893. THE SOCIETY.

" Proceedings of the Royal Society. Vol. LII, Nos. 317-318. 8° London, 1893. THE SOCIETY.

" Proceedings of the Zoological Society of London. Part 4. 8° London, 1893. THE SOCIETY.

" Transactions of the Zoological Society of London. Vol. XIII, part 5. 4° London, 1893. THE SOCIETY.

" Quarterly Journal of the Geological Society. Vol. XLIX, No. 194. 8° London, 1893. THE SOCIETY.

" Report on the 62nd Meeting of the British Association for the advancement of Science held at Edinburgh in August 1892. 8° London, 1893.

" The Geographical Journal. Vol. I, Nos. 4-6. 8° London, 1893. ROYAL GEOGRAPHICAL SOCIETY.

MADRID.—Boletin de la Sociedad Geografica de Madrid. Tome XXXIII, Nos. 4-6, and XXXIV, Nos. 1-3. 8° Madrid, 1893. THE SOCIETY.

MANCHESTER.—Memoirs and Proceedings of the Manchester Literary and Philosophical Society. Vol. VII, No. 1. 8° Manchester, 1893. THE SOCIETY.

" Transactions of the Manchester Geological Society. Vol. XXII, parts 4-8. 8° Manchester, 1893. THE SOCIETY.

MELBOURNE.—Special Reports of the Department of Mines, Victoria, for 1892 and 1893. issued under the authority of the Minister of Mines. Flsc. Melbourne 1893. DEPARTMENT OF MINES, VICTORIA.

MOSCOW.—Bulletin de la Société Impériale des Naturalistes de Moscou. Nos. 3-4. 8° Moscou, 1893. THE SOCIETY.

NAPLES.—Rendiconto dell' Accademia delle Scienze Fisiche e Matematiche. 2ª serie, Vol. VII, fasc. 3-5. 4° Napoli, 1893. THE ACADEMY.

NEWCASTLE-UPON-TYNE.—Annual Report of the Council of the North of England Institute of Mining and Mechanical Engineers, and Accounts, for the year 1891-92; and List of Council, Officers, and Members for the year 1892-93. 8° Newcastle-upon-Tyne, 1892. THE INSTITUTE.

" Transactions of the North of England Institute of Mining and Mechanical Engineers. Vol. XLI, part 6; and XLII, part 1. 8° Newcastle-upon-Tyne, 1893. THE INSTITUTE.

NEW HAVEN.—Transactions of the Connecticut Academy of Arts and Sciences. Vol. VIII, part 2, and IX, part 1. 8° New Haven, 1892-1893. THE ACADEMY.

OTTAWA.—Geological Survey of Canada. Contributions to Canadian Palæontology. By J. F. Whiteaves. Vol. I, part 4. 8° Ottawa, 1892. THE SURVEY.

PARIS.—Annuaire Géologique Universel, Tome VIII, fasc. 3-4. 8° Paris, 1893. THE EDITOR.

Titles of Books.	*Donors.*
PARIS.—Bulletin de la Société Géologique de France. 3me Série, Tome XX, Nos. 3-4. 8° Paris, 1893.	THE SOCIETY.
„ Compte Rendu des Séances de la Société Géologique de France. 3me serie Tome XXI. 8° Paris, 1893.	THE SOCIETY.
„ Mémoires de la Société Géologique de France. Tome III, fasc. 3. 4° Paris, 1892.	THE SOCIETY.
„ Comptes Rendus des Séances de la Société de Geographie. Nos. 5-10. 8° Paris, 1893.	THE SOCIETY.
PHILADELPHIA.—Journal of the Academy of Natural Sciences. 2nd séries, Vol. IX, part 3. 4° Philadelphia, 1892.	THE ACADEMY.
„ Proceedings of the Academy of Natural Sciences. Part II. 8° Philadelphia, 1892.	THE ACADEMY.
„ Journal of the Franklin Institute. Vol. CXXXV, Nos. 3-5. 8° Philadelphia, 1893.	THE INSTITUTE.
QUEBEC.—Transactions of the Literary and Historical Society of Quebec. No. 21. 8° Quebec, 1892.	THE SOCIETY.
RICHMOND.—Catalogue of the University of Virginia for session 1892-93, and announcements for session 1893-94. 8° Richmond, 1894.	THE UNIVERSITY.
ROME.—Atti della Reale Accademia dei Lincei. Rendiconti, Série V, Semestre I, Vol. II, fasc 4-7. 8° Roma, 1893.	THE ACADEMY.
ST. PETERSBURG.—Bulletins du Comité Géologique. Vol. XI, Nos. 5-8, and Supplement to Vol. XI. 8° St. Petersbourg, 1893.	THE COMMISSION.
„ Mémoires du Comité Géologique. Vol. XII, No. 2. 4° St. Petersbourg, 1893.	THE COMMISSION.
SYDNEY.—Journal and Proceedings of the Royal Society of New South Wales. Vol. XXVI. 8° Sydney, 1893.	THE SOCIETY.
„ Proceedings of the Linnean Society of New South Wales. Vol. VII, parts 3-4. 8° Sydney, 1893.	THE SOCIETY.
TAIPING.—Perak Museum Notes. No. 1. 8° Taiping, 1893.	GOVERNMENT OF PERAK.
TORONTO.—Transactions of the Canadian Institute. Vol. III, part 1, No. 5. 8° Toronto. 1892.	THE INSTITUTE.
VIENNA.—Annalen des K. K. Naturhistorischen Hof-Museums. Band VII, Nos. 3-4. 8° Wien, 1892.	THE MUSEUM.
„ Verhandlungen der K. K. Geologischen Reichsanstalt. Nos. 17-18 (1892), and Nos. 1-5 (1893). 8° Wien, 1892-1893.	THE INSTITUTE.
VENICE.—Atti del Reale Istituto Veneto di Scienze, Lettere ed Arti. Série VII, Tomo III, Appendix to disp. 10; and Tomo IV., disp. 3-4. 8° Venezia, 1892-1893.	THE INSTITUTE.
WASHINGTON.—Memoirs of the National Academy of Sciences. Vol. V. 4° Washington, 1891.	THE ACADEMY.
„ Report of the Director of the Mint upon the production of the precious metals in the United States during the calendar year 1892. 8° Washington, 1893.	UNITED STATES MINT.
YOKOHAMA.—Seismological Journal of Japan. Vol. XVII. 8° Yokohama, 1893.	THE SOCIETY.
ZÜRICH.—Vierteljahrschrift der Naturforschenden Gesellschaft in Zürich. Jahrg XXXVII, heft 3-4. 8° Zürich, 1892.	THE SOCIETY.

G. I. C. P. O.—No. 5 D. G. Survey.—5-9-93.—620.

DONATIONS TO THE MUSEUM.

FROM 1ST AUGUST TO 31ST OCTOBER 1893.

A large weathered specimen of limestone from "Madhupur, E. I. R." and another from Katni, Jubbulpore.

PRESENTED BY JAS. CLEGHORN, BALLYGANJ.

A large block of Steatite from Raiwala, Jeypore State, and smaller specimens from Kanheri village, Bhandara District, and from the marble rocks, Jubbulpore.

PRESENTED BY THE OFFICIATING REPORTER, ECONOMIC PRODUCTS TO THE GOVERNMENT OF INDIA.

ADDITIONS TO THE LIBRARY.

FROM 1ST JULY TO 30TH SEPTEMBER 1893.

Titles of Books. *Donors.*

ABEL, *Sir F. A.*—Mining accidents and their prevention. 8° New York, 1889.

BALL, *Dr. V.*—The volcanoes of Barren Island and Narcondam in the Bay of Bengal. 8° Pam., Hertford, 1893. THE AUTHOR.

BLOCHMANN, *Dr. Friedrich.*—Untersuchungen über den Bau der Brachiopoden. Text and Plates. 4° Jena, 1892.

BONNEY, *Prof. T. G.*—The Year-book of Science for 1892. 8° London, Paris and Melbourne, 1893.

BRONN'S Klassen und Ordnungen des Thier-Reichs. Band IV., lief. 44-45. 8° Leipzig, 1893.

FOREL, *F. A.*—Le Leman (The Lake of Geneva). Tome 1. 8° Lausanne, 1892.

HUGHES, *Herbert W.*—Text-book of Coal-mining. 8° London, 1892.

KAYSER, *E.*, and LAKE, *P.*—Text-book of Comparative Geology. 8° London, 1893.

KUNHARDT, WHEATON *B.*—The Art of Ore-dressing in Europe. 8° New York, 1889.

LUNGE, *George*, AND HURTER, *F.*—The Alkali-makers' Hand-book. 8° London, 1891.

MAR, *Alexander Del.*—A History of the precious metals from the earliest times to the present. 8° London, 1880.

PHILLIPS, *W. B.*, AND PROCHASKA, *E.*—Weddings' Basic Bessemer Process. 8° New York, 1891.

POMPECKJ, *Dr. J. F.*—Beiträge zu einer Revision der Ammoniten des Schwäbischen Jura. Lief. 1. 8° Stuttgart, 1893.

ROBERTS, *R. D.*—The Earth's History. 8° London, 1893.

SUESS, *Ed.*—Die Zukunft des Silbers. 8° Wien and Leipzig, 1892.

DR. WILL. KING.

TRYON, *Geo. W.*—Manual of Conchology, Vol. XII, part 55, and 2nd series, Vol. VI, part 31. 8° Philadelphia, 1893.

WAHNSCHAFFE, *Dr. Felix.*—Die Ursachen der Oberflächengestaltung des Norddeutschen Flachlandes. 8° Stuttgart, 1893.

WATT, *Dr. George.*—Dictionary of the Economic Products of India, Vol. VI, parts 3-4. 8° Calcutta, 1893. GOVERNMENT OF INDIA.

WILSON, *Eugene B.*— Mine ventilation, practical and theoretical. 8° New York, 1891.

25

PERIODICALS, SERIALS, ETC.

Titles of Books. *Donors.*

American Geologist. Vol. XI, Nos. 1-3. 8° Minneapolis, 1893.

American Journal of Science. Vol. XLVI, Nos. 271-272, 8° New Haven, 1893.

American Naturalist. Vol. XXVII, Nos. 318-319. 8° Philadelphia, 1893.

Annalen der Physik und Chemie. Neue Folge, Band XLIX, heft 3-4; and L, heft 1. 8° Leipzig, 1893.

Annals and Magazine of Natural History. Vol. XII, Nos. 67-69. 8° London, 1893.

Athenæum. Nos. 3425-3437. 4° London, 1893.

Beiblätter zu den Annalen der Physik und Chemie. Band XVII, Nos. 5-7. 8° Leipzig, 1893.

Chemical News. Vol. LXVII, No. 1751 to LXVIII, No. 1763. 4° London, 1893.

Colliery Guardian. Vol. LXV, No. 1694 to LXVI, No. 1706. Fol., London, 1893.

Geographische Abhandlungen. Band V, heft 3. 8° Wien, 1893.

Geological Magazine. New series, Decade III, Vol. X, Nos. 7-8. 8° London, 1893.

Indian Engineering. Vol. XIV, Nos. 1-12. Flsc., Calcutta, 1893.

PAT. DOYLE.

Industries and Iron. Vol. XV, Nos. 1066-1078. 4° London, 1893.

London, Edinburgh, and Dublin Philosophical Magazine, and Journal of Science. 5th series, Vol. XXXVI, Nos. 218-220. 8° London, 1893.

Mining Journal. Vol. LXIII, Nos. 3016-3028. Fol., London, 1893.

Natural Science. Vol. II, No. 13. 8° London and New York, 1893.

Nature. Vol. XLVIII, Nos. 1233-1245. 4° London, 1893.

Neues Jahrbuch für Mineralogie, Geologie und Palæontologie. Band II, heft 1. 8° Stuttgart, 1893.

Oil and Colourman's Journal. Vol. XIV, Nos. 155-157. 4° London, 1893.

Palœontographica. Band XL, lief. 3-4. 4° Stuttgart, 1893.

Palæontologische Abhandlungen. Neue Folge, Band II, heft. 2. 4° Jena, 1893.

Petermann's Geographischer Mittheilungen. Band XXXIX, Nos. 6-8. 4° Gotha, 1893.

THE EDITOR.

Scientific American. Vol. LXVIII, Nos. 22-25; and LXIX, Nos. 1-9. Fol., New York, 1893.

Scientific American. Supplement. VOL. XXXV, No. 909 to XXXVI, No. 921. Fol., New York, 1893.

The Indian Engineer. Vol. XVII, Nos. 325—336. 4° Calcutta, 1893.

J. MACINTYRE.

The Pioneer. New series, 1st Edition, July to September 1893. Fol., Allahabad, 1893.

schermak's Mineralogische und Petrographische Mittheilungen. Band XIII, heft 1—2. 4° Wien, 1893.

Repertorium und General Register der Zeitschrift für Krystallographie und Mineralogie. By P. Groth and F. Grünling. Theil II. 8° Leipzig, 1893.

Zeitschrift für Krystallographie und Mineralogie. By P. Groth. Band XXI, heft 5-6, and XXII, heft 1. 8° Leipzig, 1893.

GOVERNMENT SELECTIONS, REPORTS, ETC.

BENGAL.—Discovery of the exact size of Asokas Classic Capital of Pataliputra, the Palibothra of the Greeks and description of the superficial remains. By L. A. Waddell, M.B. 4° Calcutta, 1892.

