RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

VOL. XVII, PART 2.

1884.

CONTENTS.

The RECORDS OF THE GEOLOGICAL SURVEY OF INDIA will be issued at intervals of about three months (February, May, August, November), and forwarded to subscribers—

	s. d.		Rs. 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.

ADDRESS—

Superintendent of Geological Survey of India.
Geological Survey Office, Indian Museum,
CALCUTTA.

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. The first Volume (1868) contains only 3 numbers.

[*From page 3 of Cover.*]

VOL. II, pp. XV, 363, pls. 45 (*complete*).
- „ pt. 1 (1881). Siwalik Rhinocerotidæ, by R. LYDEKKER, pp. 62, pls. 11 (1 double).
- „ „ 2 (1881). Supplement to Siwalik and Narbada Proboscidia, pp. 4 (63-66).
- „ „ 3 (1882). Siwalik and Narbada Equidæ, pp. 32 (67-98), pls. 5 (xi-xv).
- „ „ 4 (1883). Siwalik Camelopardalidæ, pp. 44, pls. 7 (1 double).
- „ „ 5 (1883). Siwalik Selenodont Suina, etc., pp. 35, pls. 3.
- „ „ 6 (1884). Siwalik and Narbada Carnivora, pp. 178, pls. 21.

Vol. III, pt. 1 (1884). Additional Siwalik Perissodactyla and Proboscidia, pp. 34, pls. 5.

(SER. VII, XIV.)—TERTIARY AND UPPER CRETACEOUS FAUNA OF WESTERN INDIA.

VOL. I, pt. 1 (1871). Tertiary Crabs from Sind and Kach, by F. STOLICZKA, pp. 16, pls. 5.
- „ „ 1 (new 2) (1880). Sind Fossil Corals and Alcyonaria, by P. MARTIN DUNCAN, pp. 110, pls. 28.
- „ „ 3. The Fossil Echinoidea of Sind, by P. MARTIN DUNCAN and W. PERCY SLADEN: *Fas. 1* (1882). The *Cardita beaumonti* beds, pp. 20, pls. 4. *Fas. 2* (1882). The Ranikot Series in Western Sind, pp. 80, pls. 16.
- „ „ 4 (1883). The Fossil Echinoidea of Kachh and Kattywar, by P. Martin Duncan and W. Percy Sladen, pp. 91, pls. 1—13.

(SER. XIII.)—SALT-RANGE FOSSILS, BY WILLIAM WAAGEN, PH.D.

I. Productus-Limestone Group: 1 (1879). Pisces, Cephalopoda, pp. 72, pls. 6.
- „ „ 2 (1880). Gasteropoda 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, *fas. 1* (1882). Brachiopoda, pp. 62 (329-390), pls. 4 (xxv-xxviii).
- „ „ 4, *fas. 2* (1883). Brachiopoda, pp. 156 (391-546), pls. 21 (xxix-xlix).

The price fixed for these publications is 4 annas (6 pence) per single plate.

To be had at the Geological Survey Office, Indian Museum, Calcutta; or through any Bookseller. London: Trübner & Co.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1884. [May.

Note on the Earthquake *of 31st December 1881, by* R. D. Oldham, A.R.S.M., *Geological Survey of India.* (With a map.)

On the morning of the 31st December 1881 a severe earthquake was felt over a large portion of the Indian peninsula and Bengal, affecting also the Burmese coast and causing much damage in the Andaman and Nicobar islands. A considerable amount of material, comprising newspaper extracts, official reports and private letters, having been placed at my disposal, I propose giving a brief notice of the more important features of the shock.

In Bengal it was felt as far as Chunar (?), Gaya, and Hazaribagh; Akra, in the 24-Parganas, was shaken; and at Akyab it was followed by the eruption of a mud volcano in Ramri.[1] There is no record of its having been felt at Rangoon or Moulmein; at Tenasserim it is doubtful, though it was felt in the Mergui archipelago; to the south it is reported as having been 'severe' at Acheen in Sumatra, and in N. Lat. 3° 54′, E. Long. 91° 21′ it was felt by the ship *Mount Stuart;* at Ootacamund it is recorded, as also at Calicut: thus the area over which it was felt measures about 1,600 miles from north to south and 1,500 miles from east to west, or 2,000,000 square miles in all.

Such briefly is the summary of the information contained in the daily papers, and as no observation of scientific value is recorded in them which has not been placed at my disposal in another form, I shall refrain from repeating the vague, when not misleading, statements of the time and nature of the shock which were so given to the world.[2]

There is, however, one published notice which contains much valuable information. I refer to the note by General Walker, and Major M. W. Rogers, R.E. (originally published in the Annual Report of the Trigonometrical Survey, and

[1] Records, G. S. I., Vol. XV, p. 141.

[2] I may, however, mention one letter by Mr. W. G. Simmons of Calcutta published in the *Indian Daily News.* He seems to have been at some trouble to collect information, and I have to thank him for liberally placing it at my disposal.

reprinted in the Proceedings of the Asiatic Society of Bengal, March 1883, page 60) on the records left by the earthquake, and its consequent sea-wave on the tidal gauges fixed along the shores of the Bay of Bengal, illustrated by reductions from the original records and a chart of the Bay of Bengal, on which Major Rogers has marked what he considered to be the focus of the disturbance. For the benefit of those who may not have access to the original, I subjoin a short abstract of the information contained.

At Port Blair, the forced sea-wave, indicating the arrival of the earth-wave, is indicated at 7*h*. 44′;[1] the first sea-wave arrived at 8*h*. 3′, followed by others at 15 minutes interval, with a height of 3 feet from crest to hollow, the disturbance not subsiding entirely till 21*h*.

Diamond Harbour.—Sea-wave hardly perceptible; arrived at 15*h*. 10.′

Dablat.—First sea-wave at 13*h*.; disturbance continued till 21*h*.

False Point.—Forced sea-wave at 7*h*. 54′. Sea-waves small; the first arrived at 11*h*. 15.′

Vizagapatam.—The sea-wave arrived at 10*h*. 43′, followed by others until midnight.

Madras.—Sea-wave arrived at 10*h*. 18.′

Negapatam.—The first wave, which arrived at 10*h*. 15′, measured 4 feet from crest to hollow, and was followed by others until midnight.

Paumben.—First wave at 11*h*. 32′; disturbance lasted till midnight.

At Calcutta the time of arrival of the earthquake was noted by Mr. James Murray, who writes, in reply to my enquiries, that he was reading in an upstairs room when feeling the shock he immediately ran downstairs and marked on the glass of his standard regulating clock the exact position of the second's hand and then waited to note the time of cessation of the motion; afterwards he carefully took with a second's watch the time that it occupied to do all he had done between the moment when he first felt the shock and when he made the mark on the glass of his clock, adding this and the error of the clock on that morning, he obtained the times of commencement and cessation as 7*h*. 37′ 45″ and 7*h*. 42′ 0″, Calcutta mean time, or 7*h*. 55′ 2″ and 7*h*. 59′ 17″ Port Blair mean time, respectively. This, I may add, is the only observation of real value made at the time and not automatically recorded that I know of in connection with this shock.

At Madras a clock in the office of the Master Attendant, electrically controlled from the astronomical observatory, was stopped at 7*h*. 5′ 45″ local time, or 7*h*. 55′ 36″ Port Blair mean time.

Port Blair is the only place where any damage was done to masonry buildings, and it is to be regretted that the damage should be so little instructive as is the case. The infantry barrack, of which I have drawings showing the damage done, is a long, narrow building situated on the crest of a hill, the major axis bearing N. 20° E., while the cross-walls bear E. 20° S. The latter were severely cracked, while with a single exception not a crack has opened in the longitudinal walls; this might indicate a direction nearly N. 20° E. or S. 20° W., but

[1] These times differ from those originally given, having been retaken with greater care from the original records. The times here and throughout this notice are reduced to Port Blair mean time, and for the sea-wave are the time of arrival of the crest of the first wave.

is most probably, as will be seen from the sequel, due to their being of less solid construction. As regards the angle of emergence the cracks do not indicate much, merely pointing to a nearly horizontal or nearly vertical emergence; the former would be indicated by the fact that a chimney shaft 60 feet high was cracked but not overthrown as it certainly must have been by a severe shock with a moderate angle of emergence, but as this supposition is irreconcileable with the position of the seismic vertical obtained from more trustworthy observations we must suppose the angle of emergence to have been nearly horizontal and the violence of the shock to have been considerably exaggerated.

In the Car Nicobar extensive damage was done to the cocoanut groves and huts of the natives, and vents similar to those described in connection with the Cachar earthquake of 1869[1] were opened in the sandy soil. It was noted by Major W. B. Birch, to whose report I am indebted for the facts, that on the margin of the seashore the trees were left standing, while further inland they were overthrown. This may have been due to the fact that the edge of the land was protected from the earthquake by the slope of the seaward face being steeper than that of the emergence of the wave but I am inclined to believe that Major Birch's suggestion, that the soil near the sea margin is firmer than that further inland, is more likely to be the true explanation. The sea-wave broke on this island and it is recorded that the water penetrated into the houses of the Burmese residents which stood on platforms of less than 2½ feet high, while those on higher platforms escaped.

I will now proceed to the discussion of the data available, which are, *firstly*, the records of the arrival of the earth-wave at Calcutta, Madras, False Point, Port Blair, and Kisseraing; and, *secondly*, the records of the arrival of the sea-wave at the stations mentioned above; the latter, however, are owing to irregularities in the depth of the Bay of Bengal of no use in determining the position of the seismic vertical. Of the first category, the records from Madras and Calcutta are undoubtedly good, those from Port Blair and False Point are good as far as they go, but only pretend to give the time to the nearest minute, while the fifth is, as will be subsequently shown, unfortunately open to an element of doubt.

It has been pointed out by Professor Milne that if the earth-wave arrives at two points on the earth's surface at the same moment of absolute time and a straight line be drawn joining those two points, the seismic vertical should lie somewhere on the line bisecting it at right angles, supposing, that is to say, that the surface of the earth were a plane and its substance homogeneous; on the same suppositions if the time of arrival is known at three stations and circles be drawn round the two at which the arrival was latest with radii equal to the distance traversed by the wave in the respective absolute differences of time between its arrival at those stations and at the first station, and a circle be drawn passing through the first station and touching the circles drawn round the second and third stations, the centre of that circle will represent the position of the seismic vertical. Neither of the assumptions are, of course, theoretically correct, but these constructions give a rapid and convenient method of finding the approximate position

[1] Memoirs, G. S. I., Vol. XIX, part I.

of the seismic vertical. I have, for the purposes of the first construction, taken the time of arrival at Calcutta and Madras as identical and represented it on the map by fine firm lines; the second construction is not represented, but the centres obtained are indicated by dots with the letters C. M. B. for the centre deduced from the Calcutta, Madras, and Port Blair observations, and F. M. B. for that due to those at False Point, Madras, and Port Blair. It will be seen that the first-named lies within 30 miles of the true position of the seismic vertical, the error being due almost entirely to the unavoidable distortion of the map; the other shows a greater error, due partly to a less average accuracy of the observations and partly to the fact that the stations are less favourably situated for applying the construction. Taking Calcutta, False Point, and Port Blair, we get an impossible centre at the mouth of the Irrawadi, the fact being that this construction is only practically applicable when the three stations form a pretty open triangle. The Madras, False Point, and Kisseraing observations give the centre where Major Rogers placed it, but this result is vitiated both by the small inaccuracy of the False Point observation and the greater one at Kisseraing, which will be referred to hereafter.

Starting with the C. M. B. centre, a brief investigation proves it to be about 30 miles too far south; so taking Lat. 15° Long. 89° as the centre provisionally, we find that the geodetic distance from this point to

	Feet.
Port Blair is	1,804,475
Calcutta is	3,117,585
False Point is	2,888,620
Madras is	3,177,850
Kisseraing is	3,563,660

Subtracting the distance to Port Blair and dividing the results by the respective differences of time, we get a velocity of transit as between Port Blair and

	Feet per second.
Calcutta of	1,957
Madras of	1,948
False Point of	1,807
Kisseraing of	2,666

and as between Calcutta and Madras of 1,746 feet per second—a not impossible result, as the difference of distance would lie mainly in alluvial deposits, though possibly indicates that the centre is about half a mile east of the position assumed.

The low velocity as between Port Blair and False Point is easily explicable by the fact that the observations are only given to the nearest minute; had the time interval been 9 minutes instead of 10 minutes, it would give a velocity of 2,001 feet per second, while an interval of 9½ minutes would bring it almost into accord with the Calcutta and Madras observations. From this we may conclude that the time recorded at Port Blair is too early, or that at False Point too late, or possibly both. It must be borne in mind that the times were taken from the trace left by a pencil on a sheet of paper and on a scale on which it would be difficult to distinguish between, say, 7*h*. 53′ 15″ and 7*h*. 53′ 45″, though one should be recorded to the nearest minute as 7*h*. 53′ and the other as 7*h*. 54′.

The Kisseraing observation, however, gives a velocity which is inexplicable on this supposition, and I cannot but consider the error due to an actual error of observation, as, though it can be approximately reconciled with those from the western stations, this can only be done by taking the latter out of accord with each other and giving an inadmissibly high velocity to the whole series. The only published record of this observation is that in Major Roger's note, where he says that "at Madras, False Point, and Kisseraing the shock was felt at about the same minute—7*h.*·55′ A.M.;" it will be seen that this is rather vague, and a personal application to Major Rogers elicited the fact that the original record had been destroyed, and it was consequently no longer possible to estimate the degree of accuracy of the time record. I fear we must reject this observation as of insufficient accuracy for the purposes of the investigation.

The position assumed above proves to be that which best reconciles itself to the excellent observations at Calcutta and Madras, and to the automatic records at Port Blair and in a less degree False Point; I shall consequently consider that the shock did originate vertically below a point situated in Lat. 15° N., and Long. 89° E., and that it travelled with a velocity of 1,950 feet per second, being that indicated by the Madras and Calcutta and Port Blair observations. Under these circumstances the time taken by the earth-wave to travel from the seismic vertical to

Port Blair would be	15′ 25″
Calcutta "	26′ 39″
Madras "	27′ 9″

(I omit Kisseraing and False Point owing to probable inaccuracies of the records.)

Subtracting these intervals from the recorded times, we have the Port Blair mean time of the origin of the earthquake deduced from the

Port Blair record as	7*h.* 28′ 35″
Calcutta " "	7*h.* 28′ 23″
Madras " "	7*h.* 28′ 27″
Mean	7*h.* 28′ 28″

But as the Port Blair record is liable to an unknown error being merely to the nearest minute, the mean of the Calcutta and Madras results, *viz.*, 7*h.* 28′ 25″, is probably more accurate. Taking this result and reckoning back to the various stations we get the true time at

Port Blair,	7*h.* 43′ 50″	instead of	7*h.* 44′, a probable error of	+10″
False Point,	7*h.* 53′ 6″	"	7*h.* 54′ " "	+54″
Kisseraing,	7*h.* 58′ 58″	"	7*h.* 55′ " "	—3′ 58″

The depth of the focus below the level of the sea cannot unfortunately be ascertained, the only records that could give the angle of emergence being from Port Blair and, as mentioned above, they are indefinite, and all we can say is that the emergence was nearly horizontal; from this we would deduce a focus situated at a small depth, probably about 5 or 10 miles, and being improbably over 15 miles from the surface.

In the shape of the area over which the shock was felt there is a notable peculiarity as regards its eastern boundary between Akyab and Tenasserim, which seems to be real and not merely due to insufficient information, for Rangoon and Moulmein are large cities with a considerable resident European population, so that the shock if felt could hardly have escaped record.[1] In the Mergui archipelago it is recorded as slight, and it is very doubtful whether it was felt at Tenasserim. To the south, west, and north the configuration is very different; the shock is recorded as severe at Acheen; it was felt by the ship *Mount Stuart* in N. Lat. 3° 54′ E. Long. 91° 21′; to the west it was felt at Calicut; and to the north is said to have been felt at Chunar, though Gaya is possibly the extreme limit. This peculiarity may in part be due to a difference in the rocks traversed, but not being fully accounted for in that manner clearly indicates that the shock had its origin in a fissure underlying strongly to the west. If we accepted the Chunar record, it would almost be necessary to suppose the fissure curved and bending round from about S.-W. to S.-E, rejecting it we come to the conclusion that this earthquake had its origin in a straight, or nearly straight, fissure bearing about N.-W. and S.-E. and underlying to the S.-W., a far more probable configuration than the first, and one which is not absolutely incompatible with the Chunar record, if that is correct.

When we come to examine the records of the tide gauges the first point to be noticed is the absence of any record from the stations on the Burmese coast, while the wave is shown to have reached points on the western coast of the Bay situated at a greater distance from the centre. This, however, ceases to be remarkable when we examine the records from the stations on the delta of the Ganges. At Dablat the height of the wave is 12 inches, while at False Point it is but 2 inches, and merely perceptible at Diamond Harbour; if on the delta of the Ganges, exposed to the full force of the wave, the mere shoaling of the waters produced such an effect, it is not surprising that a similar shoaling at the mouth of the Irrawadi should have entirely destroyed the wave already enfeebled by the barrier stretching between Cape Negrais and the Andaman islands.

Between the centre and Port Blair the wave must have travelled by a circuitous route, and as it is impossible to say what allowance is to be made for this it becomes impracticable to correctly calculate the rate at which it travelled. In all probability the first wave recorded came round the south of the island, while the curve bears ample evidence that the subsequent long-continued and complicated disturbance was due to the interference of the two sets of waves—one travelling from the north, the other from the south.

Taking, for convenience of calculation, the time of origin of the wave as 7*h*. 28′ 30″, the error so introduced being comparatively insignificant, and in any case certainly not greater than that due to want of accuracy in the records, we find that the mean rate of transit of the wave between the centre and

		Feet per second.
Paumben	is	281
Negapatam	„	359
Madras	„	311
Vizagapatam	„	173
False Point	„	213
Dablat	„	104

[1] As this note was passing through the press a paper on 'Earthquake disturbances of the Tides on the coasts of India,' by Lieutenant-General J. T. Walker, C.B., F.R.S., etc., appeared in 'Nature,' February 14th, in which it is incidentally mentioned that the earthquake w felt at Rangoon and Moulmein.

Of these, the difference between the mean rates to Negapatam and Paumben is due to the long stretch of shallow water crossed in the latter case; but the difference between Madras and Negapatam is noticeable, and is probably due to the shallowing of the bay by the deposit in it of the silt brought down by the Kistna and Godavery rivers; this same cause has evidently affected the velocity between the centre and Vizagapatam, while the increase in velocity between the centre and False Point indicates that the wave has travelled over the depression between the two banks caused by the deposit from the Kistna and Godavery on the one hand and the Ganges and Brahmaputra on the other.

This notice, besides its direct bearing on the earthquake in question, shows the great value of a few really accurate time observations which, taken in conjunction with such simple observations as are within the power of all to make, have enabled me to fix the position of the seismic vertical, the velocity of transmission of the earth-wave, and the approximate form of the focus; had it originated inland there might not improbably have been sufficient information available to fix the depth of the focus—in the present state of our knowledge, one of the most important, if not the most important point to be determined with some degree of accuracy. Under these circumstances it is unfortunate that in the system of seismological observations recently sanctioned by Government an accurate determination of the time could not be incorporated, but with the unskilled even where not unsympathetic observers who are alone, as a rule, available, it would be impossible to secure that accuracy of record which alone would be of use; for this is especially a case where an inaccuracy, where accuracy is looked for, is worse than no record at all.

The following facts, though not strictly related to the earthquake under consideration, may with advantage be put on record here.

The master of the ship *Commonwealth* reported that he felt three shocks of earthquake on the 1st January 1882 in N. Lat. 8° 20′, E. Long. 92° 42′, and that the whole of the Car Nicobar was hidden by smoke. Major Birch on his subsequent visit to the island could find no foundation for this statement, so that in all probability it was only the smoke of a fire that was seen.

This shock was stated in the daily papers to have been felt at Khatmandu, in Nepal; but to judge from the more detailed information placed at my disposal, this cannot have been the same shock.

On the Microscopic structure *of some* Himalayan granites *and* gneissose granites, *by* COLONEL C. A. MCMAHON, F.G.S. (With a Plate.)

In my paper "On the microscopic structure of some Dalhousie rocks,"[1] I have already given an account of the structure of the gneissose granite of Dainkund, Dalhousie. This paper is occupied with a description of the "outer band" of gneissose granite at Dalhousie, called gneiss in my previous papers, and of gneissose granite found in the Sutlej valley, and in the Chor mountain near Simla. I have also, for the sake of comparison, described the microscopic structure of some

[1] Records, Vol. XVI, p. 129.

undoubtedly eruptive granites, which invade silurian and cambrian (?) rocks in the Ravi and Sutlej valleys.

In this paper I propose to follow my usual custom, and begin with a somewhat detailed account of the several specimens, and conclude with some general remarks by way of summing up the results of my investigation.

1. Granite intrusive in the schists above Darwás, from a dyke on the road between Darwás and Kilar, Pángi valley, Chamba.[1] The hand specimen shows the junction of the granite and the mica schists. A parallelism of structure, evidently due to traction, is, to a certain extent, observable in the granite. Schorl is abundant in the hand specimen, but none occurs in the slice.

M.—Quartz, orthoclase, and a silvery mica, are abundant, and there is a little triclinic felspar.

The quartz is hyaline, and contains a prodigious number of liquid cavities. Most of the orthoclase is white and opaque. The slice contains a large garnet of decidedly pink colour in transmitted light; part of it is decomposed. There are several belonites, but they do not contain any shrinkage cavities.

Viewed macroscopically, the mica is of a brilliant silvery metallic lustre, but under the microscope it is dull, and shows no colours under the polariscope.

Nos. 2, 3, and 4.—Granite intrusive in quartzite and in schistose rocks at Leo, on the Spiti river. It occurs in dykes and veins varying in thickness from 30 feet to a fraction of an inch, and penetrates the rocks in all directions. (See Records, Vol. XII, p. 60.)

2. A fine-grained granite.

3. A medium-grained granite. Muscovite having a brilliant silvery lustre is very prominent. Schorl is not visible to the naked eye. The felspar is of dull white colour, differing little in tint from the quartz. A pink garnet is visible in the hand specimen.

4. A fine-grained granite. Scarcely any muscovite is to be seen with a lens, but well-crystallised minute prisms of schorl are very abundant, and give the rock a speckled appearance.

M.—The quartz in these specimens is almost wholly of polysynthetic structure, similar to the "fish roe" quartz of the Dalhousie gneissose granite. It contains liquid cavities with movable bubbles, though not in great abundance.

Orthoclase and plagioclase are both present, and, apparently, in nearly equal quantities. The twinning is very fine, the lamellæ being extremely thin. In some crystals they are slightly curved out of the perpendicular; in other felspars cracks have been formed subsequent to the twinning, and have been filled with quartz; whilst in one instance the twinning has been faulted by a diagonal fracture. All these circumstances seem to indicate conditions of strain connected with the intrusion of the granite into the sedimentary rocks.

Muscovite is abundant in all the specimens, and in all it polarizes in delicate colours, but with extreme brilliancy, as in the Dalhousie gneissose granite. All the slices contain schorl, garnets, and a little green mica. In No. 3, the schorl and garnets are in strings, having a common direction, the result doubtless of traction. The garnets contain enclosures with fixed bubbles, and one of the en-

[1] Records, Vol. XIV, p 308.

closures is apparently a "stone cavity." Quartz enclosures are common in the schorl.

Neither magnetite nor ilmenite is present, but red ferruginous stains are not uncommon.

Nos. 5 to 12.—Granite from the cliffs above Jángí, Sutlej valley. I have described the mode in which the granite occurs in previous papers (Records, Vol. X, p. 221; Vol. XII, p. 57). The result of its study in the field on two occasions left no doubt in my mind of its intrusive character. The rock is white and fine-grained, and is composed of quartz, felspar, and biotite.

M.—Quartz is more abundant than felspar, but not notably so. Plagioclase is sparse, and is very subordinate to the orthoclase. All the slices contain microcline, except No. 7.

Garnets are present, but they are very small; some of them contain liquid cavities with extremely minute movable bubbles.

Biotite is plentiful; it occurs in large groups, in which the folia are oriented in all directions and the basal cleavage is strongly developed, and also in the form of minute rounded or hexagonal-shaped microliths scattered abundantly through the ground mass. Elongated microliths of it are also present, but they are not so numerous. It is of rich brown-green and green-brown colour in transmitted, and deep black in reflected, light.

Except in the form of microliths, muscovite is extremely scarce. The only piece of any size occurs imbedded in a group of biotite. Thousands of microliths of this mica are crowded together in many of the felspars in a way exactly similar to that described in my paper on the gneissose granites of Dalhousie.[1] At times, they are scattered about in a promiscuous manner; at others, they conform to the direction of the cleavage planes of the felspar.

In the slices of the Jángi granite under consideration, and in the gneissose granite of the Sutlej valley generally, these muscovite microliths—for such I take them to be—frequently assume very curious combinations, imitative or suggestive of organic structures, the result, I apprehend, of the imperfect development or arrested crystallisation of these microliths. At fig. 9 I have sketched a dendritic combination that occurs in one of the slices.

At fig. 10 I have given a sketch of crystals formed within a crystal ("stone enclosure") with a contraction bubble, due to shrinkage on cooling. This illustration is taken from slice No. 8. As the Jángi granite is undoubtedly an eruptive rock intrusive in the schists in which it occurs, it is interesting to compare the enclosures contained in it with those of rocks whose eruptive character is more doubtful.

Figs. 11, 12, and 13 are sketches of microscopic crystals (greatly enlarged) found in slice No. 7, which are typical of the kinds of enclosures not uncommon in the granites and gneissose granites of the Sutlej valley. No. 11 contains numerous cavities with contraction bubbles in them. No. 12 encloses stone cavities, or crystals, with bubbles in them, and gas cavities; whilst No. 13 contains cavities and crystals, one of the former of which holds a nearly rectangular crystal. The crack observable in No. 11 is probably due to shrinkage on cooling. Enclo-

[1] Records, Vol. XVI, p. 131.

sures, such as those depicted, are characteristic of igneous rocks; they show that the mass which contains them was subjected to great heat and was reduced to a more or less fluid or plastic condition; that the crystals under observation contracted on cooling, and that they either caught up the micro-crystals and the fluids and gasses now enclosed in them in the act of crystallisation, or that the mineral matter at the time of consolidation deposited these endo-crystals, and the fluid and gas, held in solution, or occluded in it, when at a high temperature.

No. 13.—Granite from a dyke near Rárang. Sutlej valley. This dyke (Records, Vol. X, p. 221) is about 300 or 400 feet wide, and cuts through thin-bedded mica schists up to the crest of the ridge, sending out large lateral veins into the schists. It is a very fine-grained rock, of much darker colour than the last, owing to the abundance of biotite present in it. The felspar is very glassy looking, and much resembles quartz in colour and aspect. A parallelism in the arrangement of the biotite, resembling incipient foliation, is, to a certain extent, observable.

M.—Quartz predominates over the felspar, and orthoclase is very subordinate to plagioclase. The slice contains no muscovite, except in the form of microliths. There are a few small garnets. In general characteristics this rock much resembles the Jángi granite, and doubtless it is only a variety of it.

The quartz contains numerous liquid cavities. The great majority of them are without bubbles; others have fixed bubbles and some few movable bubbles. A flattened variety of liquid cavity, with a fixed bubble, is common.

Several of the microliths have elongated shrinkage cavities or bubbles.

No. 14.—Granite from the centre of a dyke intrusive in mica schists at Pángi, Sutlej valley.[1] A fine-grained white granite, containing white felspar quartz, muscovite, biotite, and schorl. The muscovite is in hexagonal-shaped packets.

M.—Quartz is decidedly subordinate to felspar; plagioclase to orthoclase, and biotite to muscovite. Schorl and garnets are present. The muscovite is well crystallised and is in hexagonal plates. The cleavage of both muscovite and biotite is strongly developed, and some of the biotite is enclosed in muscovite.

The felspar is free from microliths of muscovite and biotite. A little microcline is present.

One of the garnets—or what I doubt not is a garnet—exhibits double refraction. It is colourless in transmitted light, and is evidently unaltered, so that the double refraction is not due to alteration. The garnet is also too large, and the slice is too thin to admit of the supposition that the section of the mineral under examination is superimposed on a slice of quartz or felspar, so its abnormal behaviour between crossed nicols cannot be attributed to the intervention of a doubly refractive medium. I have sometimes observed the peculiarity now noted in garnets in the gneissose granites, though the double refraction is usually very feeble.

One variety of garnet, colophonite, is said to exhibit double refraction; and, *vide* E. S. Dana's Appendix III, page 50, garnets are considered pseudo-isometric, and are referred to the triclinic system by Mallard and Bertrand. But may not

[1] Records, Vol. X, p. 221.

the occasional and generally very feeble double refraction of some of the garnets of the granites and gneissose granites of the North-West Himalayas be due to strain and be simply one of the results of pressure consequent on intrusion? It is well known that glass subjected to strain exhibits double refraction.

Liquid cavities, with fixed and movable bubbles, are abundant. The bubbles are of good size, and for the most part cover about half the area of the cavity, indicating a condition of very great heat and great subsequent contraction on cooling. The whole aspect of the rock shows that the granite, when injected into the schists, was in a completely fused or fluid condition, and cooled slowly, hence the perfectly crystalline condition of its component minerals.

No. 15.—Granite from another large dyke: Pángi, Bassáhir. Similar dykes are rather numerous in the gneissose granite between Wangtu and Pángi. Muscovite is plentiful, and a dark-green mica is rather abundant. Schorl is present in some quantity. The felspar assumes a green appearance here and there, owing apparently to the deposit of a thin superficial film of chlorite.

M.—Orthoclase is more abundant than quartz. Plagioclase is present, but in very small quantity. The double refraction of the muscovite is so great that the thinnest sections of it only show the feeblest colours in polarized light. The basal cleavage lines of the green mica are well developed in some sections. Mica is not present in the form of microliths.

Liquid cavities with movable bubbles are extremely numerous both in the quartz and in the felspar. As in the last specimen, the bubbles are large relatively to the size of the cavities, and they are remarkably lively. Much of the felspar is opaque owing to the abundance of the enclosures in it, partly liquid and partly unresolvable ones. The slice contains gas cavities, but they are not abundant. I cannot call to mind any rock in which liquid cavities are more abundant than in this specimen. I have not observed a single microlith in this slice.

As in the last rock described, this granite was evidently subjected to intense heat, and reduced by igneo-aqueous action to a fused condition and subsequently cooled slowly.

Nos. 16 to 19.—Gneissose granite: Wangtu[1] Sutlej valley, Bassáhir. These specimens contain an abundance of very black biotite, in the arrangement of which parallelism of structure is very distinct.

M.—In these slices orthoclase largely predominates over the plagioclase; whilst quartz and felspar are present in about equal proportions. Biotite and muscovite are both present; the former predominates in leaves of other than microscopic size, but the muscovite is abundant in micro-crystalline agglomerations in the form of microliths in the felspar, as described in the Jángi granite, slices 5—8.

The dendritic combinations described in connection with the Jángi granite occur in these slices, and fig. 9 is taken from one of them.

The quartz in these slices occurs in grains of moderate size, and also in fish roe grains, the latter showing a decided tendency to assume hexagonal outlines.

[1] A brief allusion to the rocks at Wangtu is contained in my paper in the 10th Volume of Records, pp. 218, 219.

The quartz contains numerous liquid cavities with bubbles, some of which are movable. Much of the felspar is very opaque; but in some the intersection of the basal and clino-diagonal cleavage planes is well seen.

This rock has all the appearance under the microscope of an ordinary granite of eruptive origin.

Nos. 20 and 21.—Granite from the neighbourhood of Wangtu.

M.—Plagioclase is the predominating felspar, though orthoclase is also present.

Microcline is abundant and is of typical character. In slice No. 14 one of the crystals is of large size. The orthoclase and microcline taken together, equal, or nearly equal, the plagioclase.

Schorl is abundant, and contains numerous inclusions of quartz. Biotite and muscovite are present, but in small quantities. The quartz is very subordinate in amount to the felspar.

Liquid cavities with movable bubbles abound in the quartz, and I have observed some with fixed bubbles in the felspar. The bubbles are of good size, and the area of the cavities appears, at a rough guess, to be about two and a half times that of the bubbles contained in them.

The quartz enclosed in the schorl contains liquid cavities with movable bubbles, whilst the schorl itself contains cavities with fixed bubbles. There are some microliths containing what appear to be shrinkage cavities in them.

Beryl from a granite dyke near Wangtu, Sutlej Valley.—I have beryl taken from a granite dyke which is intrusive in the gneissose granite at Wangtu enclosed in quartz, in felspar, and in muscovite, and it is therefore clear that beryl was the first mineral to crystallise. An examination of thin slices of the beryl under the microscope is particularly interesting, as it enables us to ascertain the condition of the fused mass at an early stage of cooling before the quartz, felspar, and muscovite had begun to crystallise.

The examination of these slices shows that the magma must have been in a fluid state, and that a considerable amount of heated gas, water, and carbon dioxide were intimately blended with it in a superheated condition when the beryl crystallised.

The number of enclosures containing bubbles to be seen in these slices is quite extraordinary. The enclosures are of various shapes; some are hexagonal, others are more or less round or of very irregular shapes. The bubbles, as a rule, occupy about half the area of the cavities which contain them. Some of the bubbles are movable, but the great majority of them are stationary. Many of the lacunæ are full of liquid, whilst others contain gas, which in many cases has contracted on cooling. Some liquid cavities contain globules of liquid carbon dioxide with enclosed vacuum bubbles—bubbles within bubbles—the inner bubbles being movable and in some cases remarkably lively. There seems to be no doubt of the larger bubble being carbon dioxide, as the inner bubble disappears when a piece of heated iron is brought near it and re-appears on cooling.

The beryl also contains some good "stone cavities" with fixed bubbles, that is to say, enclosures in which a stony base has deposited crystalline matter on cooling.