BENGAL GOVERNMENT.

Titles of Books. *Donors.*

BOMBAY.—Selections from the Records of the Bombay Government. New series, Nos. 267, 268 and 270. Flsc. Bombay, 1893. BOMBAY GOVERNMENT.

BURMA.—Twenty-sixth Annual Report on the Light-Houses and Light-Vessels off the Coast of Burma for the year 1892-93. Flsc. Rangoon, 1893.
CHIEF COMMISSIONER OF BURMA.

INDIA.—Administration Report of the Marine Survey of India for the year 1892-93 Flsc. Bombay, 1893. MARINE SURVEY DEPARTMENT.

„ Administration Report on the Railways in India for 1892-93. Part I. Flsc. Simla, 1893. GOVERNMENT OF INDIA.

„ Census of India, 1891.
Vol. I. General Tables for British Provinces and Feudatory States. Flsc. London, 1892.
„ III. The Report, and
„ IV. Administrative Tables of the Lower Provinces of Bengal and their Feudatories. Flsc. Calcutta, 1893.
„ V. The Lower Provinces of Bengal and their Feudatories. The Caste tables. Flsc. Calcutta, 1893.
REVENUE AND AGRICULTURAL DEPARTMENT.

„ Government of India. Civil Budget Estimates for the year 1893-94. Flsc. Calcutta, 1893. GOVERNMENT OF INDIA.

„ List of Civil Officers holding Gazetted appointments under the Government of India in the Home, Legislative, Foreign and Revenue and Agricultural Departments, corrected to 1st January 1893. 8° Calcutta, 1893.
GOVERNMENT OF INDIA.

„ List of Officers of the Geological Survey of India, corrected to 1st July 1893. 8°. Pam. Calcutta, 1893.
REVENUE AND AGRICULTURAL DEPARTMENT.

„ Quarterly Indian Army List. New series, No. 16. 8° Calcutta, 1893.
GOVERNMENT OF INDIA.

„ Cyclone Memoirs, No. V. Account of three cyclones in the Bay of Bengal and Arabian Sea during Nov. 1891. 8° Calcutta, 1893.
METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA.

„ India Weather Review, Annual Summary, 1892. 4°. Calcutta, 1893.
METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA.

„ Monthly Weather Review for February to April 1893. 4°. Calcutta, 1893.
METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA

„ Rainfall Data of India, 1892. Flsc. Calcutta, 1893.
METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA.

„ Register of Original Observations, reduced and corrected, February to April 1893. 4° Calcutta, 1893.
METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA.

Report on the Administration of the Meteorological Department of the Government of India for 1892-93. 4° Calcutta, 1893.
METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA.

LONDON.—First, Second, Third, Fourth and Final Reports of the Royal Commission appointed to inquire into the subject of Mining Royalties, 1890—1893. Flsc. London, 1890—1893.
REVENUE AND AGRICULTURAL DEPARTMENT.

Titles of Books. *Donors.*

MADRAS.—Madras Meridian Circle Observations, 1877 to 1879. 4° Madras, 1893.
MADRAS GOVERNMENT.

" Report on the several schemes—Hebbal-Rachenhalli-Hessar-Ghatta-Maligal Valley—for the water-supply of the Civil and Military Station and City of Bangalore. Flsc. Bangalore, 1893. MAJOR GRANT.

PUNJAB.—Final Report of the Revised Settlement of the Rawalpindi District in the Punjab, 1880—1887, with maps, by F. A. Robertson. Flsc. Lahore, 1893.
PUNJAB GOVERNMENT.

" Final Report on the Revision of Settlement (1884—1889) of the northern part of the Ferozepore District in the Punjab. Flsc. Lahore, 1893.
PUNJAB GOVERNMENT.

" Gazetteer of the Ambala District, 1892-93. 8° Lahore, 1893.
PUNJAB GOVERNMENT.

" Gazetteer of the Gurdaspur District, 1891-92. 8° Lahore, 1893.
PUNJAB GOVERNMENT.

TRANSACTIONS, PROCEEDINGS, ETC., OF SOCIETIES, SURVEYS, ETC.

ADELAIDE.—Transactions of the Royal Society of South Australia. Vol. XVI, pt. 2. and XVII, part 1. 80° Adelaide, 1893. THE SOCIETY.

ALBANY.—Geological Survey of the State of New York. Palæontology. Vol. VIII, part 1. By James Hall.. 4° Albany, 1892. THE SURVEY.

ALGIERS.—Explication Carte Géologique de l'Algérie, with map. 4° Algiers, 1890.
GEOLOGICAL SURVEY, ALGIERS.

BALTIMORE.—American Chemical Journal. Vol. XIV, Nos. 2—7. 8° Baltimore, 1892.
JOHNS HOPKINS UNIVERSITY.

" American Journal of Philology. Vol. XII, No. 4, and XIII, Nos. 1—3. 8° Baltimore, 1891. JOHNS HOPKINS UNIVERSITY.

" Johns Hopkins University Circulars. Vol. XII, Nos. 106—107. 4° Baltimore, 1898. JOHNS HOPKINS UNIVERSITY.

" Johns Hopkins University Studies in Historical and Political Science. 10th series, Nos. 4—11. 8° Baltimore, 1892.
JOHNS HOPKINS UNIVERSITY.

BATAVIA.—Nederlandsch-Indisch Plakaatboek, 1602—1811. Deel XI. 8° Batavia, 1893.
BATAVIAN SOCIETY.

BERLIN.—Abhandlungen der kōniglich Preussischen Geologischen Landesanstalt. Neue Folge, heft 6—8 and 13. 8° Berlin, 1893. THE INSTITUTE.

" Abhandlungen zur Geologischen Specialkarte von Preussen und den Thüringischen Staaten Band. X, heft 4. 8° Berlin, 1893.
THE INSTITUTE.

" Sitzungsberichte der Kōnig. Preuss. Akad. der Wissenschaftern zu Berlin. Nos. 41—55. 8° Berlin, 1892. THE ACADEMY.

" Zeitschrift der Deutschen Geologischen Gesellschaft. Band XLIV, heft 4 and XLV, heft 1. 8° Berlin, 1893. THE SOCIETY.

Titles of Books. *Donors.*

BOMBAY.—Journal of the Bombay Branch of the Royal Asiatic Society. Vol. XVIII, No. 49. 8° Bombay, 1893. THE SOCIETY.

" Journal of the Bombay Natural History Society. Vol. VII, No. 5, and VIII No. 1. 8° Bombay, 1893. THE SOCIETY.

BRESLAU.—Jahres-Bericht der Schlesischen Gesellschaft für Vaterländische Cultur, No. 70, and Supplement heft 2. 8° Breslau, 1893. THE SOCIETY.

BRISTOL.—Proceedings of the Bristol Naturalists' Society. New series, Vol. VII, part 2, and List of Officers, etc. 8° Bristol, 1893. THE SOCIETY.

BRUSSELS.—Bulletin de la Société Royale Belge de Géographie. Année, XVI, No. 6. 8° Bruxelles, 1893. THE SOCIETY.

BUDAPEST.—Természetrajzi Füzetek. Vol. XVI, Nos. 1—2. 8° Budapest, 1893. THE HUNGARIAN NATIONAL MUSEUM.

CAEN.—Bulletin de la Société Linnéenne de Normandie. 4th series, Vol. VI, fasc. 1—2. 8° Caen, 1893. THE SOCIETY.

CALCUTTA.—A Manual of the Geology of India, 2nd edition. By R. D. Oldham. 8° Calcutta, 1893. GEOLOGICAL SURVEY OF INDIA.

" Palæontologia Indica. Series IX, Vol. II, part 1. 4° Calcutta, 1893. GEOLOGICAL SURVEY OF INDIA.

" Records of the Geological Survey of India, Vol XXVI, part 3. 8° Calcutta, 1893. GEOLOGICAL SURVEY OF INDIA.

" Epigraphia Indica of the Archæological Survey of India. Vol. II, part 13. 4° Calcutta, 1893. GOVERNMENT OF INDIA.

" Imperial Institute Series. Guides to Commercial Collections. Indian Section. No. 1, Guide to Collections of 1892. 8° Calcutta, 1893. REPORTER ON ECONOMIC PRODUCTS TO THE GOVERNMENT OF INDIA.

" Journal of the Asiatic Society of Bengal. Vol. LXII, Part I, No. 2; Part II, No. 2; and Title-page and Index for Part I of 1892. 8° Calcutta, 1893. THE SOCIETY.

" Proceedings of the Asiatic Society of Bengal. Nos. 6-7. 8° Calcutta, 1893. THE SOCIETY.

" Proceedings and Journal of the Agricultural and Horticultural Society of India from January 1892 to June 1893. 8° Calcutta, 1892-1893. THE SOCIETY.

" Survey of India Department Notes for June to August 1893. Flsc. Calcutta, 1893. SURVEY OF INDIA DEPARTMENT.

CAMBRIDGE, MASS.—Bulletin of the Museum of Comparative Zoölogy. Vol. XVI, No. 13, and XXIV, Nos. 4—6. 8° Cambridge, Mass., 1893. THE MUSEUM.

COPENHAGEN.—Mémoires de l'Académie Royale des Sciences et des Lettres de Danemark. 6me série, Tome VII, No. 7. 4° Kobenhavn, 1893. THE ACADEMY.

COPENHAGEN.—Oversigt over det Kongelige Danske Videnskabernes Selskabs Forhandlinger og dets Medlemmers Arbejder i Aaret, No. 3 (1892). and No 1. (1893). 8° Kobenhavn, 1893. THE ACADEMY.

DEHRA DUN.—Spirit-Levelled Heights. No. 7, Bombay Presidency. 8° Dehra Dun, 1893. GREAT TRIGONOMETRICAL SURVEY OF INDIA.

Titles of Books. *Donors.*

DEHRA DUN.—Synopsis of the results of the operations of the Great Trigonometrical Survey of India. Vols. XXXI and XXXII. 4° Dehra Dun, 1893.
GREAT TRIGONOMETRICAL SURVEY OF INDIA.

EDINBURGH.—Scottish Geographical Magazine. Vol. IX, Nos. 7-8. 8° Edinburgh, 1893.
SCOTTISH GEOGRAPHICAL SOCIETY.

" Transactions of the Royal Scottish Society of Arts. Vol. XIII, part 2. 8° Edinburgh, 1893.
THE SOCIETY.

GLASGOW.—Glasgow University Calendar, 1893-94. 8° Glasgow, 1893.
THE UNIVERSITY.

GÖTTINGEN.—Nachrichten von der Königlichen Gesellschaft der Wisseschaften Nos. 1-10. 8° Göttingen, 1893.
THE SOCIETY.

KÖNIGSBERG.—Beiträge zur Naturkunde Preussens Herausgegeben von der Königlichen Physikalisch-Ökonomischen Gesselschaft zu Königsberg. Nos. 1-5. 4° Königsberg, 1868, 1869, 1874, 1879 and 1882.
THE SOCIETY.

" Schriften der Physikalisch-Okonomischen Gesellschaft zu Königsberg Jahrg. XXXIII. 4° Konigsberg, 1892.
THE SOCIETY.

LEIPZIG.—Mittheilungen des Vereins für Erdkunde zu Leipzig, 1892. 8° Leipzig 1893.
THE SOCIETY.

LILLE.—Annales de la Société Géologique du Nord. Vol. XX. 8° Liile, 1893.
THE SOCIETY.

LONDON.—Journal of the Chemical Society. Nos. 367—369. 8° London, 1893.

" Journal of the Iron and Steel Institute. No. II. 8° London, 1892.
THE INSTITUTE.

" Journal of the Society of Arts. Vol. XLI, Nos. 2117—2128. 8° London 1893.
THE SOCIETY.

" Proceedings of the Royal Institution of Great Britain. Vol. XIII, Part III, No. 86. 8° London, 1893.
THE INSTITUTION.

" Proceedings of the Royal Society. Vol. LII, No. 319. 8° London, 1893.
THE SOCIETY.

" Quarterly Journal of the Geological Society. Vol. XLIX, Part III, No. 195, 8° London, 1893.
THE SOCIETY.

" The Geographical Journal. Vol. II, No. 7. 8° London, 1893.
ROYAL GEOGRAPHICAL SOCIETY.

" Proceedings of the Zoological Society of London. Part I. 8° London, 1893.
THE SOCIETY.

" Transactions of the Zoological Society of London. Vol. XIII, part 6. 4° London, 1893.
THE SOCIETY.

MADRAS.—Archæological Survey of India. South Indian Inscriptions. Vol. II, part 2. 4° Madras, 1893.
GOVERNMENT OF INDIA.

MADRID.—Boletin de la Sociedad Geografica de Madrid. Tome XXXIV, Nos. 4—6. 8° Madrid, 1893.
THE SOCIETY.

MANCHESTER.—Transactions of the Manchester Geological Society. Vol. XXII, parts 9—11. 8° Manchester, 1893.
THE SOCIETY.

MELBOURNE.—Annual Report of the Secretary for Mines, Victoria, for the year 1892, Flsc. Melbourne, 1893.
DEPARTMENT OF MINES, VICTORIA.

Titles of Books. *Donors.*

MELBOURNE.—Proceedings of the Royal Society of Victoria. New series, Vol. IV, part 2. 8° Melbourne, 1893. THE SOCIETY.

MILAN.—Atti della Societa Italiana di Science Naturali. Vol. XXXIV, fasc. 2-3. 8° Milano, 1893. THE SOCIETY.

MOSCOW.—Bulletin de la Société Impériale des Naturalistes de Moscow. No. 1. 8° Moscou, 1893. THE SOCIETY.

PARIS.—Annales des Mines. 9^{me} série, Tome II, livr. 12, and III, livr. 1-3. 8° Paris, 1893. DEPARTMENT OF MINES, PARIS.

" Annuaire Géologique Universel. Tome IX, fasc. 1. 8° Paris, 1893. THE EDITOR.

" Bulletin de la Société de Géographie. 7^{me} série, Tome XIII, No. 4. 8° Paris, 1892. THE SOCIETY.

" Comptes Rendus des Séances de la Société de Géographie. Nos. 11-13. 8° Paris, 1891. THE SOCIETY.

" Bulletin de la Société Géologique de France. 3^{me} série, Tome XX, No. 5. 8° Paris, 1893. THE SOCIETY.

PHILADELPHIA.—Journal of the Franklin Institute. Vol. CXXXV, No. 6, and CXXXVI, Nos. 1-2. 8° Philadelphia, 1893. THE INSTITUTE.

PISA.—Atti della Societa Toscana di Seienze Naturali. Mémorie, Vol. XII. 8° Pisa, 1893. THE SOCIETY.

" Atti della Societa Toscana di Scienze Naturali. Processi Verbali. Vol. VIII, pp. 176-231. 8° Pisa, 1893. THE SOCIETY.

RIO DE JANEIRO.—Annuario Publicado Pelo do Rio de Janeiro. No. VIII, 1892. 8° Rio de Janeiro, 1893. IMPERIAL OBSERVATORY, RIO DE JANEIRO.

" Le Climat de Rio de Janeiro. 4° Rio de Janeiro, 1892. IMPERIAL OBSERVATORY, RIO DE JANEIRO.

ROCHESTER.—Bulletin of the Geological Society of America. Vol. III, pp. 1-541. 8° Rochester, 1892. THE SOCIETY.

ROME.—Atti della Reale Accademia dei Lincei. Rendiconti, Série V, Semestre I, Vol. II, fasc. 8-12, and Semestre II, Vol. II, fasc. 1-3. 8° Roma. 1893. THE ACADEMY.

SALEM, MASS.—Bulletin of the Essex Institute. Vol. XXIV, Nos. 4-12, and XXV, Nos. 1-6. 8°. Salem, Mass., 1893. THE INSTITUTE.

SHANGHAI.—Journal of the China Branch of the Royal Asiatic Society. New series, Vol. XXV. 8° Shanghai, 1893. THE SOCIETY.

ST. PETERSBURG.—Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg, Tome XXXVIII, No. 14, and XL, No. 1. 4° St. Pétersbourg, 1892. THE ACADEMY.

" Systematisches Sach-und Namen-Register zu der Zweiten Série der Verhandlungen der Kaiserlichen Mineralogischen Gesellschaft zu St. Pétersbourg, und den Malrialien zur Geologie Russlands, 1866-1884. 8° St. Pétersbourg, 1885. THE SOCIETY.

" Verhandlungen der Russisch-Kaiserlichen Mineralogischen Gesellschaft zu St. Pétersbourg. 2nd series, Vols. XVIII to XXVI and XXIX (1883-1892); and XVI (1893). 8° St. Pétersbourg, 1883-1893. THE SOCIETY.

STUTTGART.—Jahreshefte des Vereins für Vaterländische Naturkunde in Württemberg. Jahrg. XLIX. 8° Stuttgart, 1893.

Titles of Books. *Donors.*

SYDNEY.—Annual Report of the Department of Mines and Agriculture, New South Wales, for 1892. Flsc. Sydney, 1893.
DEPARTMENT OF MINES, NEW SOUTH WALES.

„ Australian Museum, Sydney. Catalogue of the Marine Shells of Australia and Tasmania. Part III, Gasteropoda. 8° Sydney, 1893.
THE MUSEUM.

„ Report of the Trustees of the Australian Museum, Sydney, for the year 1892. Flsc. Sydney, 1893. THE MUSEUM.

„ Proceedings of the Linnean Society of New South Wales. 2nd series, Vol. VIII, part 1. 8° Sydney, 1893. THE SOCIETY.

„ Records of the Geological Survey of New South Wales. Vol. III, part 3. 8° Sydney, 1893. THE SURVEY.

TOKIO.—Mittheilungen der Deutschen Gesellschaft für Natur und Volkerkunde Ostasiens in Tokio. Band VI, heft 51. 4° Tokio, 1893.
THE SOCIETY.

VENICE.—Atti del Reale Istituto Veneto di Scienze, Lettere ed Arti. Série VII, Tomo IV, disp. 5-6. 8° Venezia, 1893.
THE INSTITUTE.

WASHINGTON.—Bulletin of the United States Department of Agriculture. No. 3. 8° Washington, 1893.
U. S. DEPARTMENT OF AGRICULTURE.

„ United States Department of Agriculture. North American Fauna. No. VII, part 2. Flsc. Washington, 1893.
U. S. DEPARTMENT OF AGRICULTURE.

WELLINGTON.—Manual of the New Zealand Coleoptera by Captain Thomas Broun. Parts 5—7. 8° Wellington, 1893. THE INSTITUTE.

„ Transactions and Proceedings of the New Zealand Institute. Vol. XXV. 8° Wellington, 1893. THE INSTITUTE.

„ Twenty-seventh Annual Report on the Colonial Museum and Laboratory, for 1891-92. 8° Wellington, 1893. THE MUSEUM.

YORK.—Annual Report of the Yorkshire Philosophical Society for 1892. 8° York, 1893. THE SOCIETY.

ZÜRICH.—Vierteljahrschrift der Naturforschenden Gesellschaft in Zürich. Jahrg. XXXVIII, heft 1. 8° Zürich, 1893. THE SOCIETY.

MAPS.

BERLIN.—Geologische Ubersichtskarte der Randgebirge des Mainzer Beckens von A. V. Reinach. Berlin, 1892. THE INSTITUTE.

BUDAPEST.—A Vakonyi Vulkan terulet Atnezetes foldtani terkepe Geognostische Ubersichtskarte des Bakoyer Vulkan Distrëctes by Dr. Hoffmann. Karoli, Table XVI. Budapest, 1890—1892.
IMPERIAL GEOLOGICAL INSTITUTE, HUNGARY.

„ Geologische Aufnabmen der Konigl. ung Geologischen Anstalt. Rovat XXVII, XXIX, and XXXI Budapest, 1890—1892.
IMPERIAL GEOLOGICAL INSTITUTE, HUNGARY.

ST. PETERSBURG.—Carte Géologique de la Russie d'Europe, with explanatory note. St. Pétersbourg, 1893.
RUSSIAN GEOLOGICAL COMMISSION.

C. L. GRIESBACH, CENTRAL HIMÁLAYAS.

S.E. Dha

C. L. GRIESBACH DEL. & LITH.

Plate 1

Plate

Griesbach, Central Hi

Lithographed & Print

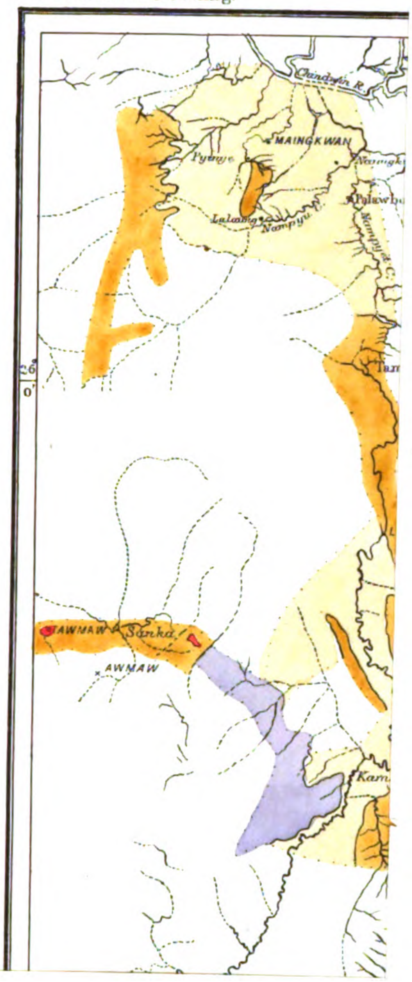
Plate 3

:4

Griesbach & Noetling.

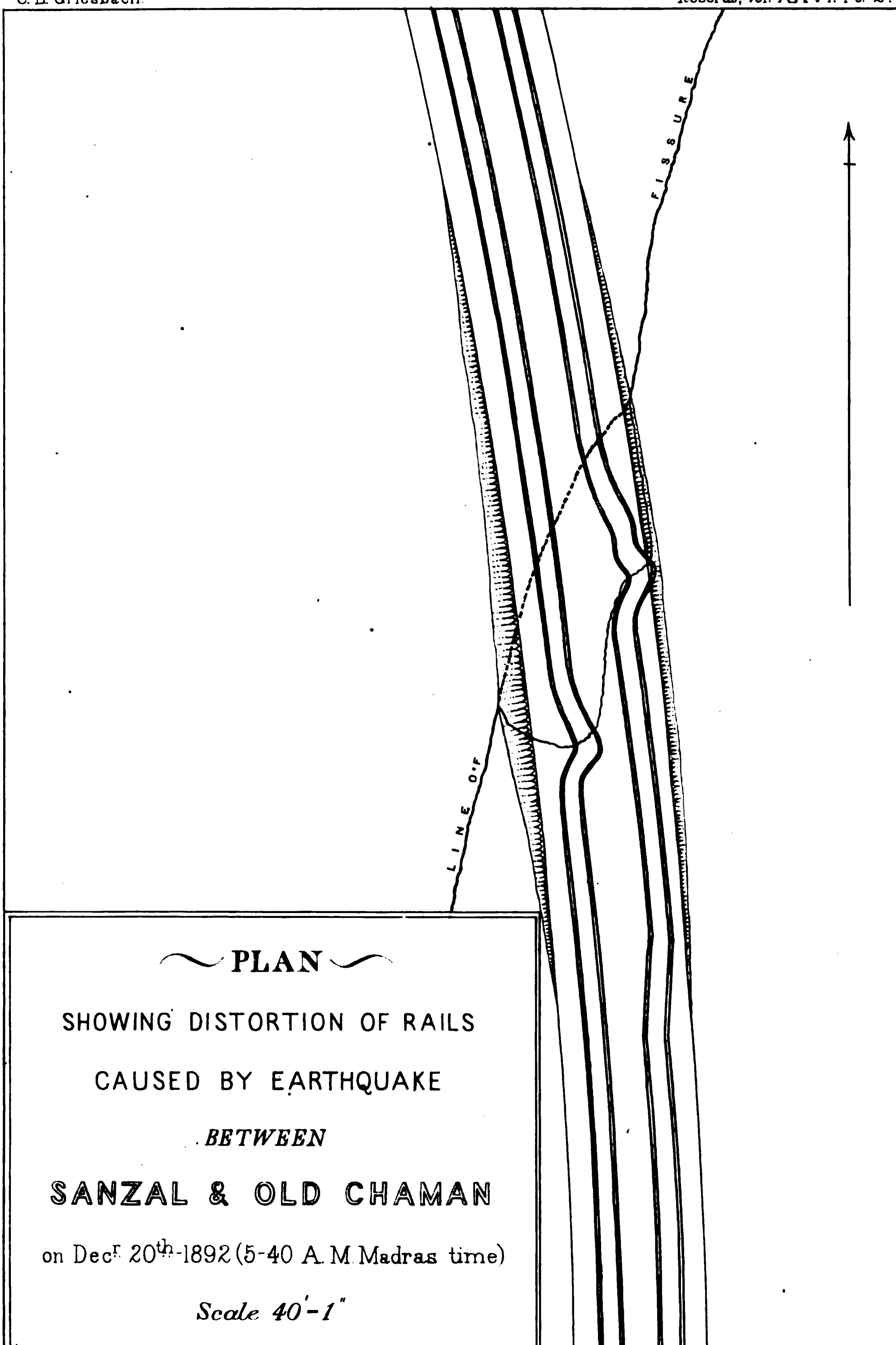
GE

2.



Office.

Plate 4



~ PLAN ~

SHOWING DISTORTION OF RAILS

CAUSED BY EARTHQUAKE

BETWEEN

SANZAL & OLD CHAMAN

on Decr. 20th. 1892 (5-40 A. M. Madras time)

Scale 40'-1"

Lithographed & Printed at. Geological Survey Office.

C. L. Griesbach.

Records, Vol: XXVI. Pt. 2 Pl. 1.

Pl. 5

Photo-etching.

Survey of India Offices, Calcutta, April 1893.

View showing distortion of Rails caused by Earthquake between Sanzal & Old Chaman.

C. L. Griesbach.

Pl. 6

Photo-etching.