Nos. 22 to 25.—Gneissose granite at Chora between Sarhan and Taranda, Sutlej valley. The extreme whiteness of the felspar is in strong contrast with the blackness of the biotite, which is abundant. A parallelism of structure in the arrangement of the biotite is, to a certain extent, observable in the hand specimen.

M.—Orthoclase and quartz are probably about equal in amount; plagioclase is also present, but is subordinate; schorl is very abundant, it is in large irregularly shaped pieces, and encloses rather large grains of quartz. The slice also contains muscovite, biotite, and garnet. The biotite and muscovite are for the most part linked together in tortuous strings; leaves of the one occasionally alternating with the other species of mica: micro-garnets, and rounded microliths of biotite are scattered rather freely through the slice.

Gas cavities are abundant, and there are good liquid cavities with movable bubbles. The flat type of liquid cavities is also common.

The slice contains numerous stone enclosures that have deposited dusty matter on cooling. One of these, depicted at figure 5, has been fractured; the fractures being probably due to contraction on cooling, and the subsequent dislocation to a tremulous movement of the viscid matrix. In other cases, instances of which are depicted at figures 6 and 7, these stone enclosures, or crystals, have either deposited minute endo-crystals on cooling, or have in the process of their own crystallisation caught up previously formed microliths and held them in their embrace during consolidation.

In either case, the instances illustrated at figs. 5, 6, and 7 show that the rock was, at one stage in its history, in a more or less liquid or fused condition.

At fig. 8 I have given another illustration from those slices, in which minute crystals are contained in another crystal, which is itself caught up in, or was deposited from, a stone enclosure.

The size of the bubbles in the liquid lacunæ relatively to the area of the cavities varies considerably, but I should think on the average the cavities cover an area of from two and a half to three times that of the bubbles.

Nos. 26 to 30.—Gneissose granite between Kalog and Báli, Sutlej valley. On the high level road, now fallen to ruin, between Nakanda and Rámpur.

M.—These slices contain some cavities that have deposited stony material, enclosures with fixed bubbles in them and microliths that contain cracks which have evidently resulted from shrinkage on cooling.

Nos. 31 to 33.—Gneissose granite from the Kot peak above the Bági road, described at Vol. X, p. 217, Records.

M.—This rock has all the appearance of a true granite under the microscope. Orthoclase and plagioclase are both present—the latter in some abundance. Biotite and muscovite are plentiful. Quartz is subordinate to the felspar.

Muscovite is present in the form of well-cleaved folia and also as microliths, the latter being very abundant. Biotite also occurs in large microscopic leaves grouped together, and in small rounded isolated ones of microscopic size scattered through the ground mass.

Long, attenuated, colourless microliths, often bent and broken, are present in considerable abundance, and appear to be imperfectly developed apatite.

Opacite occurs in some quantity; sometimes it is attached to microliths and at others is caught up inside them, in both cases being very similar to those described in my paper on the lavas of Aden. See figs. 4, 6, 11, 12, and 13 of the plate illustrating that paper. Records, Vol. XVI, p. 158.

Some microliths contain what appear to be shrinkage cavities and enclosed micro-crystals. One of the former is undoubtedly due to shrinkage on cooling, as it runs the length of the microlith and conforms to its shape. The illustration given at (*a*) of fig. 11 of the last-quoted paper applies equally to the microliths now described.

The quartz contains liquid cavities with movable bubbles, but they are not very abundant. It also contains elongated prismatic enclosures that have deposited dusty matter on cooling.

Slice 23 contains some minute prisms of schorl and some hæmatite or göthite.

Nos. 34 to 50.—Gneissose granite, Bági road. All that needs to be noted regarding these specimens is that they contain liquid cavities with movable bubbles, numerous microliths with fixed bubbles and elongated shrinkage cavities, running with the length of the microlith; and microliths cracked through shrinkage and fractured owing to a tremulous movement in the viscid matrix. These microliths have either caught up opacite at the time of formation or have deposited it on cooling, and they have opacite granules attached to them, in both cases resembling those described under Nos. 31 to 33, and which have been compared with similar bodies in the Aden lavas.

No. 51.—A dark porphyritic gneiss, from the flank of Hattu, between Hattu and Nakanda. There is a small outcrop at about the same elevation as the Nakanda travellers' bungalow. The gneiss contains small felspar "eyes" and large rectangular crystals of orthoclase.

M.—This is, I think, a metamorphic rock. It is composed of quartz in minute granules, orthoclase, a few crystals of plagioclase, and countless leaves of a dark greenish-brown mica. There is complete parallelism of structure, and all the leaves of mica not only point in the same direction, but their optical orientation is perfectly homogeneous, and when the slice is revolved under a single nicol, extinction is simultaneous in all the leaves.

Some colourless mica and some garnets are present, and countless crystals and granules of epidote. There are no liquid cavities with bubbles.

Nos. 52 and 53.—From the summit of Hattu. These specimens would, if their macroscopical appearance alone were considered, be classed as ordinary and very typical gneiss.

The felspar is present in the form of eyes, and in elongated masses or strings of eyes, and occasionally in more rectangular crystals. Many of the eyes exhibit carlsbad twinning, the twinning plane coinciding with the longest diameter of the eye. The matrix is strongly foliated, lines of dark mica curving round the felspar crystals. The cleavage planes of the rock sparkle with minute facets of mica.

M.—Quartz predominates over the felspar and plagioclase is sparse. A large crystal of orthoclase is twinned on the carlsbad type, and in one twin an intergrowth of plagioclase has taken place.

The leaves of muscovite and biotite exhibit a strong tendency to arrange themselves in strings which flow round the porphyritic crystals. The leaves of biotite and muscovite in these chains often alternate with each other, at other

[1] Records, Vol. X, p. 217.

times part of a string is formed of leaves of biotite linked together, and the other portion of leaves of muscovite combined together. The leaves do not all follow each other in straight lines, but some radiate from the chain at high angles to it. Extinction does not take place simultaneously in all the leaves of biotite as in No. 51, but the greater proportion of the leaves in the field of the microscope extinguish together.

The mica is not confined to these strings, but is also scattered promiscuously through the slice, and there are many rounded and elongated microliths of biotite in the slice. Some other colourless microliths are also present, but they are not numerous.

The quartz is in minute grains, and a general parallelism in the arrangement of these grains is distinctly observable. Flat liquid cavities, with fixed bubbles, are rather numerous.

Liquid cavities, with movable bubbles, are abundant in some grains, but not in others.

Dendritical muscovite is plentiful in one of these slices.

Slice No. 52 contains some small colourless garnets.

I think this specimen is an ordinary gneiss.

Nos. 54 to 59.—Granite from the summit of the Chor mountain. A medium-grained granite, containing quartz, felspar, a dark mica, schorl, and some small garnets. Some of the larger orthoclase crystals are seen to be macled on the carlsbad type. The rock has a speckled appearance owing to the superficial decomposition of some of the felspar.

M.—It is not possible to determine the relative proportion of quartz to felspar from mere inspection, for in some slices quartz preponderates and in others felspar. A macroscopical examination of the hand specimen, moreover, does not enable me to decide the question. On the whole, I think, quartz and felspar are pretty equally divided.

Plagioclase is present in some abundance, but it is decidedly subordinate to orthoclase.

Fibrous felspar is to be seen in one of the slices, and it shades here and there into typical microcline.

Orthoclase is occasionally seen to be twinned on the carlsbad type, and one crystal of this mineral encloses a small prism of orthoclase macled on this system.

Muscovite is very sparse except in the form of microliths, but these are so abundant in some of the felspars as to make it almost impossible to say whether the latter are monoclinic or triclinic. Some cryptocrystalline mica is also present.

The biotite, in transmitted light, is of pale greenish-brown colour in sections that display the basal cleavage; whilst sections which coincide with the cleavage, *viz.*, those normal to the optic axis, are of deep rich reddish-brown.

Garnets, colourless in transmitted light, are rather numerous. They are for the most part of good size, and frequently present regular crystallographic outlines. The larger ones generally present six-sided sections, whilst some of the minute ones appear to be in the form depicted in figs. 241, 242, and 246, page 266, J. D. Dana's System of Mineralogy, *5th edition.*

Some of the slices contain patches of chloritic matter, which appears to be a secondary product resulting from the alteration of garnet. One patch is four-sided, the sides being straight lines, and is doubtless a pseudomorph after garnet; whilst, in other cases, small groups of garnets, some of which are in process of alteration, are embedded in chloritic matter, which, it seems probable, was formed from the degradation of some of the members of these groups. One of the garnets exhibits a feeble double refraction.

The slice is stained here and there with ferric oxide apparently derived from the biotite, and this imparts rather a pink appearance to the rock viewed macroscopically.

Two of the slices contain grains of magnetite either caught up in or adjoining leaves of biotite. I have several times seen the presence of magnetite fringing biotite or hornblende attributed to the decomposition of these minerals, but I do not think there are any grounds for supposing that the magnetite has been derived from the biotite in this case, for the grains of the former are of considerable size and the biotite exhibits no signs of alteration in their neighbourhood. I think the biotite was attracted to the magnetite, by molecular attraction, at the time of crytallisation and formed upon it. Magnetic attraction even might come into play between magnetite and a mineral so rich in iron as biotite.[1] In some specimens (J. D. Dana) the percentage rises as high as 26·9.

One piece of felspar contains a large prism of quartz with pyramidal terminations. The felspar itself is a very peculiar object. It is traversed in parts by irregular straight lines running in one direction that polarise in a different tint to the body of the felspar. They are very fine lines with rather jagged sides, and they want the regularity of plagioclase twinning. Some of them are long and some of them are short; some bifurcate towards their termination, others inosculate with each other. These lines are traversed at a low angle by another set of larger and still more irregular lines, or veins, which here and there merge into the first set. The second set of lines is filled in part with cryptocrystalline mica, and in part with felspar. At their terminal ends they merge into patches of cryptocrystalline or dendritic mica. It is difficult to say whether the two sets of lines are due to intergrowth, or to cracks formed along intersecting cleavage lines before the whole of the mineral constituents of the rock had completely consolidated. Such cracking might easily occur in a viscid or partially consolidated rock subjected to great strain in the course of intrusion into hard stratified rocks, and I think the appearances above described are probably due to this cause. Other felspars appear also to have been cracked, and filled with a confusedly crystalline material which seems to be in part micaceous.

The quartz is in large and also in microscopic grains; liquid cavities with movable bubbles are not numerous, and they are of minute size; cavities with fixed bubbles containing a coloured liquid, or glass, are not uncommon. Hair-like belonites are numerous in the quartz.

"Stone enclosures," or microliths, that have deposited minerals on cooling, occur in these slices. A sketch of one is given at fig. 1. The crystal deposited

[1] Electro-magnets are now used in chemical laboratories to separate minerals rich in iron from those poor in iron.

at (*a*) has curved sides suggestive of siderite. Other crystals have been had deposited at (*b*). The microlith has cracked in two places, probably the result of contraction on cooling, and one crack has resulted, apparently, in its division into two pieces.

At figs. 2, 3, and 4, I have depicted illustrations, taken from these slices, of opacite (apparently magnetite) deposited in cavities. It is difficult to say whether the opacite was deposited on cooling from a glass which, when under high pressure, at a great heat, held it in suspension, or whether the glass was attracted to the opacite. Figs. 2 and 3 seem to me instances of the former; but whichever explanation be the true one, in either case the rock must have been in a fluid or semi-fluid state; and cases such as those depicted in figs. 1 to 4 seem to indicate that the rock, before consolidation, was in a condition of *aqueo-igneous* fusion.

No. 60.—From the crest of the ridge of the Chor mountain above Barela. This is seen to be composed of quartz, felspar, and black mica (biotite). Some of the felspars are in large porphyritic crystals. The mica is embedded in the felspar and quartz, but it principally flows in streams round the felspar crystals and gives a gneissic aspect to the rock.

M.—The quartz is in small grains with the meandering irregular outlines characteristic of the quartz of granite. It is also present in the form of micro-crystals. Orthoclase is abundant and the slice contains a large carlsbad twin. Plagioclase is plentiful, but it is very subordinate to the orthoclase. Biotite is abundant in large and in micro leaves. Muscovite is present, but sparsely so. Rounded garnets are numerous and one of them is embedded in biotite.

A cluster of epidote grains occurs in a triclinic felspar, and a few other grains are scattered about in the slice.

The felspar alluded to contains multitudes of microliths, some long and hair-like, others of somewhat stout build. Some of them apparently deposited mineral matter on cooling. Fig. 21 is an illustration of one of them.

The quartz contains numerous liquid cavities with good-sized bubbles. I have not observed movement in any of them. Gas cavities are not uncommon, and enclosures containing a coloured liquid, or glass, with fixed bubbles, similar to those in the specimen from the top of the Chor, occur in this slice also.

Nos. 61 and 62.—A felspathic schist from the vicinity of Barela. The specimen was taken from a bed below the outcrop of the gneissose granite.

M.—Under the microscope this specimen resembles a micro-gneiss. Grains, or eyes of felspar and quartz, are arranged in approximately parallel lines, the intervals between them being filled up with micro-grains of quartz and minute leaves of a brown-green mica. The felspar is principally orthoclase—a little of it is plagioclase. In one slice the felspar and quartz are eye-shaped, in the other they have the appearance of sub-angular and rounded grains.

The mica is in minute leaves. No basal cleavage is anywhere to be seen, and in one slide it is only dichroic here and there, showing that the leaves are all turned one way so as to present axial sections.

This is unquestionably a clastic rock, though whether it is a micro-gneiss, properly speaking, or whether it is a somewhat altered sandstone, made up of granitic or gneissic materials, is more difficult to determine.

The quartz is not at all hyaline, and I have detected no liquid cavities in it.

No. 63.—From the Chor mountain near Tálichog. This is a very dark specimen owing to the abundance of black mica. The hand specimen contains rectangular porphyritic crystals of felspar, one of which is $2\frac{3}{8}$ inches long by $1\frac{1}{4}$ inches wide. Two adjoining ones are twinned. In one or two places the quartz and biotite have formed streaky-looking combinations.

M.—This generally resembles No. 60 from Barela. Orthoclase predominates over plagioclase, and felspar over quartz. Garnets are numerous, and epidote is more abundant than in No. 60. Both occur enclosed in biotite and also separately.

Epidote is commonly found in syenite, and it is supposed to be the alteration product of hornblende. I have not as yet found any hornblende in these rocks.

There are nests of colourless microliths, some of which may be apatite; cracks, apparently due to shrinkage, are very common in them. Some few have deposited mineral matter on cooling, or have caught up such matter in the act of consolidation.

Liquid cavities with movable bubbles are sparse.

The outer band at Dalhousie.

The following specimens were examined, namely:—

Nos. 1, 2, 3, 4, 5, and 6, from the neighbourhood of Bagrár (Bagraur), from the vicinity of Banatu (trans-Ravi), and from the ascent between Sherpur (Sairpur) and Dalhousie.

Nos. 7, 8, and 9, from the cart road near Dunhára (Daniara).

Nos. 10, 11, and 12, from below Bátri (Rampur of the map).

Nos. 13 and 14 from Chuári (Chaohari).

Viewed macroscopically, Nos. 1 to 6 and 10 and 11 would be classed as streaky gneisses; 7, 8, 9, and 12, as gneiss verging towards the granitoid type. 13 and 14 are porphyritic gneisses, inclining towards granitoid gneiss. The porphyritic crystals are rectangular, and are oriented at varying angles to the line of pseudo-foliation.

I now proceed to give an account of the structure of these specimens as exhibited by thin slices under the microscope.

All the specimens contain quartz. In some slices the quartz predominates over the felspar; in others the latter is in the ascendancy. On the whole, quartz is probably somewhat more abundant than felspar.

Nearly all the quartz is in the form of fish roe grains, similar to that described in my paper on the gneissose-granite of Dalhousie. It meanders through the slice in strings, and fills cracks in felspar crystals. The grains are extremely minute and frequently show a tendency to hexagonal outlines.

Orthoclase is present in all the slices, and microcline is observable in slices Nos. 8, 10, 12, 13, and 14; being plentiful in No. 12, but not abundant in the others.

Plagioclase is absent in Nos. 2, 4, and 6; plentiful in No. 12, but sparse in the remaining slices. Orthoclase, therefore, largely predominates over triclinic felspar.

Biotite is present in Nos. 7, 8, 9, 10, 11, 13, and 14, and a mica, dark green in transmitted light, that is probably biotite, is present in the rest

Muscovite is present in all the slices, and it occurs both in its foliated form and as microliths. In No. 4, the latter are so abundant in some of the felspars as to nearly overpower the felspathic element and to give the felspars superficially a micro-felsitic aspect.

Cryptocrystalline mica occurs in all the specimens, and is plentiful in some slices. It is drawn out into strings, and meanders about in a stream-like course, in the manner described in my paper on the gneissose granite of Dalhousie.

Magnetite, ferrite, and garnets, are to be found in all; whilst schorl is abundant in No. 12, but absent from the other slices.

Liquid cavities with movable bubbles are present in all, except Nos. 8, 9, 10, and 11. They are of good size in Nos. 4 and 5, but are generally very minute in the remaining slices. They are very numerous in Nos. 4, 5, 7, 12, and 14, but are somewhat sparse in the others. In No. 12 they are not only abundant in the quartz, but are almost equally so in the felspar and schorl: a large garnet is also full of them. The cavities and bubbles in the schorl and garnet are relatively much larger than those in the quartz and felspar, and would seem to indicate that the schorl and garnet crystallised at an earlier stage of consolidation of the rock than the felspar and quartz. In this slice, even a microlith of muscovite contains liquid cavities with movable bubbles. In No. 14 a microlith contains seven cavities with fixed bubbles, which appear to be liquid cavities. If these are glass cavities, they would afford a strong argument in favour of the igneous origin of the rock; but even on the supposition that they are liquid cavities, the presence of numerous liquid cavities crowded into a minute microlith indicates that, when the latter consolidated, the rock must have been in a fused or plastic condition, and the intermixture of super-heated water or steam with the mineral constituents of the rock most intimate. We have already seen that when the beryl of the Wangtu eruptive granite crystallised, the granite was in a similar condition. A sketch of this microlith (much enlarged) is given at fig. 20. It reminds one very much of the microlith figured at fig. 11, taken from Jángi granite. Air or gas enclosures are present in all the slices, and are sometimes abundant.

I now proceed to note some points of special interest observed in the several slices.

In No. 1, the twinning planes of the plagioclase are sometimes very much bent out of the perpendicular, showing that they were subjected to considerable strain between the time of their crystallisation and their attainment of perfect rigidity. A similar feature is observable in some of the other slices.

At fig. 15 (*a*) I have given a sketch of a crumpled mica seen in slice No. 7, which appears to have been doubled up after crystallisation, whilst the laminæ were still pliant, in the manner described in my paper on the gneissose granite of Dalhousie (see fig. 4, plate II, of that paper). In that paper, I attributed the crumpling to traction.

The mica is muscovite, (*a*) the substance in which it is embedded is a structureless, whitish, opaque substance, analogous to leucoxene: (*b*), in the illustration, is the termination of a long string of fish roe quartz.

At fig. 14 I have given a sketch, taken from slice No. 1, in illustration of a peculiarity characteristic of these rocks; (*a*) is a narrow stream of leucoxene, or allied substance, white in reflected, but perfectly opaque in transmitted, light. The dark line (*b*) that runs along the lower border of the leucoxene is red ferrite: (*c*) is a train of magnetite, or ilmenite grains, in the stream of leucoxene: and (*d*) is a garnet. The ferrite, it will be observed, does not come into contact with the grains of magnetite or ilmenite. I do not think that the leucoxene has been produced by the decomposition, *in situ*, of the iron grains, for several reasons. In the first place, the grains of magnetite do not show any trace of decomposition along their edges, but are perfectly fresh throughout. Secondly, grains of magnetite are to be seen in other places quite unconnected with the leucoxene; whilst streams of the latter substance are common between which and the iron no direct connection can be traced. The ferrite, on the other hand, is often directly connected with magnetite. The explanation of the above facts appears to me to be as follows: when the plastic rock was at rest, the acid and aqueous vapours contained in it began to act on the iron, and leucoxene was formed by the action of the former on the ilmenite, and ferrite by the action of the latter on the magnetite. Motion succeeded to the temporary rest, and then the leucoxene and ferrite were, under the influence of traction, drawn out into strings in which the undissolved fragments of ilmenite and magnetite were frequently entangled.

This explanation, of course, involves the supposition that the iron first crystallised and was afterwards acted on by the corroding action of acid vapours contained in the rock; but this suggestion will present no difficulty to those who have studied, under the microscope, such volcanic rocks as the dolerite of Auvergne, in which the corroding action of vapours on some of the minerals contained in the lava is frequently to be observed.

Since writing the above lines, I have come across an interesting remark regarding ferrite in Mr. J. J. Harris Teall's Cheviot Andesites and Porphyrites (Geological Magazine, Decade II, Vol. X, p. 257). In describing a porphyrite showing "well-marked fluidal structure," he remarks: "The ferrite is especially abundant in fluidal bands and stripes which curve round the larger crystals in a very characteristic manner. Vogelsang describes a similar distribution of ferrite in certain of the Hungarian quartz-trachytes."

The above fact that ferrite has been observed drawn out in "fluidal bands and stripes" in true lavas by competent observers, affords an important confirmation of the conclusion I independently arrived at regarding the origin and significance of the ferrite "bands and stripes" in the rock under consideration.

The felspars (orthoclase) in these slices sometimes contain intergrowths after the manner of perthite. In some cases the mineral intergrown with it is felspar, at other times quartz.

Cracks in felspars filled up with fish roe quartz are very common, whilst occasionally the latter appears to be the residuum, left in pools, so to speak, in the interior of felspars, after the separation of the alumina and the other constituents of the felspar.

At fig. 16 I have given a sketch, taken from slice No. 6, of what appears to have been a large felspar, cracked and split into pieces and then pushed over like books on a shelf by pressure and traction. At any rate the outlines certainly suggest this idea. The cracks are filled partly with fish roe quartz, but principally by cryptocrystalline mica. The dark portion at the bottom consists of dark micaceous, imperfectly crystallised matter, running in ropy lines through the slice. The several pieces of felspar shown in the sketch are all in optical continuity with each other, and appear to be fragments of one crystal.

At fig. 18 I have represented a minute stone cavity, found in slice No. 6, in which crystalline matter has been deposited on cooling. The upper mineral has a distinctly hexagonal form, whilst the lower mass seems to be an agglomeration of stony matter rather than one crystal. Forms such as these show distinctly that the mass in which they are found was reduced to a fused or plastic condition by heat.

At fig. 17 I have depicted a cavity, seen in the same slice (No. 6), which contains a large air-bubble. The cavity was evidently once filled with air, to the expansive power of which the formation of the cavity is due, but the air contracted on cooling to its present size. The bubble, as will be seen in the sketch, seems to be a little too wide for the cavity; this appearance, however, is simply due to refraction, the empty portion of the cavity acting on the light passing through the mineral differently from the bubble of air.

Fig. 19 is another illustration of the same kind taken from slice No. 12. The cavity is in a schorl crystal, and contains air or gas that has contracted on cooling. The bubble does not contain the central transparency usually seen in air bubbles, but it shines brilliantly in reflected light like an air or gas bubble.

These cavities and contained air or gas bubbles—and they are by no means the only examples of the same kind contained in the slices under description—afford evidence to show that these rocks were subjected to sufficient heat to reduce them to a plastic condition. The bubbles on cooling appear to have contracted to about half their original size, from which I infer that the rock was raised to a high temperature. The fact that the cavities themselves are not circular, is explained by the fact that their shape is controlled by extraneous forces, and among others the crystallographic energy of the molecules of the mineral in which the cavity is formed, air or gas caught up by a mineral in the act of crystallisation would expand, not equally in all directions, but along the lines of least resistance which would usually coincide with the cleavage planes of the crystallising mineral.

Conclusion.—The rock specimens described in this paper come from an extended area. The first is that of granite intrusive in mica schists above Darwás, in the Pángi valley of Chamba; the next is granite intrusive in the schists at Leo, on the Spiti river. Other specimens are from the cliffs above Jángi, in Bassáhir, on the Upper Sutlej, and from dykes at and near Rarang and Pángi, in Bassáhir.[1]

There can be no doubt whatever of the eruptive character of these granites, for they are seen in the field to cut across the schists, and in some cases to penetrate them in all directions. I thought, therefore, that they would be good rocks to compare with the gneissose granites of neighbouring regions.

Following the line of the Sutlej river, I collected my other specimens at Wangtu, at Chora, at the Kot peak and the Bági road, at Báli, and at the Hattu mountain above Nákanda, in the neighbourhood of Simla. I then passed to the

[1] Chamba Pángi is on the River Ravi; Bassáhir Pángi is on the Sutlej.

Chor, a prominent mountain abutting on the plains; and, finally, I came to the outer band of gneissose granite at Dalhousie.

The granite from the dyke that bursts across the schists above Darwás (slice 1) is interesting, from the fact that, when viewed macroscopically, it exhibits some slight traces of incipient parallelism of structure due to traction. It possesses no other structural peculiarity worth noting. The latter fact, I may remark in passing, shows that when examining a single slice of a granitic rock under the microscope, with a view to determining whether it is of eruptive or metamorphic origin, mere negative evidence is not of much value.

The Leo granite has several points worthy of consideration. Nearly all the quartz in it is of polysynthetic structure, similar to the fish roe quartz of the Dalhousie gneissose granite; and this shows that the conclusion which I arrived at in respect of the latter—namely, that the fish roe grains do not indicate a clastic origin [1]—was sound.

Another point to be noted is that liquid cavities with movable bubbles are not very abundant in the Leo granite. Liquid cavities may be abundant in some parts of a granite and not in others; their sparseness, or even absence in a single *slice*, therefore, is of little importance in determining the igneous or metamorphic origin of a rock.[2]

Evidences of strain are seen in the Leo granite in the curvature of the twinning planes and the cracking of felspar crystals.

The muscovite of this granite polarises in delicate colours, but with extreme brilliancy, precisely as it does in the gneissose granites; the dullness of the muscovite of the Durwás and Pángi specimens, under the polariscope, does not therefore indicate any structural or varietal difference dependent on their mode of origin. Both the Leo and Darwás specimens are from dykes intrusive in schists.

In No. 3, garnets and schorl are drawn out into strings—an indication, I think, of traction.

The biotite in such rocks as the Jángi granite (Nos. 5—12) may be usefully compared with the dark mica in such rocks as the gneiss of Hattu (Nos. 51—53) and of Barela (Nos. 61 and 62). In the former, the basal cleavage of the mica is well developed, the folia are oriented in all directions, and the biotite embraces garnets or other minerals. In the gneiss alluded to, on the other hand, the dark mica is in minute scales which do not exhibit any basal cleavage; moreover, when slices of the gneiss are revolved over the analyser, the mica either fails to exhibit dichroism at all, owing to all the leaves being axial sections, or extinction takes place simultaneously in the whole, or in the majority of the leaves; an indication in both cases that the scales of mica are all in the same plane,—a fact that points to a metamorphic or clastic rather than to an igneous origin.

[1] Records, Vol. XVI, p. 180.

[2] To prevent any misapprehension of my meaning I may add that though the abundance of liquid cavities with movable bubbles is very characteristic of a plutonic eruptive rock—see remarks *ante* on the Wangtu beryl—liquid cavities are also to be found in some metamorphic rocks, as will be shown in my next paper.

"Stone enclosures," which contain endo-minerals, gas, and lacunæ with fixed bubbles in them (figs. 11—13), are to be seen in the Jángi granite.

These stone enclosures afford good evidence of the rock which contains them having been subjected to great heat and of having been reduced to a more or less fluid or plastic condition; and they are useful for comparison with similar bodies formed in the gneissose granite.

In the granite from the dyke that bursts through stratified rock at Rárang, a parallelism in the arrangements of the biotite resembling incipient foliation is to a limited extent observable on a macroscopic inspection.

In the Pángi granites liquid cavities are very numerous, and the bubbles are of large size relative to the area of the enclosures containing them. This indicates that the rock was subjected to great heat and pressure; whilst the perfectly crystalline condition of these rocks shows that they were in a fused or fluid condition and cooled slowly.

A little microcline is present in the Pángi granite (14) and it is abundant in the Wangtu granite (20, 21).

I now pass from granites proper to the gneissose granites, or what used to be called the granitoid gneisses of the Sutlej valley.

In mineral composition these rocks do not materially differ from those of the granite group above alluded to. Both classes contain quartz, orthoclase, plagioclase, microcline, biotite, muscovite, schorl, garnets, and magnetite.

With the exception of beryl and kyanite in the neighbourhood of Wangtu, and epidote and chlorite in some of the Chor specimens, I have not found any other minerals in the samples examined.

In the gneissose-granite of Chora stone cavities or crystals, containing endo-crystals and enclosures (figs. 5—8) of the same class as those found in the granites proper (figures 9—13) were found. In fig. 11 (Jángi granite) the microlith is severed by a crack, apparently the result of shrinkage. In fig. 5 (gneissose granite) the microlith is cracked in two places and dislocation has resulted owing probably to a tremulous movement passing through the viscid matrix.

The gneissose granite of the Chor mountain contains a good-sized prism of quartz, with pyramidal terminations caught up in a large piece of felspar. This seems to indicate a more or less fluid stage in which the quartz prism had time to form free from any excessive pressure from the surrounding felspar.

Stone cavities, similar to those found in the granites, which have deposited endo-crystals, or mineral matter, occur in the Chor rocks, and illustrations of these bodies are given at figs. 1—4 and 21.

These rocks also contain coloured liquid or stony enclosures with fixed bubbles, and microliths that have cracked, apparently from shrinkage on cooling.

I think the rocks which I have classed, in the above pages, as gneissose granites, afford under the microscope the same kind of evidence, and as good evidence, of having passed through a stage of *aqueo-igneous* fusion as the undoubtedly intrusive granites.

The further fact that they have been in motion has been established for the exactly similar rocks of the Dalhousie area; and I hope in a subsequent paper to give further and very convincing proof of the eruptive character of the latter.

If the Dalhousie rock is granite, I do not think this style and title can be denied to the rocks which I have classed in this paper as gneissose granites.

I must not be understood, however, to deny that in the North-West Himalayas we have to deal not only with granite and gneissose granite, but also with true gneiss. The rock found on flank and summit of Hattu looks like a very typical gneiss, and the examination of thin slices under the microscope supports the view that this is its true character.

I now pass on to consider the outer band of gneiss at Dalhousie. Viewed macroscopically, this is a streaky foliated rock of schistose aspect, to which no one from a superficial study of it in the field, or from the examination of hand specimens, would think of assigning an igneous or eruptive origin.

The question to be determined is whether these appearances are delusive, and the foliation is a pseudo-foliation due to traction, and the squeezing of a viscid rock between beds of hard strata, or between the walls of a fault, or whether the rock is a true gneiss.

In mineralogical character these rocks do not differ from the gneissose granite of Dalhousie. Like the latter, the outer band is composed of quartz, orthoclase, microcline, plagioclase, biotite, muscovite, cryptocrystalline mica, magnetite, ferrite, garnet, and schorl.

Liquid cavities with movable bubbles, on the whole, are about as numerous as in the gneissose granite.

Felspar is present in abundance in the outer band, but on the whole quartz probably predominates over it in amount. Monoclinic felspar largely predominates over triclinic felspar.

As in the gneissose granites of Dalhousie, the Sutlej, and the Chor, muscovite microliths are so abundant in some of the felspars as to nearly overpower the felspathic element.

Not only do crystals of schorl and garnet contain liquid cavities with movable bubbles, but even microliths enclose them. The presence of such cavities in these minerals, and in microliths, shows that the rock must have passed through a fused or plastic stage during which super-heated water must have been intimately mixed with the mineral forming substances in a state of flux. Fig. 20 is a sketch of one of the microliths alluded to, and it is of precisely the same character as that represented at fig. 11, by its side, taken from the Jángi granite.

Conditions of strain are indicated by the twinning planes of plagioclase being bent out of the perpendicular; whilst another felspar (fig. 16) has apparently been cracked and the resulting pieces pushed over like books on a shelf.

A crumpled mica, fig. 15, occurs in one of the slices, which will bear comparison with fig. 4, Plate II, of my paper on the gneissose granites of Dalhousie (Records, Vol. XVI, p. 133), and doubtless the explanation given of the latter applies to this one also.

Strings of a white substance resembling leucoxene, and of red ferrite, which have resulted from the decomposition of magnetite, ilmenite, or other iron-bearing minerals, are common in these slices; and at fig. 14 I have given a sketch of a train of magnetite or ilmenite fragments entangled in a stream of leucoxene, and I have given my reasons in the preceding pages for believing that the leucoxene was not derived from the decomposition of the magnetite or ilmenite *in situ*.

At fig. 18 a "stone cavity" which has deposited crystalline matter on cooling, taken from slice No. 6, is represented, which will bear comparison with similar bodies found in the Aden lavas, and represented at figs. 4, 5, and 6 of the plate which illustrates my paper on those rocks. (Records, Vol. XV., p. 159.)

At figs. 17 and 19 (the latter is enclosed in a schorl crystal), I have sketched cavities containing air or gas bubbles, which have contracted subsequent to the consolidation of the rock, and now imperfectly fill the cavities which doubtless they once fully occupied, when expanded under the influence of heat.

The facts stated above appear to me to prove that the rock under examination was subjected to great heat; that it passed through a stage of aqueo-igneous fusion, and that before its complete solidification it was subjected to great strain and pressure.

If the inferences I have drawn from the train of magnetite or ilmenite fragments in the train of leucoxene, and from the presence of a crumpled mica, are sound, it also follows that the rock, or portions of it, were in motion.

The mere fact that the rock, or a portion of it, was in motion does not, of course, prove its eruptive character. Great pressure, exerted on sedimentary or metamorphic rocks, may result in motion; as, for instance, the cases in which limestones under the influence of great pressure imitate eruptive rocks and become intrusive in others. But in the case of the Dalhousie "outer band" the whole rock has evidently been in a condition of igneo-aqueous fusion, and evidence of motion in such a rock acquires additional importance.