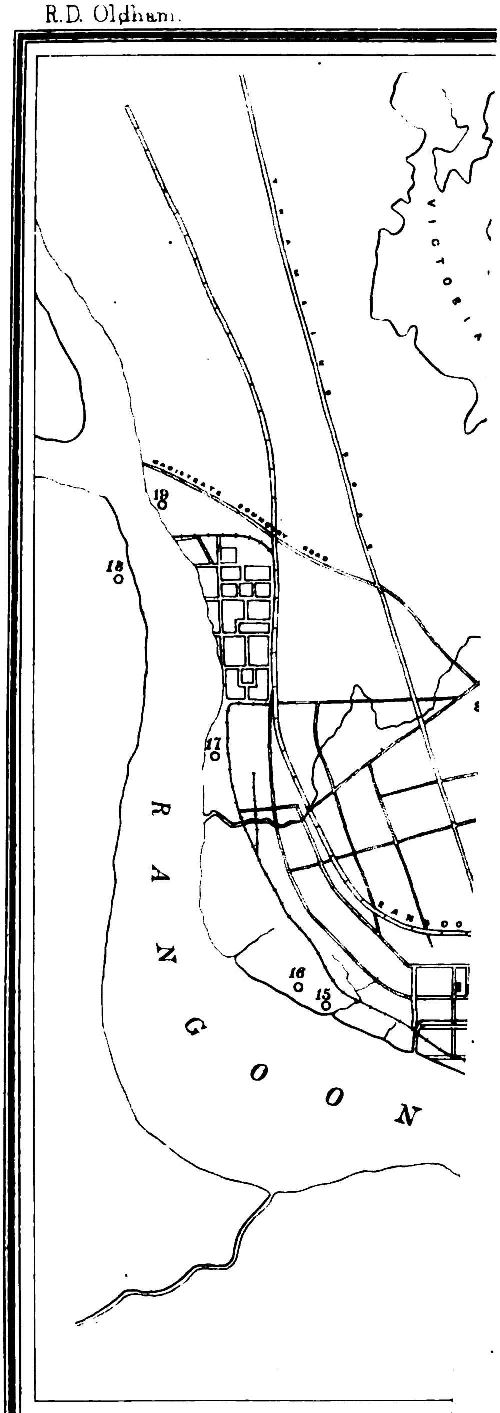
Survey of India Offices, Calcutta, May 1893.

View of the fissure produced by the Earthquake between Sanzal & Old Chaman.

Pl. 7

GEOL

R.D. Oldham.

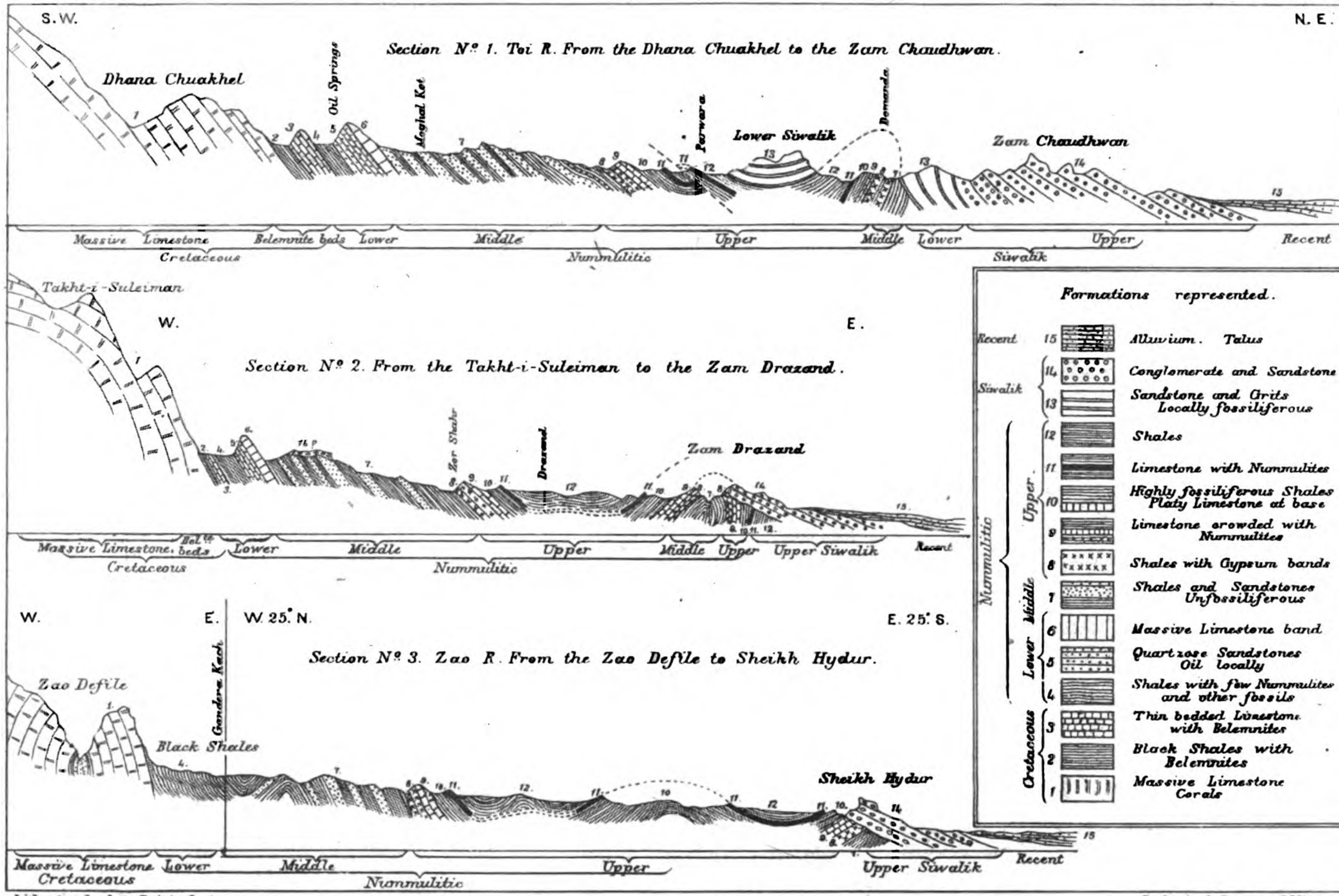


Lithographed & Printed at

Plate 8

T. D. La Touche.

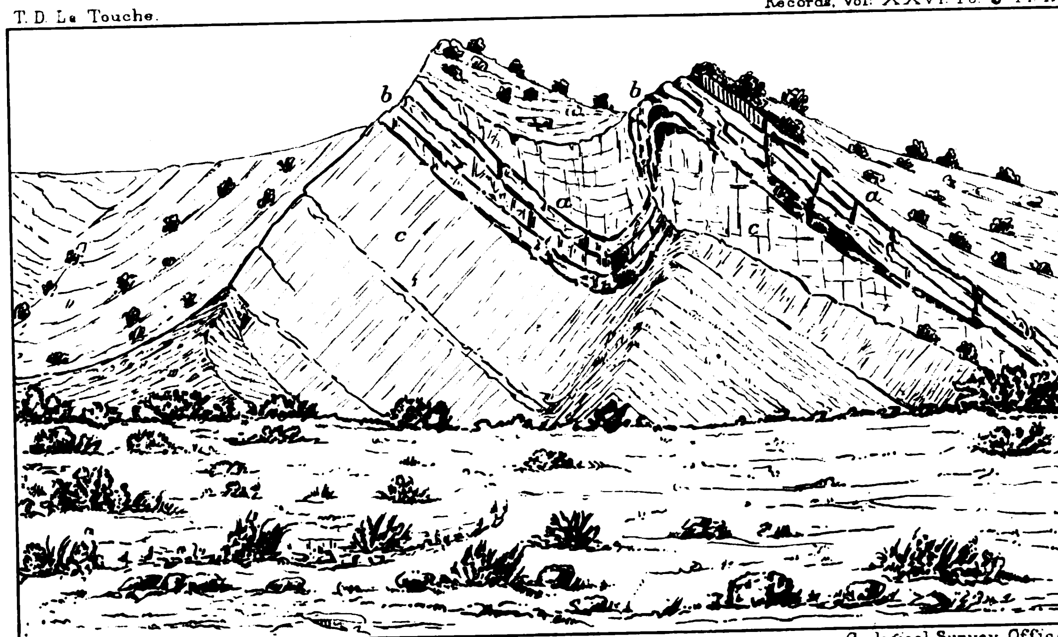
Records, Vol: XXVI. Pt. 3. Pl. I.



Lithographed & Printed at Geological Survey Office.

Records, Vol: XXVI. Pt. 3 Pl. II.

T. D. La Touche.



Lithographed & Printed at Geological Survey Office.

FOLD IN UPPER NUMMULITIC GROUP. BETWEEN PARWARA AND BASKAI

a a Upper Olive Shales No. 12. b b Limestone band No. 11. c c Lower Olive Shales No. 10.

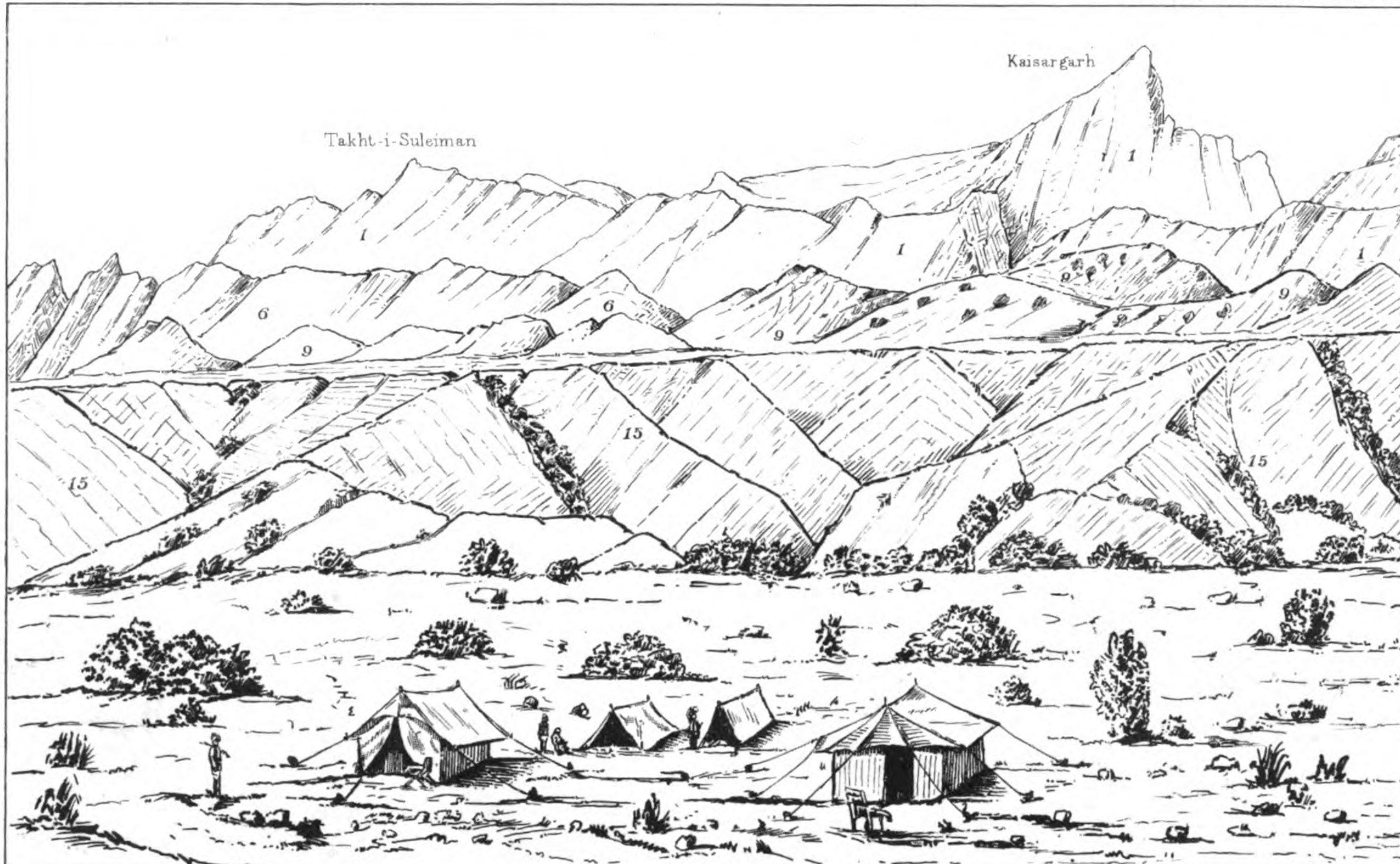
Plate 9

Plate 10

T. D. La Touche.

Records, Vol: XXVI. Pt. 3. Pl. IV.

Plate 11



Lithographed & Printed at Geological Survey Office.

THE TAKHT-I-SULEIMAN FROM THE ZAO RIVER.

1. Massive Cretaceous Limestone 6. Lr Nummulitic Limestone 9. Ridge at base of Upp. Nummulitics 15 Terrace drifts.

Plate 12

T. D. La Touche.

Records, Vol. XXVI Pt. 3. Pl. V

Lithographed & Printed at Geological Survey Office.

TERRACES IN THE TIRI CHUAKHEL, TAKHT-I-SULEIMAN IN THE DISTANCE.

Plate 13

Plate 14

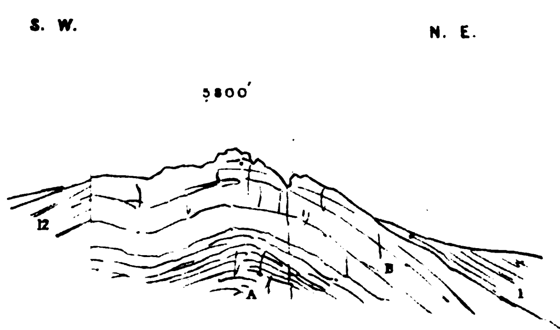
Bose. Records, Vol. XXVI. Pt. 3. Pl. I.