If we take all these facts into consideration, together with the further fact that in mineralogical composition the rock under consideration is identical with that of the neighbouring gneissose granite, which has been shown to be an eruptive rock, may we not fairly conclude that both rocks have the same origin, and that the structural difference between them, which is one of degree only, is due to the outer band having been intruded as a sheet between hard strata, or forced between the walls of a fault in a viscid or partially consolidated condition, and subjected to great pressure and squeezing at right angles to the direction of the flow? I think myself this is a reasonable inference to draw from the evidence.

It is clear, as shown in the preceding pages, that the "outer band" has passed through a stage of aqueo-igneous fusion. On the other hand, I do not think that great heat is required to explain the metamorphism of the schists in contact with the "outer band" along its northern boundary—the passage of moderately-heated water through slates seems to be all that is necessary to account for the production of micas of the class to which those in these schists belong.

In a recent tour, the results of which I hope to publish in a future paper, I found highly micaceous slates, that might be classed fairly as mica schists, intercalated between perfectly unaltered dark-blue carbo-triassic limestones—a circumstance by no means puzzling when we know that certain micas—all the hydro-micas probably—can be produced through the agency of moderately-heated water.

On the whole, then, I think there are good grounds for assigning a different origin for the "outer band" and for the schistose rocks in contact with it.

The conclusion at which I have arrived, on a consideration of all the facts of the case, is that the invasion of previously metamorphosed strata by gneissose granite, combined with the pseudo-foliation of the latter due to the pressure of hard strata on a partially cooled and imperfectly viscid rock, has imparted to the intruded rock the superficial appearance of being a member of the same metamorphic series as the schists and slates into which it has intruded.

There is no inconsistency, I would point out in conclusion, in supposing that the rock which gives evidence of having passed through a stage of aqueo-igneous fusion was partially cooled and semi-viscid where actually intruded into the schists. Observation in our own time shows that there are pauses and long intervals in volcanic action; and doubtless similar pauses took place in plutonic action during which the cooling and partial consolidation of igneous masses went on and the large porphyritic crystals found in many of them were formed. The subsequent motion of a partially consolidated viscid rock and its intrusion as a sheet between hard strata, or between the walls of a fault, would, it seems to me, naturally produce a parallelism of structure, or pseudo-foliation, as long ago pointed out by Scrope and Naumann.[1]

The "outer band" of Dalhousie seems, in some respects, to be analogous to granulite (leptynite), a foliated rock associated with gneiss and other crystalline rocks in Saxony, Bohemia, and Moravia, which is classed as eruptive by Naumann, M. M. Fouqué and Michel Lévy, and other petrographers.[2]

The mica of granulite appears to be at times disposed "in scaly seams entirely dividing the rock," a marked characteristic of the "outer band" of the Dalhousie gneissose granite.

DESCRIPTION OF THE PLATE.

Fig. 1.—Stone cavity, or microlith, in the gneissose granite of the Chor, which has deposited crystals on cooling. Taken from slices 59—64.

Figs. 2, 3, and 4.—Opacite, probably magnetite, deposited in cavities. Chor gneissose granite. Slices 59—64.

Figs. 5, 6, 7, and 8.—Illustrations of stone enclosures, in which mineral bodies, enclosed in the gneissose granite of Chora, have either deposited minute crystals on cooling, or have, in the process of their own crystallisation, caught up previously formed microliths. Slices 22—25.

Fig. 9.—Dendritic combinations of muscovite, microliths, gneissose granite, Wangtu. Sutlej valley. Slices 16—19.

Figs. 10, 11, 12, and 13.—Stone cavities containing crystals and internal cavities with contraction bubbles. Granite, Jángi, Sutlej valley. Slices Nos. 5—12.

[1] See Scrope, Q. J. G. S., Vol. XII, p. 346. And his work on Volcanoes, pp. 103, 144—202. Naumann "On the probable eruptive origin of several kinds of gneiss and gneiss-granite." Q. J. G. S., Vol. IV. Translations and Notices of Geological Memoirs, p. 1.

[2] Geikie's Text-Book of Geology, p. 124. Cotta's Rocks classified and described, p. 221. Minéralogie Micrographique, par M. M. Fouqué et Michael Lévy, p. 174.

Fig. 14.—Strings of red ferrite and a white substance resembling leucoxene in which fragments of magnetite or ilmenite are entangled. Outer band of gneissose granite, Dalhousie. Slice No. 1.

Fig. 15.—Crumpled mica. Outer band, Dalhousie. Slice No. 7.

Fig. 16.—A large felspar, cracked, split into pieces and pushed over as books on a shelf. Outer band. Slice No. 6.

Figs. 17 and 19.—Cavities containing air, or gas, that has contracted on cooling. Outer band, Dalhousie. Slices 6 and 12.

Fig. 18.—Stone cavity in which mineral matter has been deposited on cooling. Outer band, Dalhousie. Slice No. 6.

Fig. 20.—Microlith containing lacunæ with fixed bubbles. Outer band, Dalhousie. Slice No. 14.

Fig. 21.—Microlith that has deposited mineral matter on cooling. Gneissose granite, Chor. Slice No. 65.

Report on the Choi Coal Exploration,[1] *by* G. F. SCOTT, M.E. (With a map.)

In this report I purpose to take each place separately and treat of its coal prospects.

No 1. Choi, marked A on plan.

The coal here lies at the base of the hills; it had been worked previous to my arrival by means of headings driven in the hill-side and pits; there is hardly any coal left, nearly all having been worked.

A boring marked B on plan was put down to the depth of 80′ by Mr. Craythorne, but without success; it is evident that no regular seam of coal occurs, the quantity previously extracted lying in pockets. The strata are very contorted, and I question much, if coal were found, whether it would pay the cost of labour. Near the village, and along the Chablowala nuddy indications in the shape of black earth, and shale appear, but nothing substantial enough to guarantee a trial.

No. 2. Between Choi and Mungi, marked C on plan.

Leaving Choi and proceeding eastwards, the outcrop is seen on the side of the main road, and also down the hill, further east, I put down a boring marked C on the plan. On reaching limestone, I stopped the boring and commenced sinking to the black shale met with at the depth of 32′ 4″. From here a heading was driven in the direction of the dip of the coal (which is almost perpendicular), but when it had been driven 8 yards the coaly shale thinned out; another heading was driven, but that also for the same reason was abandoned. No actual seam was met with, the black shale that was followed had small parti-

[1] The exploration described in this report was suggested and carried out by the Department of Public Works. In order that so searching a trial of the ground may not be lost sight of, the account of it is appropriately published in these Records. The locality is in the Chita range, ten miles south of Attock. A general description of the ground by Mr. Wynne was published in 1877, Records, Vol. X, p. 107. The pseudo-coal-measures are those near the base of the nummulitic series which have so often raised sanguine expectations of coal in the North-West Punjab.—H. B. M.

cles of bright coal in it, but this, as was observed above, gradually thinned out to nothing. It is evident, therefore, that here and in the immediate neighbourhood where more indications are to be seen, there is not the slightest hope of any workable coal being found.

Indications of coal crop out here and there along the foot of the hills, until the place marked D on plan is reached. Here coal has been extracted by means of headings and pits; the latter are mostly full of water, so that the galleries underneath cannot be inspected; it is evident, however, from the headings that there is very little coal remaining.

No. 3. Boring at Mungi, marked D on plan.

I put down a boring to the north of the previous workings; after a depth of 11′ 4″ limestone was reached; the boring was continued in this strata to the depth of 57′; the progress being slow, and there not being the slightest chance of striking coal, it was abandoned.

There is nothing here to tempt another trial, the quantity of coal that may be left being very small.

The outcrop continues almost in a straight line to the east. To test the strata a boring was put down at the place marked E on plan.

No. 4. Boring east of Mungi, marked E on plan.

It will be seen, on referring to the account of the boring, that up to date no seam has been struck, although a depth of 100 feet has been reached. The boring is still proceeding, but I am afraid it will meet with no success.

Leaving the hills, I thought, in order to thoroughly test the locality, that a couple of deep borings should be put down in the plain where it is evident the strata lie more horizontally. Accordingly, a boring was started at the place marked F on plan. After meeting with great difficulties the strata have been bored through nearly to the depth of 200 feet, and by referring to the account, there does not seem much likelihood of meeting with success. The boring is now in stiff blue clay, and probably limestone will be met underneath; should this occur it will be useless to proceed further.

No. 5. Boring near Haro, maked F on plan.

A boring was commenced here intended to be as deep as the other, but at the depth of 55 feet an unexpected bed of sand and pebbles was encountered. All the boring pipes being required near the Haro, it was abandoned. Should, however, the present boring prove successful, it will be easy enough to start this one.

No. 6. Boring at Dheri Khot, marked G on plan.

Traces of coal having been discovered between Choi and Bagh Nilab, I thought it would be as well to put down a trial pit. On the 14th April it was commenced, and at the depth of 15 feet a heading was driven at an inclination of 1 in 3. Up to date, nothing substantial has been found, although black shale bands occur with particles of bright coal in them. I do not think it probable that a seam lies here, but very likely a small quantity of coal, similar in nature to that at Choi, may be extracted.

No. 7. West of Choi, not marked on map.

Between here and Bagh Nilab no indication of coal is found; at the latter place there are slight traces, but nothing sufficient to guarantee a trial.

Summary.

From what I have seen of this district, and from the several borings, the conclusion I have come to is, that the prospects of finding any sufficient quantity of workable coal either at Choi, Mungi, or the country lying to the west and east respectively, is very slight.

The coal itself is of a poor quality and resembles black shale more than anything else; it seems to be a good gas producer, and that is all that can be said in its favour.

The only chance of making this exploration a success has been tried,—that is, boring in the plain; had coal been struck, the seam would have lain at a more convenient angle, and there is no doubt but that there would have been a vast quantity of coal to work.

It is very evident that no seam lies in the hills, and, with the exception of Choi and Mungi, no coal has been worked, although trials have been made in various localities; it is almost conclusive, therefore, that the coal lies in pockets, and to work this seems to me to be far too speculative.

From J. T. O'CALLAGHAN, Esq., *Engineer-in-Chief, Punjab Northern State Railway, Northern Section, to the Director General of Railways,—No. 1335, dated 17th May 1883.*

I have the honour to forward herewith a report with plans on the search for coals in the Kala Chitta range of hills south of Attock carried out under the instructions conveyed in your No. 622 C of 16th November 1882.

Mr. Scott's report confirms the opinion I had already given in my No. 4074 of 22nd October 1880, to your address, and also the published opinion of the officers of the Geological Department.

While Mr. Scott was carrying out his exploration, I visited the district and went with him over most of the places where any indications of coaly matter appeared. The Kala Chitta range of hills consists almost altogether of grey nummulitic limestone, the beds of which are much contorted and are traversed by many faults. Near Choi the beds are tilted nearly vertical, and between two of the beds is a bed of brownish shale from 40 to 50 feet in thickness. This shale bed is traceable for some miles in an easterly direction from Choi, and at intervals in it pockets of black coaly shale are found. The pockets are lenticular in form and of no great extent in any direction, and when excavated have always died out within 40 or 50 feet of the surface of the ground. The so-called coal when excavated has also proved to be of little value as a fuel. It was of service in burning lime and keeping down the price of wood at a time when all prices had a tendency to undue inflation. But the attempts to make it into patent fuel fit for locomotive purpose has been a complete failure, the heat given out being much inferior to that obtained from an equal quantity of wood fuel.

In my opinion, any hope of procuring coal in the Kala Chitta range may be abandoned now and for ever. Had there been any appearance of a continuous seam of even the coaly shale found, deeper workings in it might have shown a better quality to exist below, but there is no continuity or regularity in the recurrence of these pockets, and the fine vertical section of the whole range of hills which is made visible in the channel cut by the River Indus, shows that the great disturbance of the whole formation of these hills must preclude all hopes of horizontal beds of any kinds being found—see also opinion of Superintendent, Geological Survey, expressed in his letter No. 255, dated 29th September 1880.

What grounds Mr. Johnson had for the statement made in his No. 2845 of 12th August 1882, to the Secretary to Government, Punjab, paragraph 5, that "the pocket theory was found to be erroneous, the so-called 'pockets' connected with each other and develope into seams, while the coal improves immensely in quality as the depth of the pits increased," I am at a loss to imagine. In no case has any pocket been found to extend into a seam, and without exception they have worked out in every direction in which they have been tried; and when last at Choi Mr. Johnson was unable to point out any continuous seam or to give any data on which his very sanguine report could have been founded. I can only infer that Mr. Johnson based his report on information received from a man named Craythorne, the practical miner referred to in paragraph 6 of his report. This man was originally a soldier in the 44th Regiment, and was taken from the regiment to work in the Warora Mines in 1874 or 1875, which situation he left and wandered up-country in search of work. His employment by the Executive Engineer was allowed, to assist in procuring fuel, and it was of course to his interest to make favourable reports in order that his employment might be continued. He absconded from Choi a short time before Mr. Scott's appointment.

The boring marked F is still continued and sandstone under the blue clay is reported, but this is probably only one of the thin beds of sandstone everywhere seen in the recent deposits through which the Haro river has cut its way. The ultimate results of this boring will be reported, but it does not seem necessary to delay this report for it.

In conclusion, I beg to say that Mr. Scott has taken much pains with the work on which he was employed, and I trust that he will be more successful in the Salt-range, where I understand the manager of the line is about to employ him. He has been given the usual month's notice that his services will not be required further at Choi, and the tools, &c., used by him will be stored at Pindi until required elsewhere.

From J. T. O'CALLAGHAN, Esq., *Engineer-in-Chief, Northern Section, Punjab Northern State Railway, to the Director General of Railways,—No. 1851, dated 12th June 1883.*

In continuation of my No. 1335, dated 17th May 1883, I have now the honour to forward Mr. G. Scott's supplementary report on the bore-hole put down near the Haro river at the point marked F on the plan already forwarded.

I omitted to mention that the bore-hole was put down in the bed of the river about 70 feet below the average surface of the ground, and therefore represents a hole of a depth of about 320 feet.

The record shows that nothing but alluvial deposits have been passed through; and go further to confirm the views I have always expressed regarding this district.

Supplement to report on the Choi Coal Exploration.

In this supplement, I purpose to give a further account of the deep boring near the River Haro, mentioned in No. 5 paragraph of my former report. On referring to that, it will be seen that the boring had nearly reached the depth of 200 feet, and my supposition was that a bed of limestone was close at hand. It was then thought that it would be advisable to discontinue the work, but after further discussion it was decided to go on, and see what the nature of the stone was.

Accordingly, after clearing the boring, it was re-started on the 19th May, and at the depth of 201′ 6″ sandstone was reached; the rock proved, however, to be only 4″ thick, and below, beds of loam, sand, and dark yellow clay were met. At a depth of 233′ 11″ sandstone with a total thickness of 8′ 3″ was bored through, and then again a bed composed of a mixture of loam and sand was found.

Finally, on the 7th June the boring was abandoned, the depth then reached being 252′ 6″ and the strata sandstone.

From the above short account, and from a study of the boring sheet noting the various strata pierced, the conclusion arrived at is, that even at the depth of 250 feet the boring had not gone below the silt and sediment deposited by the river: how far this deposit extends is a matter of conjecture, but, in my opinion, it would be some time before it could be bored through, and then no advantage would accrue, as it is highly probable limestone would be the strata met with.

The boring itself was put down in a ravine close to the Haro, and only 8 feet above low-water level. The cliffs which border one side of the river are 70 feet high, so that it will be seen that at the termination the boring was really 320 feet below the actual surface.

To have continued would have been a mere waste of time and money, as I have not the slightest hesitation in saying that a further search would prove utterly useless.

In my opinion, everything has been done with a view of finding a profitable seam of coal; the borings and trial pits have been put down in the most advantageous places, but without the success I confidently expected from the surface indications.

Section of Boring on the Haro River.

Depths.	Strata.	Depths.	Strata.
21′ 0″	Soil and pebbles.	194′ 5″	Loam and sand.
37′ 0″	Yellow clay.	201′ 6″	4″ sandstone.
70′ 0″	2′0″ sandstone.	204′ 9″	Loam and sandstone.
83′ 6″	Yellow clay.	211′ 2″	Loam and sand.
94′ 10″	2′ 6″ sandstone.	217′ 5″	Dark yellow clay.
108′ 0″	Yellow clay.	233′ 11″	Soft sandstone.
115′ 0″	Running sand.	242′ 0″	Loam and sand.
121′ 4″	Yellow clay.	249′ 3″	Sandstone.
144′ 2″	Blue clay.	252′ 6″	...
184′ 9″	Dark blue clay.		

NOTE.—If Mr. Scott's figures can be trusted, of which I regret to hear there is some doubt, the boring on the Haro would be of considerable geological interest, as proving that this great spread of alluvium, the principal area of which is known as the Peshawar valley, lies in a deep rock basin. It has indeed become a safe general inference, that areas of deposition are thereby areas of depression; still new facts in evidence are not superfluous. The surface level at the boring is only about 25 feet above that of the Indus, twelve miles to the west, where it turns at a right angle into its gorge through the Chita range.