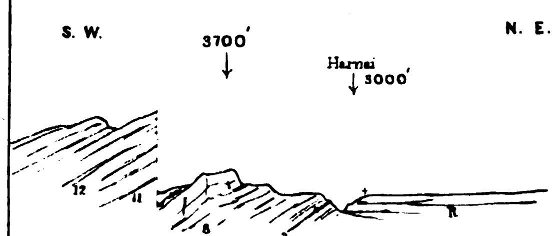
Fig. 1.

Fig. 2.

Lithographed & Printed at Geological Survey Office.

Plate 15





HILLS S. W. OF IT.

Plate 16

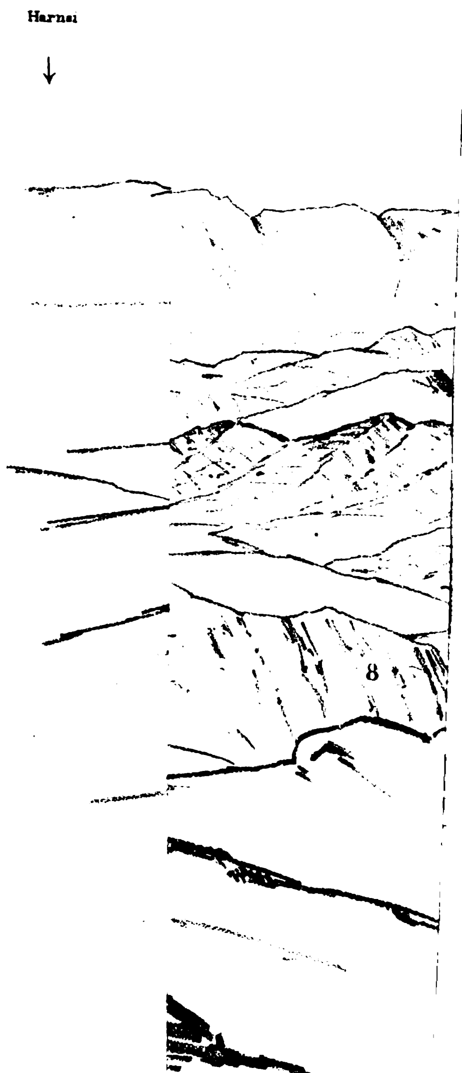
C. L. GRIES

RECORDS, VOL, XXVI. PT. 4. PL. 2.

C. L. GRIESBA

GEOL. SURV. OFFICE IMP.

C. L. GRIE



C. L. GRIESB

STATION, LOOKING S

Plate 18

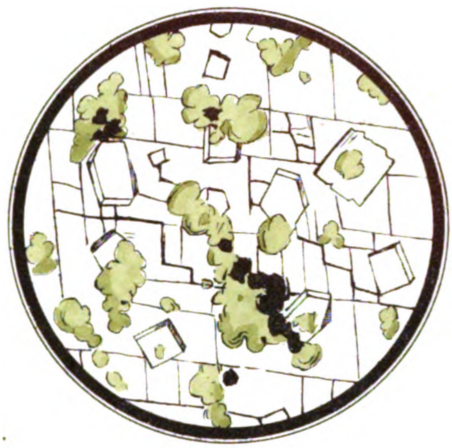


Fig. 1.

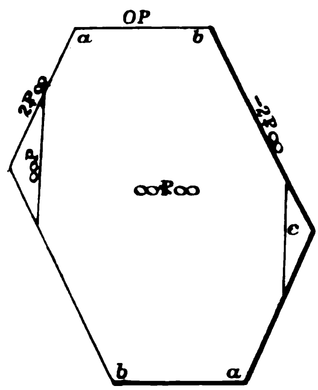


Fig. 2.

T. H. Holland Del. Lith^d & Print^d at Geol. Surv. Office.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

VOL. XXVI, PART 1.

1893.

CONTENTS.

	PAGE
ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA, AND OF THE GEOLOGICAL MUSEUM, CALCUTTA, FOR THE YEAR 1892	1
Notes *on the* Central Himalayas, *by* C. L. GRIESBACH, C.I.E., F.G.S., *Superintendent, Geological Survey of India* (with map and plate)	19
Note *on the occurrence of* Jadeite *in* Upper Burma, *by* Dr. FRITZ NOETLING, *Palæontologist, Geological Survey of India* (with a map)	26
On *the* occurrence *of* Burmite, *a new* Fossil Resin *from* Upper Burma, *by* DR. FRITZ NOETLING, *Palæontologist, Geological Survey of India*	31
Report *on the* Prospecting Operations, Mergui District, 1891-92, *by* T. W. H. HUGHES, A.R.S.M., F.G.S., *Superintendent, Geological Survey of India*	40
Tri-monthly Notes	53
DONATIONS TO THE MUSEUM.	
ADDITIONS TO THE LIBRARY.	

GEOLOGICAL SURVEY OF INDIA.

MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA.

VOL. I. Royal 8vo, pp. 309, 1859 (*out of print*).* Pt. 1, 1856 (*price* 1 Re.): Preliminary notice on the Coal and Iron of Talchir.—On the geological structure and relations of the Talchir Coal-field.—Gold-yielding deposits of Upper Assam.—On specimens of gold and gold dust from Shué-gween. Pt. 2, 1858 (*price* 2 Rs.): On the geological structure of a portion of the Khasi Hills.—On the geological structure of the Nilghiri Hills (Madras). Pt. 3, 1859 (*price* 2 Rs.): On the geological structure and physical features of the Districts of Bankura, Midnapore, and Orissa.—On the laterite of Orissa. On some fossil fish-teeth of the genus Ceratodus, from Maledi, south of Nagpur.

VOL. II. Royal 8vo, pp. 341, 1859 (*out of print*).* Pt. 1, 1860 (*price* 2 Rs.): On the Vindhyan Rocks, and their associates in Bundelkand. Pt. 2, 1860 (*price* 3 Rs.): On the geological structure of the central portion of the Nerbudda District.—On the tertiary and alluvial deposits of the central portion of the Nerbudda Valley.—On the geological relations and probable geological age of the several systems of rocks in Central India and Bengal.

VOL. III. Royal 8vo, pp. 438. Pt. 1, 1863 (*price* 3 Rs.) (*out of print*).* On the geological structure and relations of the Raniganj Coal-field.—Additional remarks on the geological relations and probable geological age of the several systems of rocks in Central India and Bengal.—Indian Mineral Statistics, I. Coal. Pt. 2, 1864 (*price* 2 Rs.): On the Sub-Himalayan Ranges between the Ganges and Ravi.

VOL. IV. Royal 8vo, pp. 450. Pt. 1, 1863 (*price* 2 Rs.): Report on the Cretaceous Rocks of Trichinopoly District, Madras. Pt. 2, 1864 (*price* 2 Rs.) (*out of print*):* On the structure of the Districts of Trichinopoly, Salem, &c. Pt. 3, 1865 (*price* 1 Re.): On the Coal of Assam, &c.

VOL. V. Royal 8vo, pp. 354. Pt. 1, 1865 (*price* 3 Rs.) (*out of print*):* Sections across N.-W. Himalaya, from Sutlej to Indus.—On the Gypsum of Spiti. Pt. 2, 1866 (*price* 1 Re.): On the Geology of Bombay. Pt. 3, 1866 (*price* 1 Re.): (*out of print*).* On the Jheria Coal-field.—Geological Observations on Western Tibet.

VOL. VI. Royal 8vo, pp. 395. Pt. 1, 1867 (*price* 8 As.): On the Neighbourhood of Lynyan, &c., in Sind.—Geology of a Portion of Cutch. Pt. 2, 1867 (*price* 2 Rs.) (*out of print*):* Bokáro Coal-field.—Rámgarh Coal-field.—Traps of Western and Central India. Pt. 3, 1869 (*price* 2 Rs. 8 As.): Tapti and Nerbudda Valleys.—Frog-beds in Bombay—*Oxyglossus pusillus.*

VOL. VII. Royal 8vo, pp. 342. Pt. 1, 1869 (*price* 3 Rs.): Vindhyan Series.—Mineral Statistics.—Coal.—Shillong Plateau. Pt. 2, 1870 (*price* 1 Re.): Karharbár Coal-field.—Deoghar Coal-field. Pt. 3, 1871 (*price* 1 Re.): Aden water-supply.—Káranpura Coal-fields.

VOL. VIII. Royal 8vo, pp. 353. Pt. 1, 1872 (*price* 4 Rs.): On the Kadapah and Karnul Formations in the Madras Presidency. Pt. 2, 1872 (*price* 1 Re.): Itkhuri Coal-field.—Daltonganj Coal-field.—Chope Coal-field.

VOL. IX. Royal 8vo, pp. iv, 358. Pt. 1, 1872 (*price* 4 Rs.): Geology of Kutch. Pt. 2, 1872 (*price* 1 Re.): Geology of Nagpúr.—Geology of Sirban Hill.—Carboniferous Ammonites, pp. 65.

VOL. X. Royal 8vo, pp. 359. Pt. 1 (*price* 3 Rs.): Geology of Madras.—Sátpura Coal-basin. Pt. 2, 1874 (*price* 2 Rs.): Geology of Pegu.

VOL. XI. Royal 8vo, pp. 338. Pt. 1, 1874 (*price* 2 Rs.): Geology of Dárjiling and Western Duars. Pt. 2, 1876 (*price* 3 Rs.): Salt-region of Kohát, Trans-Indus.

VOL. XII. Royal 8vo, pp. 363. Pt. 1, 1877 (*price* 3 Rs.): South Mahrátta Country. Pt. 2, 1876 (*price* 2 Rs.): Coal-fields of the Nága Hills.

VOL. XIII. Royal 8vo, pp. 248. Pt. 1, 1877 (*price* 2 Rs. 8 As.): Wardha Valley Coal-field. Pt. 2, 1877 (*price* 2 Rs. 8 As.): Geology of the Rájmahál Hills.

VOL. XIV. Royal 8vo, pp. 313, 1878. Geology of the Salt-range in the Punjab.

VOL. XV. Royal 8vo, pp. 192. Pt. 1, 1878 (*price* 2 Rs. 8 As.): Geology of the Aurunga and Hutár Coal-fields (Palamow). Pt. 2, 1880 (*price* 2 Rs. 8 As.): Ramkola and Tatapani Coal-fields (Sirguja).

VOL. XVI. Royal 8vo, pp. 264. Pt. 1, 1879 (*price* 1 Re. 8 As.): Geology of Eastern Coast from Lat. 15° to Masulipatam. Pt. 2, 1880 (*price* 1 Re. 8 As.): The Nellore Portion of the Carnatic. Pt. 3, 1880 (*price* 2 Rs.): Coastal Region of the Godávari District.

VOL. XVII. Royal 8vo, pp. 305. Pt. 1, 1879 (*price* 3 Rs.): Geology of Western Sind. Pt. 2, 1880 (*price* 2 Rs.): Trans-Indus extension of the Punjab Salt-range.

VOL. XVIII. Royal 8vo, pp. 300. Pt. 1, 1881 (*price* 2 Rs.) Southern Afghanistan. Pt. 2, 1881 (*price* 1 Re. 8 As.) (*out of print*).* Mánbhum and Singhbhum. Pt. 3, 1881 (*price* 2 Rs.): Pránhita-Godávari Valley.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

VOL. XXVI, PART 2.

1893.

CONTENTS.

PAGE

Notes *on the* earthquake *in* Balúchistán *on the* 20th December 1892, *by* C. L. GRIESBACH, C.I.E., *Superintendent, Geological Survey of India* 57

Further Note *on* Burmite, *a new amber-like fossil resin from* Upper Burma, *by* DR. OTTO HELM of Danzig. (Translated from the German by PROFESSOR BRUHL, Civil Engineering College, Sibpur 61

Note *on the* Alluvial deposits *and* Subterranean water-supply *of* Rangoon, *by* R. D. OLDHAM, A.R.S.M., *Superintendent, Geological Survey of India.* (With a map) . 64

Tri-monthly Notes 70

DONATIONS TO THE MUSEUM.

ADDITIONS TO THE LIBRARY.

GEOLOGICAL SURVEY OF INDIA.

Vol. II, pp. xv, 363, pls. 45. 1881-84. Pt. 1; Siwalik Rhinocerotidæ. Pt. 2; Supplement to Siwalik and Narbada Proboscidia. Pt. 3; Siwalik and Narbada Equidæ. Pt. 4; Siwalik Camelopardalidæ. Pt. 5; Siwalik Selenodont Suina, etc. Pt. 6; Siwalik and Narbada Carnivora.

Vol. III, pp. xxiv, 264, pls. 38. 1884-86. Pt. 1; Additional Siwalik Perissodactyla and Proboscidia. Pt. 2; Siwalik and Narbada Bunodont Suina. Pt. 3; Rodents and new Ruminants from the Siwaliks. Pt. 4; Siwalik Birds. Pt. 5; Mastodon Teeth from Perim Island. Pt. 6; Siwalik and Narbada Chelonia. Pt. 7; Siwalik Crocodilia, Lacertilia and Ophidia. Pt. 8; Tertiary Fishes.

Vol. IV, pt. 1. 1886. Siwalik Mammalia (Supplement 1), pp. 18, pls. 6.

" " " 2. 1886. The Fauna of the Karnul caves: (and addendum to Pt. 1); pp. 40 (19-58), pls. 5 (vii—xi).

" " " 3. 1887. Eocene Chelonia from the Salt-range: pp. 7 (59—65), pls. 2 (xii—xiii).

(SER. VII, XIV.)—TERTIARY AND UPPER CRETACEOUS FAUNA OF WESTERN INDIA, *by* P. MARTIN DUNCAN *and* W. PERCY SLADEN, *except* PT. 1, *by* F. STOLICZKA.

VOL. I, pp. 16 + 110 + 382 + 91 = 599, pls. 5 + 28 + 58 + 13 = 104. 1871—85. Pt. 1; Tertiary Crabs from Sind and Kach. Pt. 1 (new 2); Sind Fossil Corals and Alcyonaria. Pt. 3, The Fossil Echinoidea of Sind: *Fas. 1*, The *Cardita beaumonti* beds; *Fas. 2*, The Ranikot Series in Western Sind; *Fas. 3*, The Khirthar Series; *Fas. 4*, The Nari (Oligocene) Series; *Fas. 5*, The Gaj (miocene) Series; *Fas. 6*, The Makrán (pliocene) Series: Pt. 4, The Fossil Echinoidea of Kach and Kattywar.

(SER. XIII.)—SALT-RANGE FOSSILS, BY WILLIAM WAAGEN, PH.D.

Productus-Limestone Group: Vol. I, pt. 1 (1879). Pisces, Cephalopoda, pp. 72, pls. 6.
" " " 2 (1880). Gastropoda and supplement to pt. 1, pp. 111 (73-183), pls. 10 (1 double), (vii-xvi).
" " " 3 (1881). Pelecypoda, pp. 144 (185-328), pls. 8 (xvii-xxiv).
" " " 4 (1882-85). Brachiopoda, pp. 442 (329-770), pls. 62 (xxv-lxxxvi).
" " " 5 (1885). Bryozoa—Annelida—Echinodermata, pp. 64 (771-834), pls. 10 (lxxxvii-xcvi).
" " " 6 (1886). Cœlenterata, pp. 90 (835-924), pls. 20 (xcvii-cxvi).
" " " 7 (1887). Cœlenterata, Protozoa, pp. 74 (925-998), pls. 12 (cxvii-cxxviii).

Geological Results: Vol. IV, pt. 1 (1889), pp. 1—88, pls. 4.
" " " " " 2 (1891), pp. 89—242, pls. 8.

The price fixed for these publications is 4 annas (6 pence) per single plate.

RECORDS OF THE GEOLOGICAL SURVEY OF INDIA.

VOL. I, 1868.

Part 1.—Annual report for 1867. The coal-seams of the Tawa Valley. On the prospects of useful coal being found in the Garrow Hills. Copper in Bundelcund. Meteorites.

Part 2.—On the coal-seams of the neighbourhood of Chanda. Coal near Nagpur. Geological notes on the Surat collectorate. The cephalopodous fauna of the South Indian cretaceous deposits. Lead in the district of Raepore. Coal in the Eastern Hemisphere. Meteorites.

Part 3.—General results obtained from an examination of the gastropodous fauna of the South Indian cretaceous deposits. Notes on route from Poona to Nagpur *viâ* Amednuggur, Jalna, Loonar, Yeotmahal, Mangali, and Hingunghat. On the agate-flake found by Mr. Wynne in the pliocene (?) deposits of the Upper Godavery. The boundary of the Vindhyan series in Rajputana. Meteorites.

VOL. II, 1869.

Part 1.—The valley of the Poorna river, West Berar. On the Kuddapah and Kurnool formations. Geological sketch of the Shillong Plateau. On the occurrence of gold in the district of Singhboom, &c. Memorandum on the wells now being sunk at the European Penitentiary, and at the site for the Central Jail, Hazareebagh. Meteorites.

6

Part 2.—Annual report for 1868. Note on Pangshura Tecta and the other species of Chelonia from the newer tertiary deposits of the Nerbudda Valley. Sketch of the metamorphic rocks of Bengal.

Part 3.—Preliminary notes on the geology of Kutch, Western India. Contributions to the geology and physical geography of the Nicobar Islands.

Part 4.—On the beds containing silicified wood in Eastern Prome, British Burmah. Mineralogical statistics of Kumaon division. The coal-field near Chanda. Lead in the Raipur district. Meteorites.

VOL. III, 1870

Part 1.—Annual report for 1869. On the geology of the neighbourhood of Madras. On the alluvial deposits of the Irawadi, more particularly as contrasted with those of the Ganges.

Part 2.—Geology of Gwalior and vicinity. On the slates at Chiteli, Kumaon. On the lead vein near Chicholi, Raipur district. The Wardha river coal-fields, Berar and Central Provinces. Report on the coal at Korba in the Bilaspur district.

Part 3.—The Mohpani coal-field. On the lead-ore at Slimanabad, Jabalpur district. On the occurrence of coal east of Chhatisgurh in the country between Bilaspur and Ranchi. On petroleum in Burma. On the petroleum locality of Sudkal, near Futtijung, west of Rawalpindi. On the occurrence of argentiferous galena and copper in the district of Manbhum, S. W. Frontier of Bengal. Assays of iron ores.

Part 4.—On the geology of Mount Tilla, in the Punjab. The copper deposits of Dhalbhum and Singbhum: 1.—The copper mines of Singbhum; 2.—On the copper of Dhalbhum and Singbhum. Meteorites.

VOL. IV, 1871.

Part 1.—Annual report for 1870. Enquiry into an alleged discovery of coal near Gooty, and of the indications of coal in the Cuddapah district. Mineral statistics of the Kumaon division.

Part 2.—The axial group in Western Prome. Geological structure of the Southern Konkan. On the supposed occurrence of native antimony in the Straits Settlements. On the composition of a deposit in the boilers of steam-engines at Ranigunj. On the plant-bearing sandstones of the Godavari valley, on the southern extension of rocks belonging to the Kamthi group to the neighbourhood of Ellore and Rajamandri, and on the possible occurrence of coal in the same direction.

Part 3.—The progress and results of borings for coal in the Godavari valley near Dumagudem and Bhadrachalam. On the Narbada coal-basin. Sketch of the geology of the Central Provinces. Additional note on the plant-bearing sandstones of the Godavari valley.

Part 4.—The ammonite fauna of Kutch. The Raigur and Hengir (Gangpur) Coal-field. Description of the sandstones in the neighbourhood of the first barrier on the Godavari, and in the country between the Godavari and Ellore.

VOL. V, 1872.

Part 1.—Annual report for 1871. Rough section showing the relations of the rocks near Murree (Mari), Punjab. Mineralogical notes on the gneiss of South Mirzapur and adjoining country. Description of the sandstones in the neighbourhood of the first barrier on the Godavari, and in the country between the Godavari and Ellore.

Part 2.—On the geological formations seen along the coasts of Biluchistan and Persia from Karachi to the head of the Persian Gulf, and on some of the Gulf Islands. On a traverse of parts of the Kummummet and Hanamconda districts in the Nizam's Dominions. The geology of Orissa. On a new coal-field in the south-eastern part of the Hydrabad (Deccan) territory.

Part 3.—On Maskat and Massandim on the east coast of Arabia. An example of local jointing. On the axial group of Western Prome. On the geology of the Bombay Presidency.

Part 4.—On exploration for coal in the northern region of the Satpura basin. On the value of the evidence afforded by raised oyster banks on the coasts of India, in estimating the amount of elevation indicated thereby. On a possible field of coal-measures in the Godavari district, Madras Presidency. On the lameta or infra-trappean formation of Central India. On some recently discovered petroleum localities in Pegu. Correction regarding the supposed eozoonal limestone of Yellam Bile.

VOL. VI, 1873.

Part 1.—Annual report for 1872. The geology of the North-West Provinces.

Part 2.—The Bisrampur coal-field. Mineralogical notes on the gneiss of South Mirzapur and adjoining country.

Part 3.—Notes on a celt found by Mr. Hacket in the ossiferous deposits of the Narbada Valley (Pliocene of Falconer): on the age of the deposits, and on the associated shells. On the Barakars (coal-measures) in the Beddadanole field, Godavari district. On the geology of parts of the Upper Punjab. Coal in India. The salt-springs of Pegu.

Part 4.—On some of the iron deposits of Chanda, Central Provinces. Barren Island and Narkondam. Stray notes on the metalliferous resources of British Burmah.

Vol. VII, 1874.

Part 1.—Annual report for 1873. On the geological structure of the hill ranges between the Indus Valley in Ladak and Shah-i-Dula on the frontier of Yarkand territory. On some of the iron ores of Kumaon. On the raw materials for iron-smelting in the Raniganj field. On the habitat in India of the elastic sandstone, or so-called Itacolumyte. Geological notes on part of Northern Hazaribagh.

Part 2.—Geological notes on the route traversed by the Yarkand embassy from Shah-i-Dula to Yarkhand and Kashgar. On the occurrence of jade in the Karakash Valley, on the southern borders of Turkistan. Notes from the Eastern Himalaya. Petroleum in Assam. Coal in the Garo Hills. On the discovery of a new locality for copper in the Narbada Valley. Potash-salt from East India. On the geology of the neighbourhood of Mari hill station in the Punjab.

Part 3.—Geological observations made on a visit to the Chaderkul, Thian Shan range. On the former extension of glaciers within the Kangra district. On the building and ornamental stones of India. Second note on the materials for iron manufacture in the Raniganj coal-field. Manganese ore in the Wardha coal-field.

Part 4.—The auriferous rocks of the Dambal hills, Dharwar district. Remarks on certain considerations adduced by Falconer in support of the antiquity of the human race in India. Geological notes made on a visit to the coal recently discovered in the country of the Luni Pathans, south-east corner of Afghanistan. Note on the progress of geological investigation in the Godavari district, Madras Presidency. Notes upon the subsidiary materials for artificial fuel.

Vol. VIII, 1875.

Part 1.—Annual report for 1874. The Altum-Artush considered from a geological point of view. On the evidences of 'ground-ice' in tropical India, during the Talchir period. Trials of Raniganj fire-bricks.

*Part 2 (out of print).**—On the gold-fields of south-east Wynaad, Madras Presidency. Geological notes on the Khareean hills in the Upper Punjab. On water-bearing strata of the Surat district. Sketch of the geology of Scindia's territories.

Part 3.—The Shapur coal-field, with notice of coal explorations in the Narbada region. Note on coal recently found near Moflong, Khasia Hills.

Part 4.—Note on the geology of Nepal. The Raigarh and Hingir coal-fields.

Vol. IX, 1876.

*Part 1 (out of print).**—Annual report for 1875. On the geology of Sind.

Part 2.—The retirement of Dr. Oldham. On the age of some fossil floras in India. Description of a cranium of Stegodon Ganesa, with notes on the sub-genus and allied forms. Note upon the Sub-Himalayan series in the Jamu (Jummoo) Hills.

Part 3.—On the age of some fossil floras in India. On the geological age of certain groups comprised in the Gondwana series of India, and on the evidence they afford of distinct zoological and botanical terrestrial regions in ancient epochs. On the relations of the fossiliferous strata at Maleri and Kota, near Sironcha, C. P. On the fossil mammalian faunæ of India and Burma.

Part 4.—On the age of some fossil floras in India. On the osteology of Merycopotamus dissimilis. Addenda and Corrigenda to paper on tertiary mammalia. Occurrence of Plesiosaurus in India. On the geology of the Pir Panjal and neighbouring districts.

Vol. X, 1877.

Part 1.—Annual report for 1876. Geological notes on the Great Indian Desert between Sind and Rajputana. On the occurrence of the cretaceous genus Omphalia, near Namcho Lake, Tibet, about 75 miles north of Lhassa. On Estheria in the Gondwana formation. Notices of new and other vertebrata from Indian tertiary and secondary rocks. Description of a new Emydine from the upper tertiaries of the Northern Punjab. Observations on underground temperature.

4

Part 3.—On the tertiary zone and underlying rocks in the North-west Punjab. On fossil floras in India. On the occurrence of erratics in the Potwar. On recent coal explorations in the Darjiling district. Limestones in the neighbourhood of Barakar. On some forms of blowing-machine used by the smiths of Upper Assam. Analyses of Raniganj coals.

Part 4.—On the geology of the Mahanadi basin and its vicinity. On the diamonds, gold, and lead ores, of the Sambalpur district. Note on 'Eryon Comp. Barrovensis,' McCoy, from the Sripermatur group near Madras. On fossil floras in India. The Blaini group and the 'Central Gneiss' in the Simla Himalayas. Remarks on some statements in Mr. Wynne's paper on the tertiaries of the North-west Punjab. Note on the genera Chœromeryx and Rhagatherium.

VOL. XI, 1878.

Part 1.—Annual report for 1877. On the geology of the Upper Godavari basin, between the river Wardha and the Godavari, near the civil station of Sironcha. On the geology of Kashmir, Kishtwar, and Pangi. Notices of Siwalik mammals. The palæontological relations of the Gondwana system. On 'Remarks, &c., by Mr. Theobald upon erratics in the Punjab.'

Part 2.—On the geology of Sind (second notice). On the origin of the Kumaun lakes. On a trip over the Milam Pass, Kumaun. The mud volcanoes of Ramri and Cheduba. On the mineral resources of Ramri, Cheduba, and the adjacent islands.