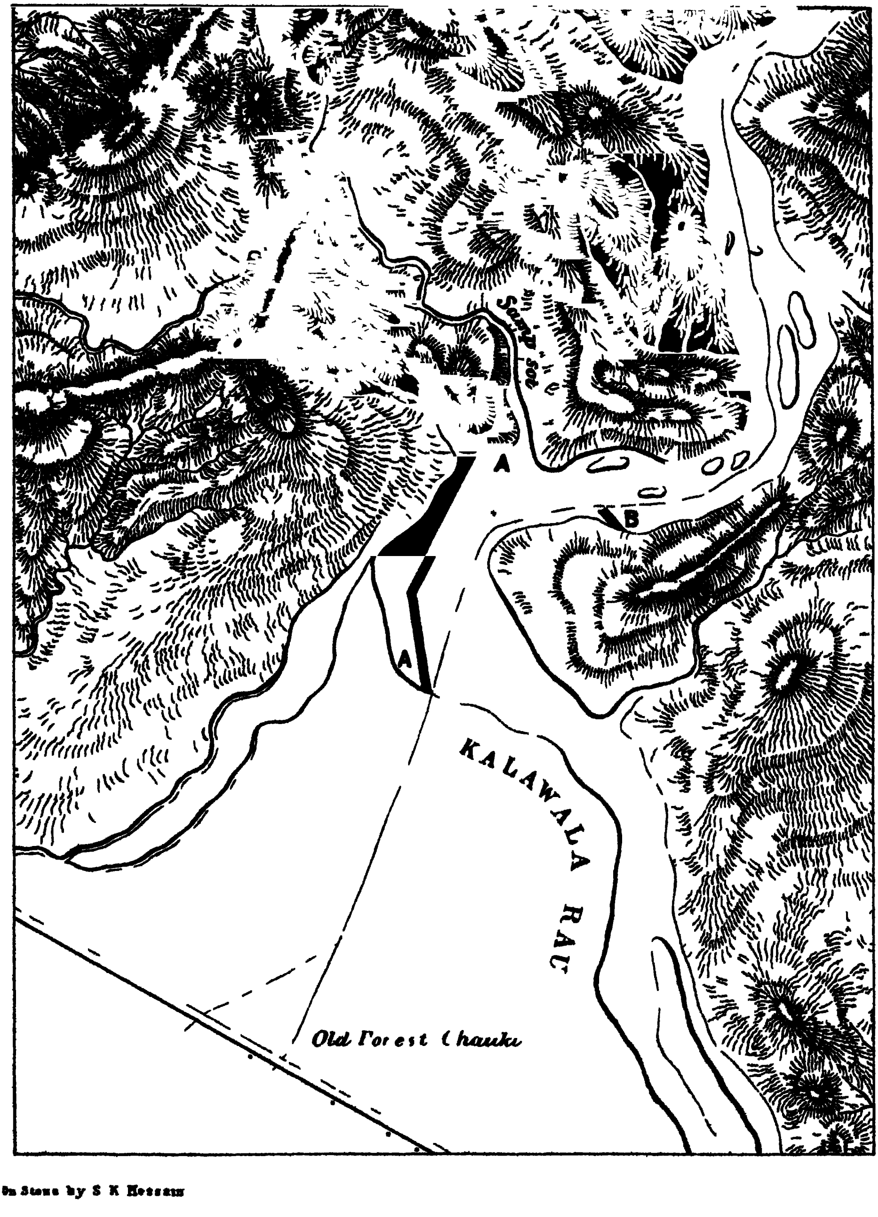
The expectation to find the coal flat and abundant under the alluvium in a region of extreme contortion as exhibited in the surrounding hills, is a speculation that could only occur to the "practical man."—H. B. M.

On the re-discovery of certain localities *for* fossils *in the* Siwalik *beds, by* R. D. OLDHAM, A.R.S.M., *Geological Survey of India.* (With a map.)

Having recently had the good fortune to re-discover the long-lost fossil locality described by Sir Proby Cautley at the base of the section in the Siwalik hills, it has been considered desirable to put on record a detailed description of the locality.

For this discovery I am mainly indebted to Mr. A. Smythies, Deputy Conservator of Forests, who, when deputed a short while ago to enquire into the question of the effect which the clearing of the forests from the slopes of the Siwaliks has had on the floods that annually enter and cross the Eastern Jumna Canal, made careful enquiries of the survivors of those who were employed on its construction as to the locality from which the fossils had been obtained; the result of his enquiries was that they had been discovered during the excavations carried on in connection with the works in the Kalawala Rao. These, which are shown in the annexed sketch plan, consist of the principal bund, A, which was designed to throw the waters of the stream into a channel which does not enter the canal, and a small spur, B, higher up stream, intended to guide the current against the principal dam. On visiting the spot we found at the head of both the principal dam and the spur a very peculiar rock, a conglomerate with a calcareous sandy matrix full of fragments of clay and decomposed slate with hardly a particle of harder rock; such might very properly be called a "clay conglomerate," but "clay marl" must be acknowledged to be a misleading name; still gravelly clays are sometimes improperly called marls, and the name might be applied by an engineer who did not profess to be a geologist. Through this rock are scattered, though not abundantly, small fragments of bone, always broken, water-worn, and disjointed, and without exception converted into oxide of iron (hæmatite). As described by Sir Proby Cautley, reptilian teeth were not uncommon; besides these we found a mammalian molar imbedded in a portion of the ramus, a piece of the thigh bone of a small animal about the size of a sheep, a piece of a rib of some large animal, and portion of the carapace of a tortoise.

As regards its position in the section, the bed is exposed in the Kalawala Rao on the southern side of the anticlinal fully 1,000 feet above the lowest beds seen; here there are two distinct beds, but in the valleys to the west three or more are occasionally seen. The same or similar beds are well seen in the Kotri and Kusumri Raos, but I was unable to detect them in the Badshai Rao (Timli pass), while to the eastwards I doubt not it would be found if searched for, as I have seen a very similar bed in the Dholkund Rao, but at the time expecting to find the fossils in a clay bed I did not search it.



On Stone by S K Hossain

SOUTH ENTRANCE OF THE KALAWALA PASS, SIWALIK HILLS

Scale 4 = 1 Mile

This has an important bearing on the discovery of similar fossils on the northern face of the Nahan hill;[1] it is of course possible that the lower beds of the Siwalik range are of the same age as those of which the Nahan hill is formed, but taking into consideration their very different mineralogical facies and the fact that they being situated at a greater distance from the Himalayas are far more exclusively composed of sand and pass up into coarse conglomerates, it can hardly be called probable, and it is far more likely that the Nahan fossils were either of an entirely different age or that they were obtained from an outlier of the middle Siwaliks, as has been suggested by Mr. Medlicott (Mem. Geol. Surv. India, III, 105), and again by Mr. Theobald (Rec. Geol. Surv. India, XIV, 71).

On some of the Mineral Resources *of the* Andaman Islands *in the neighbourhood of* Port Blair, *by* F. R. MALLET, *Deputy Superintendent, Geological Survey of India.*

Towards the end of last year specimens of various minerals, which had been discovered in the neighbourhood of Port Blair by Mr. M. V. Portman, Assistant Superintendent, were sent to the Geological Survey Office for examination. Amongst them were found ores of chromium, copper, iron, and sulphur. Later on Mr. Portman himself visited Calcutta, bringing with him further samples. Judging from these, and from the account given by Mr. Portman of the ores as found *in situ*, the indications seemed to be sufficiently promising to make an examination of the ground advisable. I was accordingly directed to proceed to Port Blair and carry out such investigation.

Geological character of the country near Port Blair.

Although it may be assumed with some degree of probability that the geological structure of the Andamans is of very much the same character throughout, the only portion of the islands concerning which we possess any certain knowledge, from direct observation, is that comparatively near Port Blair. Messrs. Kurz[2] and Ball[3] have shown that the strata are mainly sandstone and shale, which have been much altered in places through the intrusion of eruptive rocks.

From Mount Harriet, one of the culminating points of a ridge to the north of the station, and about 1,200 feet above the sea, a wide bird's-eye view can be obtained, which gives a good general idea of the orography, and indeed of the geology too, of the surrounding country. The island for many miles to the north of the harbour and Port Mouat is traversed by a number of parallel ridges, running a little east of north, which, like the Mount Harriet ridge itself, are probably formed, in the main, of sandstone and shale, with rather a high dip in most places. The sandstone is generally fine-grained, of yellowish-white, grey, or greenish tints. Nests of lignite have been found in it here and there. Occasionally it includes subordinate layers of conglomerate, composed of small, well-rolled, mostly quartzose pebbles. More or less calcareous beds are also found

[1] *Vide* Mem. Geol. Surv. India, III, pp. 15-16. Rec. Geol. Surv. India, XIV, 71, note.
[2] Report on the vegetation of the Andaman Islands, p. 2.
[3] J. A. S. B., 1870, Vol. XXXIX, Pt. 2, p. 231.

amongst the sandstones, but I am only aware of one band of pure limestone.[1] Between some of the ridges, at least, there are level bottoms of alluvial land. Although this part of the island would seem to be composed very largely of sedimentary strata, eruptive rocks are by no means absent, serpentine, &c., having been met with in several places. The structure of the hills to the south of the harbour appears to be less regular, and this irregularity would seem to be due to the greater development of eruptive rocks there. Of these the most important is serpentine, which occurs both in large masses and in dykes. The north-east part of Rutland island is mainly formed of it, the rock being dark green and often spangled with small crystals of bronzite. Seams of white (triclinic?) felspar, a few inches thick, traverse it here and there, but are not common. There are also occasional thin seams of cellular quartz, containing some earthy oxide of iron, or of manganese, in the cavities. Small layers of brown opal have been met with in the same connection. These seams occur between joints in the serpentine: the jointing is often strongly marked, and, when highly developed in one direction only, gives the rock somewhat the appearance of bedding. Serpentine is also largely developed at Bird's Nest Cape and to the north, at Homfray's Ghát, and other places. Hornblendic, chloritic, and felspathic forms of rock are frequently found in association with it.

On referring to the map of India one sees that the line of elevation constituting the Arakán Yoma is represented further south by the Alguada reef, Preparis and Coco islands, and the Andamans. The orographical connection between the Arakán and Andaman ranges is accompanied by an equally close geological one. The formations of the latter "are extremely similar in appearance to the Negrais rocks of the Arakán Yoma, and in all probability belong to the same group."[2] Serpentinous intrusions are also common in the rocks of both localities.

In as far as any *a priori* opinion can be formed from the above geological connection as to the metallic wealth of the Andamans, such opinion must be of an unfavourable character, as no useful ores are known to occur in the Arakán Yoma. "The only ores [in Burma] which need be noticed for practical purposes," says Mr. Theobald, "are those of iron, tin, lead, copper, antimony, none of which, save iron, are known west of the Sittoung,"[3] and the localities noticed by the same writer, where iron has been worked, are to the east of the Irrawádi. The apparent barrenness of the Arakán hills, however, cannot be taken as conclusively proving that the Andamans are equally unproductive, although certainly tending to suggest that such may be the case.

Hematite, pyrite, and chalcopyrite at Ráng-u-Cháng.

Along the sea coast at Ráng-u-Cháng, a place some miles south of Port Blair, are highly altered or eruptive rocks. Here and there these are traversed by veins, the main constituent of which is hematite, but which include a considerable proportion of pyrite (iron pyrites) and chalcopyrite (copper pyrites) in much smaller quantity. The veins constituted of these ores are very irregular and sometimes

[1] P. 85.
[2] Manual of the Geology of India, Pt. 2, p. 723.
[3] *Supra*, Vol VI, p. 91.

branching, but short and strangulated, none that I saw being traceable for more than a few yards. In one place I observed a mass of pure pyrite more than a foot thick and two feet long, but it could be seen that vein died out completely within a few feet. Although, therefore, individual specimens of somewhat imposing dimensions can be obtained, I saw nothing leading me to suppose that the mineral could be profitably worked. Nothing like a steady vein is to be seen, and it would be obviously hopeless to mine on the chance of meeting with scattered irregular nest-like veins like the above. The same remarks apply to the copper pyrites. The proportion is too small, and the cupriferous veins too irregular, to allow of profitable work, although an occasional lump of some size may be obtained.

In the jungle, perhaps 50 yards from the beach and the above-mentioned veins, Mr. Portman had excavated some tons of ore, from what seems to be a true lode running in a N.—S. direction. At the main excavation the lode is several feet thick at least, but the entire breadth was not exposed at the time of my visit. The ore, taken in bulk, is composed mainly of chloritic quartz and hematite (occurring chiefly as micaceous iron). The other constituents are iron- and copper-pyrites. Although large lumps of good hematite can be obtained (one that I saw contained a couple of cubic feet of mineral free from admixture), the ore in bulk is worthless as an ore of iron, firstly on account of the large proportion of quartz, and secondly on account of the pyrites, which is still more fatal. The quartz might be separated to a considerable extent by picking, but it would be impossible to free the ore from sulphur in this way. To mine in hard rock, and then hand-pick such a sulphurous ore, would be manifestly impracticable, when high-class ore in inexhaustible quantity is to be had on the surface in so many parts of India. The amount of iron pyrites is too small to allow of the ore being worked for sulphur, and the proportion of copper pyrites is quite insignificant, although here and there a lump of some size may be obtained, one piece that I secured containing a couple of pounds of solid ore.

The above is the opinion that I formed on the spot, but I have, since my return to Calcutta, been able to check it by assays of the ore. A quantity, weighing perhaps a couple of tons, and which may be taken as a fair sample of the whole, had been brought in to Port Blair, and at my request Mr. Portman had about three-quarters of the amount broken up small. The broken ore and dust were thoroughly mixed together, and a large bagful taken, which was reduced to powder in the laboratory here and mixed again. On assay it yielded—

	Per cent.		Per cent.
Copper	·10	= Copper-pyrites	·30
Sulphur	10·74	= Iron-pyrites[1]	20·13
Insoluble siliceous residue	37·60		

More than half a million tons of pyrites are now used per annum in England for the manufacture of sulphuric acid. The average percentages of sulphur in the mineral imported from different countries are as follows:—

	Per cent.
Spanish and Portuguese	46 to 50
Westphalian	44·5

[1] After deducting the sulphur in the copper-pyrites.

	Per cent.
Belgian	44
Swedish	42
Italian	35 to 46
Irish	35
Cornish	28

Out of 550,000 tons imported about 1880, 500,000 were from Spain and Portugal.[1] Cornish and Irish pyrites "are, as a rule, cupreous ores, but of very low value. Their chief fault is the poor percentage of sulphur, whereby the cost of carriage and manipulation, &c., is, of course, very largely increased. All payments for storing, carrying, breaking, burning the ore, and treatment of the burnt residue, are as large for weak as for rich qualities, and therefore far heavier, relatively."[2] With reference to the value of these ores, 65,916 tons were raised in the United Kingdom in 1872, valued at £39,470, or £0-11-11$\frac{3}{4}$ a ton: in 1882, 11,074 tons were raised in Ireland, valued at £5,743, or £0-10-4$\frac{1}{2}$ a ton. It will be seen, then, that the poorest class of ore in the English market contains about three times as much sulphur as that of Ráng-u-Cháng, and although the ore derives its value in part from the small amount of copper it contains, which is extracted from the residue after the pyrites is burnt, still it only fetches 10 or 12 shillings a ton. The Ráng-u-Cháng ore would be unsaleable at any price, as the proportion of sulphur is so low that the ore would not support combustion in the kilns. The pyrites could not be concentrated by hand-picking, firstly, because it is too much scattered through the gangue; and secondly, because, being much more brittle than the quartz and hematite with which it is associated, it would be broken during the operation into a powder which would require subsequent washing for its separation. Such 'smalls' do not fetch more than a third the price of pyrites in lumps. At present there is no demand for pyrites in India, but were such to spring up, ore like that hitherto obtained in the Andamans could not possibly contend against that from Spain.

It is well known that many pyritous lodes contain little or no good ore at the surface, but at a moderate depth are rich enough. This, however, is due to the decomposition of the back of the lode, and the carrying down of the valuable constituents in solution as sulphates. The Ráng-u-Cháng ore is perfectly fresh and unchanged close to the surface, and consequently there is no such reason to anticipate an improvement by sinking deeper. The lode may improve below the surface, but there are no grounds for anticipating that it will. The same may be said with reference to the longitudinal extension By excavating along the course of the lode it may be found richer in some parts than where it has been tried, but it is quite as likely that it may be found very much the same,[3] or even poorer. I recommended that a cut should be made across the lode at the present excavation, so as to ascertain the entire width, but at the time labour could not be spared.

[1] A Manual of the Alkali Trade, by John Lomas, p. 13.

[2] *Ibid.*, p. 11.

[3] Mr. Portman had made a smaller excavation at some distance from the main one, and the ore was of the same character.

The ore was also assayed for gold, and found to contain a minute trace only, with no silver.

Pyritous vein at south Corbyn's cove.

A little south of Corbyn's cove the road to Brookesabád crosses a vein, which, on the west side of the road, is five yards thick. The rock is a ferruginous and chloritic quartz containing a little iron pyrites disseminated through it, and copper pyrites in still smaller amount. Between the road and the sea the vein is less definitely marked, being represented by several irregular smaller veins. One of these consists of quartz containing a fair proportion of copper pyrites[1] mixed with iron pyrites. As the vein is two feet thick at one point, large blocks of ore can be obtained presenting rather an attractive appearance, but within a few feet the vein thins out to two or three inches, then thickens somewhat again, and a few feet further on dies out altogether. Taking the main vein in bulk, the proportion of copper ore is very low, while as a source of sulphur the amount of pyrites is quite insignificant. The pyritous quartz was assayed for gold (and silver) and found to contain none.

The vein runs about S. 20° W., and may possibly be a continuation of that at Ráng-u-Cháng. If so, there is a considerable change in the character of the ore, that at Corbyn containing much less iron and more copper.

Clay-ironstone nodules in shale.

Some of the shales in and about Port Blair contain lenticular nodules of clay-ironstone of varying size up to 6 or 8 inches diameter. They are not sufficiently plentiful, however, to be of any practical use.

Magnetic iron sand.

A specimen of black iron-sand from Havelock Island, which was sent to me by Colonel Cadell, the Chief Commissioner, was found to consist of magnetite.

Chromite at Chakargaon.

In Volume XVI, p. 204, an extract is given from an official letter of Mr. Portman's to the Chief Commissioner, describing the position in which a large block of chromite, and some smaller pieces, were found at the village of Chakargaon. Mr. Portman pointed out the locality to me, of which I subsequently made a close examination. The village is situated at the foot of an irregular line of rounded hill which runs south-westwards from Mount Haughton, and which is formed of sandstone and shale with some subordinate calcareous strata. The large block of chromite was found a little south of the village by the side of a small watercourse. It was a loose piece resting on, and partly embedded in, a talus composed of sandstone fragments. The other lumps were found close by in a similar position. Just south of the block is a somewhat larger watercourse, in which an almost continuous section of the rocks is exposed from the foot of the hill to near the top. They are exclusively shale and sandstone, with a high dip to the south-east, and no fragments of serpentine (or of chromite) are to be found in the stream. The hill is, I believe, beyond doubt composed entirely of shale and sandstone from the position in which the chromite was found to the summit. As there is every reason to suppose that the chromite here, as in so many other parts of the world, occurs in connection with serpentine, it is, I think, certain that

[1] About 30 per cent., or 10 per cent. of copper.

the blocks did not come from the hill-side above. From the site of the block there is a gentle slope downwards for about 20 yards, at the foot of which an alluvial flat begins, beneath which there may be a mass of chromiferous serpentine which formerly extended over the position of the block, but which has been cut away by denudation. At the very foot of the hill, indeed, there is a mass, some feet across, of a serpentinous rock mixed with calcite.[1] Similar rock can be traced at intervals along the foot of the hill, both to the south-west and the north-east, but although I followed it for about a mile, not a single piece of chromite was to be seen in connection with it.[2] I had a trench excavated across the outcrop of this rock at Chakargaon, but no chromite had been met with at the time I left Port Blair. I think the continuation of this trench would be the best way to carry on the work, although I cannot say that I feel very sanguine of success. That there is a deposit of chromite concealed somewhere not far from the spot where the blocks were found, is clear, but that such deposit is a large or persistent one is more doubtful. If a strong vein, or number of lenticular masses extending along a certain line, existed of such ore, which is not liable to decomposition, the mineral would most probably betray itself by fragments along the outcrop. Yet none such have been found except in the one spot.

Chromite at Rutland Island.

The occurrence of the mineral at Chakargaon being an indication that the Andamanese serpentine is more or less chromiferous, it seemed to me that the localities where serpentine was known to occur elsewhere should be examined. With this view I went with Mr. Portman in the G. S. *Celerity* to Rutland Island, the north-eastern part of which is almost wholly composed of the rock in question.[3] I ascended four different streams, but in none of them was a single pebble of chromite to be found. Mr. Dawson, however, in washing for platinum in three of these streams,[4] obtained more or less fine black sand, which on examination proved to be the mineral we were in search of. On the sea beach, at the mouth of one of the streams, similar sand, which had been brought down by the current and then beaten back by the waves, was met with in layers more than an inch thick. When the sand from all these localities is examined under the microscope, it is seen that, in considerable proportion, the grains are well-formed octahedral crystals, with the edges scarcely at all rounded by attrition. By pounding, sifting, and elutriating the massive chromite of Chakargaon, a sand can be artificially produced which, to the naked eye, resembles that of Rutland Island, except that it is less lustrous in appearance. Under the microscope, however, no crystals can be detected, the sand being made up of irregular broken fragments. It is the crystalline facets of the Rutland Island sand which gives it its lustre.

Taking, then, into account that not a single fragment of massive chromite was found, and that the sand could not, apparently, have been produced from the comminution of such, I am strongly inclined to believe that the mineral occurs

[1] The "diorite and porphyritic trap," mentioned at p. 204, Vol. XVI, do not exist.

[2] The hill has been completely cleared of jungle, so that the outcrop is not concealed by vegetation.

[3] P. 80.

[4] P. 85.

disseminated through the serpentine in minute crystals, and therefore in a form of no practical value. I should mention that one of the streams ascended was not more than half a mile long altogether, the place where the sand was obtained being about midway in its course. Even, then, putting the crystalline character of the sand out of count, it is difficult to believe that the substance in mass could be so completely and finely comminuted during so short a journey.

Search for chromite elsewhere.

I also examined the serpentine at Bird's Nest Cape, at Homfray's Ghát, in the hills south of Corbyn and Protheroepur, and in more than one locality north of the harbour, but found no massive chromite at any of those localities. I cannot help suspecting, therefore, that the mineral is not very plentiful in that part of the Andamans. The contrast between the streams in Rutland Island and those in the Hánlé Valley in Ladák,[1] where also serpentine is largely developed, is very marked. In the latter, lumps of chromite, often many pounds in weight, are scattered about in plenty.

Search for platinum.

In the not very numerous cases in which platinum has been traced to its parent rock in other parts of the world, it appears to have been found, in most instances, either in auriferous quartz veins traversing crystalline rocks, or (accompanied frequently by chromite) in serpentine. Search was consequently made for it at Rutland Island. Mr. Dawson, the gunner of the *Celerity*, who had had many years' experience in Australian gold-washing, washed in three different streams, but not a single particle of the metal was found.

Limestone.

About 300 yards north-east of Chota Protheroepur a band of massive cream-coloured and greenish-white limestone, containing veins of calcspar, outcrops at the foot of the hill. The strata dip at a high angle, and the band is several yards thick, but does not show above the alluvium for more than 30 yards or so along the strike. The same band outcrops again, however, with a thickness of 10 or 12 yards, in a hillock about half a mile N. 35° E. of the village. Although it is only exposed at the south-west end of the hillock, it probably extends the whole length, for say 100 yards, beneath the surface soil; if so, there is a large supply above the level of the alluvium, and consequently available by open quarry. On the north-west side of the village of South Corbyn the rock outcrops a third time, forming a small hillock. The band seems to be about 8 or 10 yards thick, dipping at 70°: part of the limestone there is reddish.

An analysis of the rock from the first-named outcrop gave—

Carbonate of lime	96·45
„ „ magnesia (by diff.)	·09
„ „ iron	1·16
Insoluble residue (mostly sand)	2·30
	100·00

As there appears to be a considerable (although not unlimited) supply available from free-draining quarries, and a much larger quantity by going beneath

[1] Memoirs, G. S. I., Vol. V, p. 166.

the level of the alluvium, it is worth consideration whether this limestone could not be profitably exported to Calcutta.[1] The most distant outcrop is less than a mile from the sea at Corbyn, where the stone could be loaded into boats and taken round to the harbour Lime has for some years past been imported into Calcutta from Katni, in the Jabalpur district; if it pays to transport it more than seven hundred miles by railway, it would certainly seem that it ought to pay to transport the stone about the same distance by the much cheaper sea carriage[2] The Andaman stone is fully equal in purity to the best of that from Katni, an analysis of the latter yielding—

Carbonate of lime	94 65
" " magnesia (by diff.)	2 98
" " iron	·58
Insoluble residue	1·79
	100·00[3]

Besides its use for lime, the Andaman stone would make a good cream-coloured marble. It could be quarried in large blocks, or in slabs, several feet in length and breadth. A reddish marble could also be obtained.

While on the subject of lime, I may mention that there is an inexhaustible supply of volcanic ash, or puzzolana, at Barren Island, similar to that obtained from some of the extinct volcanoes of Central France, and so largely used there as an ingredient of hydraulic mortar.

Serpentine.

Mr. Ball has already alluded to the serpentine at Homfray's Ghát, from an economic point of view.[4] The stone is mostly weathered and shattery on the surface, and to obtain it in a perfectly sound condition it would be necessary to quarry some distance into the hill-side. Scattered over the hill, however, especially near the top, are numerous large blocks of stone which have resisted disintegration to a great extent, and some of which are fairly sound, although, being more or less fissured, it is doubtful if slabs of large size could be cut from them. But if serpentine should be locally required in small quantity, for the supply of which it would not pay to open a regular quarry, these blocks would be worth attention.

Serpentine is known to exist in many other places, but, taking quality into account, there is none, perhaps, more favourably situated than that just mentioned.

Jasper.

In the midst of some reclaimed land at Aberdeen Mr. Portman discovered a large mass of variegated red jasper, which has doubtless been exposed through the denudation of the softer rocks around it. It would make a handsome ornamental stone if polished, but in cutting large slabs there would be some risk of meeting with drusy cavities which occur here and there through the rock.

[1] The lime now used at Port Blair is made from coral, but I was informed by Colonel Protheroe, the Deputy Superintendent, that it is of rather inferior quality, as the salt cannot be thoroughly washed out of the raw material, and subsequently effloresces out of the mortar.

[2] In this connection it may be noted that 100 maunds of (pure) limestone yields 56 maunds of quicklime and 73 of slaked lime.

[3] Vol. XVI, p. 112.

[4] J. A. S. B., 1870, Vol. XXXIX, Pt. 2, p. 237.

The Intertrappean beds *in the* Deccan *and the* Laramie group *in* Western North America, *by* M. NEUMAYR. (*Translated from the Neues Jahrbuch für Mineralogie, etc., 1884, Vol. I.*)

White's recent work on the fossil land and fresh-water shells of North America[1] gives for the first time a good account of these forms, the literature concerning which was formerly so scattered as only to be studied with much trouble; many relations are shown to extra American forms, amongst which I propose to consider at least one, since the subject not only possesses interest itself, but also serves the purpose of correcting a former erroneous opinion of mine.

Many years ago Hislop[2] described several shells occurring in some fresh-water beds at Nagpur interstratified with the enormous basalt masses of the Indian peninsular, known as the Deccan trap. The most generally received opinion is that these beds belong to a period on the boundary between the cretaceous and tertiary epochs; since, however, a *Unio* resembling our European *U. flabellatus* was found, and the genus *Acella,* which at that time was only known in the pliocene of Slavonia and living in North America, is represented, I ventured to point out the possibility that the intertrappean beds might belong to the later tertiaries.[3] A comparison between the fossils of these intertrappean beds and those of the Laramie beds of North America which lie between the chalk and eocene shows very close relations between the two, and I can no longer hold my former opinion in the face of these results.

Though the number of the genera of the fresh-water shells of Nagpur is far from small, the greater part is so indifferent, or the preservation and description so insufficient, as to render only the smaller half of use for judging of the character of the fauna; amongst these the most important is *Physa prinsepi*, Sow., which reminds one of the large kinds of Physa of the Paris and London eocene, but which is also closely related to the Laramie fossils of America, as *Ph. copei*, Wh., and *Ph. disjuncta*, Wh. The above-mentioned exceedingly attenuated *Limneæ* which have been grouped together in the subgenus *Acella,* and which are represented in the Laramie beds by *A. haldemani*, Wh., form another striking occurrence; *Paludina virapai*, Hisl., closely resembles *Hydrobia anthonyi*, M. and H. Among the snails a few other similar cases occur, the forms, however (*Paludina acicularis—Hydrobia recta, Paludina conoidea—Hydrobia subconica*), are so little distinctive that I place small value on them. The Valvata are the only characteristic gasteropod types of Nagpur not represented in the Laramie beds of North America.

Among the mussels the Unios are foremost; they have much in common in general appearance, but *U. carteri*, Hisl., a form of the type of the European *U. flabellatus*, is the only one that shows any close connection with *U. gonionotus*, Wh., and *U. gonioumbonatus*, Wh., of North America. Finally, *Corbicula ingens*, Hisl., is remarkably similar to *Corbicula cleburni*, White.

[1] White, a review of non-marine fossil mollusca of N. America. Extract from the annual report of the Director of the U. S. Geological Survey, 1881-82.

[2] On the tertiary deposits associated with trap-rock in the East Indies. Quart. Journ. Geol. Soc., 1860, page 154.

[3] Neumayr und Paul, Congerien- und Paludinen-schichten Westslavoniens. Abhandlungen der geolog. Reichsanstalt, Vol. VII, 1875.

Whether in the one or the other case there may be actual identity, or whether it is, as I think more probable, a case of near related vicarious species, I cannot decide. On the whole the following forms may be correlated :—

Nagpur.	Laramie.
Physa prinsepi	*Ph. copei.*
„ „ var. *elongata*	*Ph. disjuncta.*
Acella attenuata	*Ac. haldemani.*
Paludina virapai	*Hydrobia anthonyi.*
Unio carteri	*Unio gonionotus.* „ *gonioumbonatus.*
Corbicula ingens	*Corb. cleburni.*

These facts justify the conclusion that the intertrappean beds of India are the most nearly related of any fresh-water beds yet known to the Laramie beds of North America—a result which agrees well with the most generally received opinions with regard to the age of both. Whether both belong to cretaceous or tertiary formations the fresh-water shells give no decided means of judging; many forms—for example, the large *Physa*, *Melania wyomingensis*, and others of the Laramie beds—are nearly related to tertiary types, but side by side with this are found surprising relations to European cretaceous forms. I will not, however, enter here more particularly upon this point, since Dr. Tausch is at present engaged in my institute upon studies which will yield evidence in this direction.

ADDITIONS TO THE MUSEUM.

252 specimens of metallic ores, 18 of rocks and 100 of fossils, from New South Wales; also 9 Geological maps and sections, illustrating the geology of New South Wales.

PRESENTED BY THE MINISTER FOR MINES, SYDNEY.

A block of 'boghead mineral,' from Hartley, New South Wales.

PRESENTED BY THE AUSTRALIAN KEROSINE OIL AND MINERAL CO., SYDNEY.

Antimony ores from New South Wales, and specimens illustrating the smelting of the same.

PRESENTED BY H. HERRENSCHMIDT, ESQ., SYDNEY.

Cobalt and manganese ores from New South Wales, and specimens illustrating their treatment.

PRESENTED BY MESSRS. HERRENSCHMIDT AND CONSTABLE, SYDNEY.

An ingot of star-antimony from New South Wales.

PRESENTED BY JOHN S. MELVILLE, ESQ., SYDNEY.

37 models of large Australian gold nuggets; 6 cores from diamond drill borings and 10 geological maps, illustrating the geology of Victoria.

PRESENTED BY THE MINISTER FOR MINES, VICTORIA.

A collection of minerals, ores and fossils from Victoria.

PRESENTED BY THE BALLARAT SCHOOL OF MINES.

One slab of Chunar sandstone, 5′ × 5′, and 4 smaller ones, from Chunar.

PRESENTED BY THE BENGAL STONE CO., CALCUTTA.

A specimen of bornite with galena, from Bairuki, Deogarh, Bengal.

PRESENTED BY MESSRS. BIRD & CO., CALCUTTA.

Upper Vindhyan sandstone with dentritic markings (Chhardar stone) from Punnah, Central India, and a specimen of calcareous tufa containing roots, found near the Ken river, Punnah, Central India.

PRESENTED BY THE MAHARAJA OF PUNNAH.

A specimen of sapphire with tourmaline, from Pádar, Káshmir.

PRESENTED BY H. H. THE MAHARAJA OF KASHMIR.

A specimen of cervantite, from Moulmein.

PRESENTED BY G. DAWSON, ESQ., MOULMEIN.

An ingot of tin, from Mount Bischoff ore, Tasmania.

PRESENTED BY THE TASMANIAN COMMISSIONER, CALCUTTA EXHIBITION, 1883-84.

Specimens of bornite with galena; chalcocite, with malachite; and galena with cerussite and malachite, from Bairuki, Deogarh, Bengal.

PRESENTED BY MESSRS. BIRD & CO., CALCUTTA.

14 specimens of 'Certaldo marble' (gypsum artificially hardened), from Tuscany, Italy.

PRESENTED BY DUFF BRUCE, ESQ., CALCUTTA.

A series of ores and minerals from Tasmania.

PRESENTED BY THE TASMANIAN COMMISSIONER, CALCUTTA EXHIBITION, 1883-84.