Part 3.—Note on the progress of the gold industry in Wynaad, Nilgiri district. Notes on the representatives of the Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.

Part 4.—On the geographical distribution of fossil organisms in India. Submerged forest on Bombay Island.

VOL. XII, 1879.

Part 1.—Annual report for 1878. Geology of Kashmir (third notice). Further notices of Siwalik mammalia. Notes on some Siwalik birds. Notes of a tour through Hangrang and Spiti. On a recent mud eruption in Ramri Island (Arakan). On Braunite, with Rhodonite, from near Nagpur, Central Provinces. Palæontological notes from the Satpura coal-basin. Statistics of coal importations into India.

Part 2.—On the Mohpani coal-field. On Pyrolusite with Psilomelane occurring at Gosalpur, Jabalpur district. A geological reconnoissance from the Indus at Kushalgarh to the Kurram at Thal on the Afghan frontier. Further notes on the geology of the Upper Punjab.

Part 3.—On the geological features of the northern part of Madura district, the Pudukotai State, and the southern parts of the Tanjore and Trichinopoly districts included within the limits of sheet 80 of the Indian Atlas. Rough notes on the cretaceous fossils from Trichinopoly district, collected in 1877-78. Notes on the genus Sphenophyllum and other Equisetaceæ, with reference to the Indian form Trizygia Speciosa, Royle, (Sphenophyllum Trizygia Ung.). On Mysorin and Atacamite from the Nellore district. On corundum from the Khasi Hills. On the Joga neighbourhood and old mines on the Nerbudda.

Part 4.—On the 'Attock Slates' and their probable geological position. On a marginal bone of an undescribed tortoise, from the Upper Siwaliks, near Nila, in the Potwar, Punjab. Sketch of the geology of North Arcot district. On the continuation of the road section from Murree to Abbottabad.

VOL. XIII, 1880.

Part 1.—Annual report for 1879. Additional notes on the geology of the Upper Godavari basin in the neighbourhood of Sironcha. Geology of Ladak and neighbouring districts, being fourth notice of geology of Kashmir and neighbouring territories. Teeth of fossil fishes from Ramri Island and the Punjab. Note on the fossil genera Nöggerathia, Stbg., Nöggerathiopsis, Fstm., and Rhiptozamites, Schmalh., in palæozoic and secondary rocks of Europe, Asia, and Australia. Notes on fossil plants from Kattywar, Shekh Budin, and Sirgujah. On volcanic foci of eruption in the Konkan.

Part 2.—Geological notes. Palæontological notes on the lower trias of the Himalayas. On the artesian wells at Pondicherry, and the possibility of finding such sources of water-supply at Madras.

Part 3.—The Kumaun lakes. On the discovery of a celt of palæolithic type in the Punjab. Palæontological notes from the Karharbari and South Rewah coal-fields. Further notes on the correlation of the Gondwana flora with other floras. Additional note on the artesian wells at Pondicherry. Salt in Rajputana. Record of gas and mud eruptions on the Arakan coast on 12th March 1879 and in June 1843.

Part 4.—On some pleistocene deposits of the Northern Punjab, and the evidence they afford of an extreme climate during a portion of that period. Useful minerals of the Arvali region. Further notes on the correlation of the Gondwana flora with that of the Australian coal-bearing system. Note on reh or alkali soils and saline well waters. The reh soils of Upper India. Note on the Naini Tal landslip, 18th September 1880.

Vol. XIV, 1881.

Part 1.—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts, being fifth notice of the geology of Kashmir and neighbouring territories. Note on some Siwalik carnivora. The Siwalik group of the Sub-Himalayan region. On the South Rewah Gondwana basin. On the ferruginous beds associated with the basaltic rocks of north-eastern Ulster, in relation to Indian laterite. On some Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on the lower trias of the Himalayas.' On some mammalian fossils from Perim Island, in the collection of the Bombay Branch of the Royal Asiatic Society.

Part 2.—The Nahan-Siwalik unconformity in the North-western Himalaya. On some Gondwana vertebrates. On the ossiferous beds of Hundes in Tibet. Notes on mining records, and the mining record office of Great Britain; and the Coal and Metalliferous Mines Acts of 1872 (England). On cobaltite and danaite from the Khetri mines, Rajputana; with some remarks on Jaipurite (Syepoorite). On the occurrence of zinc ore (Smithsonite and Blende) with barytes, in the Karnul district, Madras. Notice of a mud eruption in the island of Cheduba.

Part 3.—Artesian borings in India. On oligoclase granite at Wangtu on the Sutlej, north-west Himalayas. On a fish-palate from the Siwaliks. Palæontological notes from the Hazaribagh and Lohardagga districts. Undescribed fossil carnivora from the Siwalik hills in the collection of the British Museum.

Part 4.—Remarks on the unification of geological nomenclature and cartography. On the geology of the Arvali region, central and eastern. On a specimen of native antimony obtained at Pulo Obin, near Singapore. On Turgite from the neighbourhood of Juggiapett, Kistnah district, and on zinc carbonate from Karnul, Madras. Note on the section from Dalhousie to Pangi *viâ* the Sach Pass. On the South Rewah Gondwana basin. Submerged forest on Bombay Island.

Vol. XV, 1882.

Part 1.—Annual report for 1881. Geology of North-west Kashmir and Khagan (being sixth notice of geology of Kashmir and neighbouring territories). On some Gondwana labyrinthodonts. On some Siwalik and Jamna mammals. The geology of Dalhousie, North-west Himalaya. On remains of palm leaves from the (tertiary) Murree and Kasauli beds in India. On Iridosmine from the Noa-Dibing river, Upper Assam, and on platinum from Chutia Nagpur. On (1) a copper mine lately opened near Yongri hill, in the Darjiling district; (2) arsenical pyrites in the same neighbourhood; (3) kaolin at Darjiling (being 3rd appendix to a report on the geology and mineral resources of the Darjiling district and the Western Duars). Analyses of coal and fire-clay from the Makum coal-field, Upper Assam. Experiments on the coal of Pind Dadun Khan, Salt-range, with reference to the production of gas, made April 29th, 1881. Report on the proceedings and results of the International Geological Congress of Bologna.

Part 2.—General sketch of the geology of the Travancore State. The Warkilli beds and reported associated deposits at Quilon, in Travancore. Note on some Siwalik and Narbada fossils. On the coal-bearing rocks of the valleys of the Upper Rer and the Mand rivers n Western Chutia Nagpur. On the Pench river coal-field in Chhindwara district, Central Provinces. On borings for coal at Engsein, British Burma. On sapphires recently discovered in the North-west Himalaya. Notice of a recent eruption from one of the mud volcanoes in Cheduba.

Part 3.—Note on the coal of Mach (Much) in the Bolan Pass, and of Sharag or Sharigh on the Harnai route between Sibi and Quetta. New faces observed on crystals of stilbite from the Western Ghâts, Bombay. On the traps of Darang and Mandi in the North-western Himalayas. Further note on the connexion between the Hazara and the Kashmir series. On the Umaria coal-field (South Rewah Gondwana basin). The Daranggiri coal-field, Garo Hills, Assam. On the outcrops of coal in the Myanoung division of the Henzada district.

Part 4.—On a traverse across some gold-fields of Mysore. Record of borings for coal at Beddadanol, Godavari district, in 1874. Note on the supposed occurrence of coal on the Kistna.

Vol. XVI, 1883.

Part 1.—Annual report for 1882. On the genus Richthofenia, Kays (Anomia Lawrenciana, Koninck). On the geology of South Travancore. On the geology of Chamba. On the basalts of Bombay.

Part 2.—Synopsis of the fossil vertebrata of India. On the Bijori Labyrinthodont. On a skull of Hippotherium antilopinum. On the iron ores, and subsidiary materials for the manufacture of iron, in the north-eastern part of the Jabalpur district. On lateritic and other manganese ore occurring at Gosulpore, Jabalpur district. Further notes on the Umaria coal-field.

Part 3.—On the microscopic structure of some Dalhousie rocks. On the lavas of Aden. On the probable occurrence of Siwalik strata in China and Japan. On the occurrence of Mastodon angustidens in India. On a traverse between Almora and Mussooree made in October 1882. On the cretaceous coal-measures at Borsora, in the Khasia Hills, near Laour, in Sylhet.

Part 4.— Palæontological notes from the Daltonganj and Hutar coal-fields in Chota Nagpur. On the altered basalts of the Dalhousie region in the North-western Himalayas. On the microscopic structure of some Sub-Himalayan rocks of tertiary age. On the geology of Jaunsar and the Lower Himalayas. On a traverse through the Eastern Khasia, Jaintia, and North Cachar Hills. On native lead from Maulmain and chromite from the Andaman Islands. Notice of a fiery eruption from one of the mud volcanoes of Cheduba Island, Arakan. Notice.—Irrigation from wells in the North-Western Provinces and Oudh.

VOL. XVII, 1884.

Part 1.—Annual report for 1883. Considerations on the smooth-water anchorages or mud banks of Narrakal and Alleppy on the Travancore coast. Rough notes on Billa Surgam and other caves in the Kurnool district. On the geology of the Chuari and Sihunta parganas of Chamba. On the occurrence of the genus Lyttonia, Waagen, in the Kuling series of Kashmir.

Part 2.—Notes on the earthquake of 31st December 1881. On the microscopic structure of some Himalayan granites and gneissose granites. Report on the Choi coal exploration. On the re-discovery of certain localities for fossils in the Siwalik beds. On some of the mineral resources of the Andaman Islands in the neighbourhood of Port Blair. The intertrappean beds in the Deccan and the Laramie group in western North America.

Part 3.—On the microscopic structure of some Arvali rocks. Section along the Indus from the Peshawar Valley to the Salt-range. On the selection of sites for borings in the Raigarh-Hingir coal-field (first notice). Note on lignite near Raipore, Central Provinces. The Turquoise mines of Nishâpûr, Khorassan. Notice of a further fiery eruption from the Minbyin mud volcano of Cheduba Island, Arakan. Report on the Langrin coal-field, South-west Khasia Hills. Additional notes on the Umaria coal-field.

Part 4.—On the geology of part of the Gangasulan pargana of British Garhwal. On fragments of slates and schists imbedded in the gneissose granite and granite of the North-west Himalayas. On the geology of the Takht-i-Suleman. On the smooth-water anchorages of the Travancore coast. On auriferous sands of the Subansiri river, Pondicherry lignite, and Phosphatic rocks at Musuri. Work at the Billa Surgam caves.

VOL. XVIII, 1885.

Part 1.—Annual report for 1884. On the country between the Singareni coal-field and the Kistna river. Geological sketch of the country between the Singareni coal-field and Hyderabad. On coal and limestone in the Doigrung river, near Golaghat, Assam. Homotaxis, as illustrated from Indian formations. Afghan field-notes.

Part 2.—A fossiliferous series in the Lower Himalaya, Garhwal. On the probable age of the Mandhali series in the Lower Himalaya. On a second species of Siwalik camel (Camelus Antiquus, nobis ex Falc. and Caut. MS.). On the Geology of Chamba. On the probability of obtaining water by means of artesian wells in the plains of Upper India. Further considerations upon artesian sources in the plains of Upper India. On the geology of the Aka Hills. On the alleged tendency of the Arakan mud volcanoes to burst into eruption most frequently during the rains. Analyses of phosphatic nodules and rock from Mussooree.

Part 3.—On the geology of the Andaman Islands. On a third species of Merycopotamus. Some observations on percolation as affected by current. Notice of the Pirthalla and Chandpur meteorites. Report on the oil-wells and coal in the Thayetmyo district, British Burma. On some antimony deposits in the Maulmain district. On the Kashmir earthquake of 30th May 1885. On the Bengal earthquake of 14th July 1885.

Part 4.—Geological work in the Chhattisgarh division of the Central Provinces. On the Bengal earthquake of July 14th, 1885. On the Kashmir earthquake of 30th May 1885. On the results of Mr. H. B. Foote's further excavations in the Billa Surgam caves. On the mineral hitherto known as Nepaulite. Notice of the Sabetmahet meteorite.

VOL. XIX, 1886.

Part 1.—Annual report for 1885. On the International Geological Congress of Berlin. On some Palæozoic Fossils recently collected by Dr. H. Warth, in the Olive group of the Salt-range. On the correlation of the Indian and Australian coal-bearing beds. Afghan and Persian Field notes. On the section from Simla to Wangtu, and on the petrological character of the Amphibolites and Quartz-Diorites of the Sutlej valley.

Part 2.—On the geology of parts of Bellary and Anantapur districts. Geology of the Upper Dehing basin in the Singpho Hills. On the microscopic characters of some eruptive rocks from the Central Himalayas. Preliminary note on the Mammalia of the Karnul Caves. Memorandum on the prospects of finding coal in Western Rajputana. Note on the Olive Group of the Salt-range. On the discussion regarding the boulder-beds of the Salt-range. On the Gondwana Homotaxis.

Part 3.—Geological sketch of the Vizagapatam district, Madras. Preliminary note on the geology of Northern Jesalmer. On the microscopic structure of some specimens of the Malani rocks of the Arvali region. On the Malanjkhandi copper-ore in the Balaghat district, C. P.

Part 4.—On the occurrence of petroleum in India. On the petroleum exploration at Khátan. Boring exploration in the Chhattisgarh coal-fields. Field-notes from Afghanistan: No. 3, Turkistan. Notice of a fiery eruption from one of the mud volcanoes of Cheduba Island, Arakan. Notice of the Nammianthal aerolite. Analysis of gold dust from the Meza valley, Upper Burma.

VOL. XX, 1887.

Part 1.—Annual report for 1886. Field-notes from Afghanistan: No. 4, from Turkistan to India. Physical geology of West British Garhwal; with notes on a route traverse through Jaunsar-Bawar and Tiri-Garhwal. On the geology of the Garo Hills. On some Indian image-stones. On soundings recently taken off Barren Island and Narcondam. On a character of the Talchir boulder beds. Analysis of Phosphatic Nodules from the Salt-range, Punjab.

Part 2.—The fossil vertebrata of India. On the Echinoidea of the cretaceous series of the Lower Narbada Valley, with remarks upon their geological age. Field-notes: No. 5—to accompany a geological sketch map of Afghanistan and North-eastern Khorassan. On the microscopic structure of some specimens of the Rajmahal and Deccan traps. On the Dolerite of the Chor. On the identity of the Olive series in the east with the speckled sandstone in the west of the Salt-range in the Punjab.

Part 3.—The retirement of Mr. Medlicott. Notice of J. B. Mushketoff's Geology of Russian Turkistan. Crystalline and metamorphic rocks of the Lower Himalaya, Garhwal, and Kumaun, Section I. Preliminary sketch of the geology of Simla and Jutogh. Note on the 'Lalitpur' meteorite.

Part 4.—Note on some points in Himalayan geology. Crystalline and metamorphic rocks of the Lower Himalaya, Garhwal, and Kumaun, Section II. The iron industry of the western portion of the district of Raipur. Notes on Upper Burma. Boring exploration in the Chhattisgarh coal-fields. (Second notice.) Some remarks on Pressure Metamorphism, with reference to the foliation of the Himalayan Gneissose-Granite. A list and index of papers on Himalayan Geology and Microscopic Petrology, published in the preceding volumes of the Records of the Geological Survey of India.

VOL. XXI, 1888.

Part 1.—Annual report for 1887. Crystalline and metamorphic rocks of the Lower Himalaya, Garhwal, and Kumaun, Section III. The Birds'-nest or Elephant Island, Mergui Archipelago. Memorandum on the results of an exploration of Jessalmer, with a view to the discovery of coal. A facetted pebble from the boulder bed ('speckled sandstone') of Mount Chel in the Salt-range in the Punjab. Examination of nodular stones obtained by trawling off Colombo.

Part 2.—Award of the Wollaston Gold Medal, Geological Society of London, 1888. The Dharwar System, the chief auriferous rock series in South India. On the Igneous rocks of the districts of Raipur and Balaghat, Central Provinces. On the Sangar Marg and Mehowgala coal-fields, Kashmir.

Part 3.—The Manganese Iron and Manganese Ores of Jabalpur. 'The Carboniferous Glacial Period.' The sequence and correlation of the pre-tertiary sedimentary formations of the Simla region of the Lower Himalayas.

Part 4.—On Indian fossil vertebrates. On the geology of the North-west Himalayas. On blown-sand rock sculpture. Re-discovery of Nummulites in Zanskar. On some mica-traps from Barakar and Raniganj.

VOL. XXII, 1889.

Part 1.—Annual report for 1888. The Dharwar System, the chief auriferous rock-series in South India. (Second notice.) On the Wajra Karur diamonds, and on M. Chaper's alleged discovery of diamonds in pegmatite near that place. On the generic position of the so-called Plesiosaurus Indicus. On flexible sandstone or Itacolumite, with special reference to its nature and mode of occurrence in India, and the cause of its flexibility. On Siwalik and Narbada Chelonia.

Part 2.—Note on Indian Steatite. Distorted pebbles in the Siwalik conglomerate. 'The Carboniferous Glacial Period.' Notes on Dr. W. Waagen's 'Carboniferous Glacial Period.' On the oil-fields of Twingoung and Beme, Burma. The gypsum of the Nehal Nadi, Kumaun. On some of the materials for pottery obtainable in the neighbourhood of Jabalpur and of Umaria.

Part 3.—Abstract report on the coal outcrops in the Sharigh Valley, Baluchistan. On the discovery of Trilobites by Dr. H. Warth in the Neobolus beds of the Salt-range. Geological notes. On the Cherra Poonjee coal-field, in the Khasia Hills. On a Cobaltiferous Matt from Nepál. The President of the Geological Society of London on the International Geological Congress of 1888. Tin-mining in Mergui district.

Part 4.—On the land-tortoises of the Siwaliks. On the pelvis of a ruminant from the Siwaliks. Recent assays from the Sambhar Salt-Lake in Rajputana. The Manganiferous Iron and Manganese Ores of Jabalpur. On some Palagonite-bearing raps of the Rájmahál hills and Deccan. On tin-smelting in the Malay Peninsula. Provisional index of the local distribution of important minerals, miscellaneous minerals, gem stones, and quarry stones in the Indian Empire. Part 1.

8 a

VOL. XXIII, 1890.

Part 1.—Annual report for 1889. On the Lakadong coal-fields, Jaintia Hills. On the Pectoral and pelvic girdles and skull of the Indian Dicynodonts. On certain vertebrate remains from the Nagpur district (with description of a fish-skull). Crystalline and metamorphic rocks of the Lower Himalayas, Garhwál and Kumaun, Section IV. On the bivalves of the Olive-group, Salt-range. On the mud-banks of the Travancore coast.

Part 2.—On the most favourable sites for Petroleum explorations in the Harnai district, Baluchistan. The Sapphire Mines of Kashmir. The supposed Matrix of the Diamond at Wajra Karur, Madras. The Sonapet Gold-field. Field Notes from the Shan Hills (Upper Burma). A description of some new species of Syringosphæridæ, with remarks upon their structures, &c.

Part 3.—On the Geology and Economic Resources of the Country adjoining the Sind-Pishin Railway between Sharigh and Spintangi, and of the country between it and Khattan. (With a map.) Report of a Journey through India in the winter of 1888-89, by Dr. Johannes Walther, translated from the German, by R. Bruce Foote. On the Coal-fields of Lairungao, Maosandram, and Mao-be-lar-kar, in the Khasi Hills. (With 3 plans.) Further Note on Indian Steatite. Provisional Index of the Local Distribution of Important Minerals, Miscellaneous Minerals, Gem Stones, and Quarry Stones in the Indian Empire (continued from p. 286. Vol. XXII).

Part 4.—Geological sketch of Naini Tal; with some remarks on the natural conditions governing mountain slopes. (With a map and plate.) Notes on some Fossil Indian Bird Bones. The Darjiling Coal between the Lisu and the Ramthi rivers, explored during season 1890-91. (With a map.) The Basic Eruptive Rocks of the Kadapah Area. The Deep Boring at Lucknow. Preliminary Note on the Coal Seam of the Dore Ravine, Hazara (with two plates).

VOL. XXIV, 1891.

Part 1.—Annual report for 1890. On the Geology of the Salt-Range of the Panjab, with a re-considered theory of the Origin and Age of the Salt Marl (with five plates). On Veins of Graphite in decomposed Gneiss (Laterite) in Ceylon. Extracts from the Journal of a trip to the Glaciers of the Kabru, Pandim, &c. The Salts of the Sambhar Lake in Rajputana, and of the Saline efflorescence called 'Reh' from Aligarh in the North-Western Provinces. Analysis of Dolomite from the Salt-Range, Panjab.

Part 2.—Preliminary Report on the Oil locality near Moghal Kot, in the Sheráni country, Suleiman Hills. On Mineral Oil from the Suleiman Hills. Note on the Geology of the Lushai Hills. Report on the Coal-fields in the Northern Shan States. Note on the reported Namsèka Ruby-mine in the Mainglôn State. Note on the Tourmaline (Schorl) Mines in the Mainglôn State. Note on a Salt spring near Bawgyo, Thibaw State.

Part 3.—Boring Exploration *in the* Daltongunj Coal-field, *Palamow* (with a map). *Death of* DR. P. MARTIN DUNCAN. Contributions *to the* study *of the* Pyroxenic varieties *of* Gneiss *and of the* Scapolite-bearing Rocks.

Part 4.—On a Collection of Mammalian Bones from Mongolia. Further note on the Darjeeling Coal Exploration. Notes on the Geology and Mineral Resources of Sikkim (with a map). Chemical and Physical notes on Rocks from the Salt-Range, Punjab (with two plates).

VOL. XXV, 1892.

Part 1.—Annual report for 1891. Report *on the* Geology *of* Thal Chotiáli *and part of the* Mari country (with a map and 5 plates). Petrological Notes *on the* Boulder-bed *of the* Salt Range, Punjáb, Subrecent *and* Recent Deposits *of the valley plains of* Quetta, Pishin and the Dasht-i-Bedaolat; *with appendices on the* Chamans *of* Quetta; *and the* Artesian water supply *of* Quetta *and* Pishin (with one plate).

Part 2.—Geology *of the* Saféd Kóh (with 2 plates of sections). Report *on a* Survey *of the* Jherria Coal-field (with a map and 3 section plates).

Part 3.—*Note on the* Locality *of* Indian Tscheffkinite. Geological Sketch *of the* country north of Bhamo. Preliminary Report *on the* economic resources *of the* Amber *and* Jade mines area *in* Upper Burma. Preliminary Report *on the* Iron-Ores *and* Iron-Industries *of the* Salem District. *On the* Occurrence *of* Riebeckite *in* India. Coal *on the* Great Tenasserim River, Mergui District, Lower Burma.

Part 4.—Report *on the* Oil-Springs *at* Moghal Kot *in the* Shirani Hills (with 2 plates) Second Note *on* Mineral Oil *from the* Suleiman Hills. *On a* New, Fossil, Amber-like Resin *occurring in* Burma. Preliminary notice *on the* Triassic Deposits *of the* Salt-Range.

VOL. XXVI, 1893.

Part 1.—Annual report for 1892. Notes *on the* Central Himalayas (with map and plate). Note *on the occurrence of* Jadeite *in* Upper Burma (with a map). On *the* occurrence *of* Burmite, *a new* Fossil Resin *from* Upper Burma. Report *on the* Prospecting Operations, Mergui District, 1891-92.

Part 2.—Notes *on the* earthquake *in* Balúchistán *on the* 20th December 1892 (with 2 plates). Further Note *on* Burmite, *a new amber-like fossil resin from* Upper Burma. Note *on the* Alluvial deposits *and* Subterranean water-supply *of* Rangoon (with a map).

Part 3.—On the Geology *of the* Sherani Hills (with maps and plates). On Carboniferous Fossils *from* Tenasserim (with 1 plate). *On* a deep Boring *at* Chandernagore. Note *on* Granite *in the districts of* Tavoy *and* Mergui (with a plate).

A number of the Records will be issued in the months of February, May, August, and November in each year. Each number will contain the additions to Library and donations to Museum up to the first of the next preceding month,—that is, to the end of March, June, September, and December.

Some extra copies of special papers are printed, and may be available separately.

	s.	d.		R	a.
Subscription for the year	4	0	or	2	0
Price of each Number	2	0	„	1	0

Postage, if for India, 4 annas additional.

„ „ Great Britain, 8 annas or 1s. per annum.

* Second-hand copies are sometimes available at a premium.

Apply to—

The Registrar, Geological Survey of India,

CALCUTTA.

MISCELLANEOUS PUBLICATIONS.

A Manual of the Geology of India. 4 Vols. With map. 1879-1887—
- Vol. 1. Peninsular Area. } By H. B. Medlicott, and W. T. Blanford. Price 8
- Vol. 2. Extra-Peninsular Area. } rupees (*out of print*).*
- Vol. 3. Economic Geology. By V. Ball. Price 5 rupees (*out of print*).*
- Vol. 4. Mineralogy. By F. R. Mallet. Price 2 rupees.

A Manual of the Geology of India, 2nd edition. By R. D. Oldham. (1893.) Price 8 rupees.

Popular guides to the geological collections in the Indian Museum, Calcutta—
- No. 1. Tertiary vertebrate animals. By R. Lydekker. 1879. Price 2 annas.
- No. 2. Minerals. By F. R. Mallet. (1879.) Price 2 annas.
- No. 3. Meteorites. By F. Fedden. (1880.) Price 2 annas.
- No. 4. Palæontological collections. By O. Feistmantel. (1881.) Price 2 annas.
- No. 5. Economic mineral products. By F. R. Mallet. (1883.) Price 2 annas.

Descriptive catalogue of the collection of Minerals in the Geological Museum, Calcutta. By F. R. Mallet. (1883.) Price 2 rupees.

Catalogue of the remains of Siwalik Vertebrata contained in the Geological Department of the Indian Museum. By R. Lydekker, Pt. I. Mammalia. (1885.) Price 1 rupee. Pt. II. Aves, Reptilia, and Pisces. (1886.) Price 4 annas.

Catalogue of the remains of Pleistocene and Pre-Historic Vertebrata contained in the Geological Department of the Indian Museum. By R. Lydekker. (1886.) Price 4 annas.

Catalogue of the Library of the Geological Survey of India. By W. R. Bion. (1884.) Price 1 rupee.

Bibliography of Indian Geology. By R. D. Oldham. (1888.) Price 1 rupee 8 annas.

* Second-hand copies are sometimes available at a premium.

To be had on application to the Registrar, Geological Survey of India, Calcutta, or through any Bookseller. London: Kegan, Paul, Trench, Trübner & Co.