3 specimens of meteorites, and 22 of rocks with 12 microscopic slides, from France.

PRESENTED BY PROFESSOR DAUBRÉE (MUSÉUM D'HISTOIRE NATURELLE), PARIS.

A collection (158) tertiary fossils from Australia and New Zealand.

PRESENTED BY J. F. BAILEY, ESQ., MELBOURNE.

ADDITIONS TO THE LIBRARY.

FROM 1ST JANUARY TO 31ST MARCH 1884.

Titles of Books. *Donors.*

ALBRECHT, PAUL.—Épiphyses Osseuses sur les Apophyses Épineuses des Vertèbres d'un Reptile (Hatteria Punctata, Gray). 8° Pam. Bruxelles, 1883.

THE AUTHOR.

„ Sur la Fente Maxillaire double sous-muqueuse et les 4 Os Intermaxillaires de l'Ornithorynque Adulte Normal. 8° Pam. Bruxelles, 1883.

THE AUTHOR.

„ Sur les Copulæ Intercostoïdales et les Hémisternoïdes du Sacrum des Mammifères. 8° Pam. Bruxelles, 1883.

THE AUTHOR.

BADEN-POWELL, B. H., and KIPLING, J. L.—Descriptive catalogue of Punjab contributions to the Calcutta International Exhibition, 1883. 8° Calcutta, 1883.

B. H. BADEN-POWELL.

BERTRAND, ÉMILE.—Nouveau minéral des environs de Nantes. 8° Pam. Paris, 1883.

THE AUTHOR.

BROGGER, W. C.—Die Silurischen Etagen 2 und 3 im Kristianiagebiet und auf Eker. 8° Kristiania, 1882.

ROYAL UNIVERSITY, NORWAY.

Titles of Books. *Donors.*

BRONN'S Klassen und Ordnungen des Thier-Reichs. Band I. Protozoa. Lief. 20—25. Band VI, Abth. III, Reptilien, Lief. 41. 8° Leipzig, 1883-1884.

CABASSE, BART.—Descriptive catalogue of exhibits from Tonquin at the Calcutta International Exhibition, 1883-84. 8° Calcutta, 1883.

COMMISSIONER FOR TONQUIN.

CALCUTTA INTERNATIONAL EXHIBITION, 1883-84. Official Catalogue. 3rd Issue. 8° Calcutta, 1883.

CAPPER, JOHN.—Hand-book to the Ceylon Court, Calcutta International Exhibition. 8° Colombo, 1883.

COMMISSIONER FOR CEYLON.

Catalogue of a choice and valuable collection of ancient and modern Japanese curios and works of art; exhibited at the Calcutta International Exhibition, 1883, by Messrs. Kuhn & Co. of Yokohama, and formed by them during 15 years' residence and travel in Japan. 8° Yokohama, 1883.

MESSRS. KUHN & CO.

Catalogue of exhibits in the Victorian Court at the Calcutta International Exhibition, 1883-84. 4° Melbourne, 1883.

COMMISSIONER FOR VICTORIA.

Catalogue of the exhibits in the Tasmania Court at the Melbourne International Exhibition, 1880. 8° Hobart Town, 1880.

COMMISSIONER FOR TASMANIA.

Coal-Land Law, and regulations thereunder, 1873 and 1882. 8° Pam. Washington, 1873 and 1882.

HOME DEPARTMENT.

COPE, E D.—Systematic Catalogue of Vertebrata of the Eocene of New Mexico, collected in 1874. 8° Pam. Washington, 1875.

HOME DEPARTMENT.

DALL, W. H.—Report on Mount St. Elias. 4° Pam. Washington, 1875.

HOME DEPARTMENT.

DE KERHALLET, C. P.—The Azores or Western Islands. Translated by George M. Totten. 8° Pam. Washington, 1874.

HOME DEPARTMENT.

DRUMMOND, WILLIS.—Segregation of Mineral and Agricultural Lands. 8° Pam. Washington, 1872.

HOME DEPARTMENT.

DUMONT, J. B.—Synoptical Tables of Modern Chemistry. Vol. I. Inorganic Chemistry. Part III, Metals. 8° Calcutta, 1883.

FAIJA, HENRY.—Portland Cement for users. 2nd edition. 8° London, 1884.

FORSYTH, JAMES W., and GRANT, F. D.—Report on an expedition up the Yellowstone river made in 1875. 8° Pam. Washington, 1875.

HOME DEPARTMENT.

FRANKLAND, P. F.—Agricultural Chemical Analysis. 8° London, 1883.

GANOT'S Elementary Treatise on Physics experimental and applied, for the use of colleges and schools. Translated and edited by E. Atkinson. 10th edition. 8° London, 1881.

Titles of Books. *Donors.*

GANOT'S Natural Philosophy for general readers and young persons. Translated and edited by E. Atkinson. 4th edition. 8° London, 1881.

GILBERT, G. K.—Report on the Geology of the Henry Mountains. 2nd edition. 4° Washington, 1880.

HOME DEPARTMENT.

GORRINGE, HENRY H.—The Rio de la Plata. 8° Pam. Washington, 1875.

HOME DEPARTMENT.

GRESLEY, W. S.—A glossary of terms used in Coal Mining. 8° London, 1883.

HARTLEY, F. W.—The Gas Analyst's Manual. 8° London, 1879.

HECTOR, JAMES.—Hand-book of New Zealand. 3rd edition. 8° Wellington, 1883.

COLONIAL MUSEUM, WELLINGTON.

HILGARD, EUGENE W., & HOPKINS, F. V.—Reports upon the specimens obtained from borings made in 1874 between the Mississippi River and the Lake Borgne, at the site proposed for an outlet for flood waters. 8° Pam. Washington, 1878.

HOME DEPARTMENT.

HUMPHREYS, A. A., and ABBOT, H. L.—Report upon the Physics and Hydraulics of the Mississippi River. 4° Washington, 1876.

HOME DEPARTMENT.

JUST, THOMAS C.—Tasmania! A description of the Island of Tasmania and its resources. Compiled for the Sydney International Exhibition, 1879. 8° Launceston, 1879.

COMMISSIONER FOR TASMANIA.

.. The official hand-book of Tasmania compiled under the instructions of the Government Board of Immigration of that Colony. 2nd edition. 8° Launceston, 1883.

COMMISSIONER FOR TASMANIA.

KING, WILLIAM.—The Singareni Coal Field and others adjoining to or in the Madras Presidency. 8° Pam. Madras, 1883.

THE AUTHOR.

LUDLOW, WILLIAM.—Report of a reconnaissance from Carroll, Montana territory, on the Upper Missouri, to the Yellowstone National Park, and return, made in the summer of 1875. 4° Washington, 1876.

HOME DEPARTMENT.

" Report of a reconnaissance of the Black Hills of Dakota, made in the summer of 1874. 4° Washington, 1875.

HOME DEPARTMENT.

MARCOU, JULES.—Note sur la Géologie de la Californie. 8° Pam. Paris, 1883.

THE AUTHOR.

MASON, REVD. F.—Burma, its people and productions; or, notes on the fauna, flora, and minerals of Tenasserim, Pegu, and Burma. Vol. I, Geology, Mineralogy, and Zoology; Vol. II, Botany. Re-written and enlarged by W. Theobald. 8° Hertford, 1882-83.

CHIEF COMMISSIONER, BRITISH BURMA.

McKean's Patent Rock Boring Machinery. 4° Glasgow, 1883.

THE EXHIBITORS.

Titles of Books. *Donors.*

MILLER, WM. ALLEN.—Introduction to the study of Inorganic Chemistry. New edition. 8° London, 1879.

MUELLER, FERDINAND VON.—Observations on new vegetable fossils of the Auriferous Drifts. 2nd Decade. 8° Melbourne, 1883.

DEPARTMENT OF MINES AND WATER SUPPLY, MELBOURNE.

MUKHARJI, T. N.—A hand-book of Indian products, art-manufactures, and raw materials. 8° Calcutta, 1883.

THE AUTHOR.

NEW SOUTH WALES, its progress and resources; and official catalogue of exhibits from the Colony forwarded to the International Exhibition of 1883-84 at Calcutta. 8° Sydney, 1883.

COMMISSIONER FOR NEW SOUTH WALES.

NEWTON, HENRY, and JENNEY, WALTER P.—Report on the geology and resources of the Black Hills of Dakota. 4° Washington, 1880.

HOME DEPARTMENT.

PALEONTOLOGIE Française. 1re Série, Animaux Invertébrés, Terrain Crétacé, livr. 30.
„ „ „ „ Jurassique, „ 65-66. 8° Paris, 1884.

PEACOCK, R. A.—Saturated steam, the motive power in volcanoes and earthquakes; great importance of electricity. 2nd edition. 8° London, 1882.

THE AUTHOR.

PENNING, W. HENRY.—Engineering Geology. 8° London, 1880.

QUENSTEDT, FR. AUG.—Handbuch der Petrefaktenkunde. Auflage III. Lief. 13-14. 8° Tübingen, 1883.

REPORT on the Icelandic committee from Wisconsin on the character and resources of Alaska. 8° Pam. Washington, 1875.

HOME DEPARTMENT.

REPORT on the two kinds of coal submitted by the Chesapeake and Ohio Railroad Coal Agency. 8° Pam. Washington, 1878.

HOME DEPARTMENT.

REPORT upon the Yellowstone National Park for 1872, 1877, 1879, and 1880. 8° Pam. Washington, 1873-1881.

HOME DEPARTMENT.

REUSCH, HANS. H.—Silurfossiler og Pressede Konglomerater i Bergensskifrene. 8° Kristiania, 1882.

ROYAL UNIVERSITY, NORWAY.

SCHUMACHER, E.—Erläuterungen zur Geologischen Karte der Umgegend von Strassburg. With a map. 8° Pam. Strasburg, 1883.

KAIS. UNIVERS. BIBLIOTHEK.

SPECIAL catalogue of exhibits in the Tasmanian Court at the Calcutta International Exhibition, 1883-84. 8° Calcutta, 1883.

COMMISSIONER FOR TASMANIA.

STANLEY, D. S.—Report on the Yellowstone Expedition of 1873. 8° Pam. Washington, 1874.

HOME DEPARTMENT.

Titles of Books. *Donors.*

STOW, J. P.—South Australia: its history, productions, and natural resources. Written for the Calcutta Exhibition. 8° Adelaide, 1883.

COMMISSIONER FOR SOUTH AUSTRALIA.

SUPPLEMENTARY instructions in relation to Mineral and Agricultural Lands under the Mining Acts of Congress. 8° Pam. Washington, 1871.

HOME DEPARTMENT.

THE Marshall Group, North Pacific Islands. 8° Pam. Washington, 1870.

HOME DEPARTMENT.

ULRICH, G. H. F.—Notes and observations on the Nuggetty Reef, Maldon. (Quarter sheet 14, N. W.) 8° Pam. Melbourne.

COMMISSIONER FOR VICTORIA.

United States Mining Laws, and regulations thereunder, 1872, 1879, and 1881. 8° Pam. Washington, 1872, 1879, and 1881.

HOME DEPARTMENT.

VERBEEK, R. D. M.—Topographische en Geologische Beschrijving van een gedeelte van Sumatra's Westkust. With Folio Atlas. 8° and Fol. Batavia, 1883.

DIRECTOR OF INSTRUCTION, BATAVIA.

WARREN, G. K.—An essay concerning important physical features exhibited in the valley of the Minnesota river, and upon their signification. 8° Pam. Washington, 1874.

HOME DEPARTMENT.

WEBSTER'S Patent Aluminium Metals. 8° London, 1883.

THE EXHIBITORS.

WEX, GUSTAV.—First and second treatises on the decrease of water in springs, creeks, and rivers, contemporaneously with an increase in height of floods in cultivated countries. 8° Pam. Washington, 1880-81.

HOME DEPARTMENT.

WHITE, C. A.—Preliminary report upon Invertebrate Fossils collected by the expeditions of 1871, 1872, and 1873, with descriptions of new species. 8° Pam. Washington, 1874.

WHITFIELD, R. P.—Preliminary report on the Palæontology of the Black Hills. 8° Pam. Washington, 1877.

HOME DEPARTMENT.

PERIODICALS, SERIALS, &c.

American Journal of Science. 3rd Series, Vol. XXVI, No. 156, to XXVII, No. 158. 8° New Haven, 1883-1884.

THE EDITORS.

Annalen der Physik und Chemie. Neue Folge, Band XX, heft 4, No. 12*b*; and XXI, Nos. 1—2. 8° Leipzig, 1883-1884.

Annales des Sciences Géologiques. Tome XIV, Nos. 2—4. 8° Paris, 1883.

Annales des Sciences Naturelles. 6^me^ Série, Botanique, Vol. XVI, Nos. 1—6, and XVII, No. 1: 6^me^ Série, Zoologie et Paléontologie, Vol. XV, Nos. 2—4. 8° Paris, 1883-1884.

Titles of Books. *Donors.*

Annals and Magazine of Natural History. 5th Series, Vol. XIII, Nos. 73—75. 8° London, 1884.

Athenæum. Nos. 2929—2940. 4° London, 1883-1884.

Beiblätter zu den Annalen der Physik und Chemie. Band VII, Nos. 11—12, and VIII, No. 1. 8° Leipzig, 1883-1884.

Bibliothèque Universelle. Archives des Sciences Physiques et Naturelles. 3me Période, Tome X, Nos. 10—12. 8° Genève, 1883.

Bibliothèque Universelle et Revue Suisse. 3me Période, Tome XX, Nos. 59—60, and XXI, No. 61. 8° Lausanne, 1883-1884.

Botanisches Centralblatt. Band XVI, Nos. 10—13, and XVII, Nos. 1—8. 8° Cassel, 1883-1884.

Chemical News. Vol. XLVIII, Nos. 1255—1257, and XLIX, Nos. 1258—1266. 4° London, 1883-1884.

Colliery Guardian. Vol. XLVII, Nos. 1197—1208. Fol. London, 1883-1884.

Das Ausland. Jahrg. LVI, Nos. 50—52, and LVII, Nos. 1—7. 4° Munchen, 1883-1884.

Geological Magazine. New Series, Decade III, Vol. I, Nos. 1—2. 8° London, 1884.

Iron. Vol, XXII, Nos 570—572, and XXIII, Nos. 573—581. Fol. London, 1883-1884.

Journal of Science. 3rd Series, Vol. V, No. 120, and VI, No. 121. 8° London, 1883-1884.

THE EDITOR.

JUST, LEOPOLD—Botanischer Jahresbericht. Jahrg. IX, Abth. I, heft 1. 8° Berlin, 1883.

London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science. 5th Series, Vol. XVII, Nos. 103—105. 8° London, 1884

Mining Journal with Supplement. Vol LIII, Nos. 2520—2524, and LIV, Nos. 2525—2531. Fol. London, 1883-1884.

Naturæ Novitates. Nos. 24—25 (1883); and Nos. 1—3 (1884). 8° Berlin, 1883-1884.

Nature. Vol. XXIX, Nos. 737—748. 4° London, 1883-1884.

Neues Jahrbuch für Mineralogie, Geologie und Palæontologie. Jahrg. 1884, Band I, heft 1—2. 8° Stuttgart, 1884.

Petermann's Geographische Mittheilungen. Band XXIX, No. 12, and XXX, Nos. 1—2. 4° Gotha, 1883-1884.

Professional Papers on Indian Engineering. 3rd Series, Vol. I, No. 4. flsc. Roorkee, 1883.

THOMASON COLLEGE OF CIVIL ENGINEERING.

Quarterly Journal of Microscopical Science. New Series, Vol. XXIV, No. 93. 8° London, 1884.

Zeitschrift für Naturwissenschaften. 4th Series, Band II, heft 5. 8° Halle, 1883.

GOVERNMENT SELECTIONS, REPORTS, &c.

ASSAM.—Report on the Census of Assam for 1881. flsc. Calcutta, 1883.

REVENUE AND AGRICULTURAL DEPARTMENT.

BENGAL.—HUNTER, W. W.—Statistical Account of Bengal. Vols. I—XX. 8° London, 1875-1877.

GOVERNMENT OF BENGAL.

BOMBAY.—Gazetteer of the Bombay Presidency. Vol. XV, pts. 1—2. 8° Bombay, 1883.

BOMBAY GOVERNMENT.

Titles of Books. *Donors.*

BOMBAY.—Report on the Administration of the Bombay Presidency for 1882-83. flsc. Bombay, 1884.

BOMBAY GOVERNMENT.

.. Selections from the Records of the Bombay Government. New Series, No. 157. 8° Bombay, 1882.

BOMBAY GOVERNMENT.

BRITISH BURMA.—Report on the Administration of British Burma during 1882-83. flsc. Rangoon, 1883.

CHIEF COMMISSIONER, BRITISH BURMA.

HYDERABAD.—Report on the Administration of the Hyderabad Assigned Districts for 1882-83. flsc. Hyderabad, 1883.

RESIDENT, HYDERABAD.

INDIA.—Annual Statement of the Trade and Navigation of British India with Foreign Countries, and of the Coasting Trade of the several Presidencies and Provinces in the year ending 31st March 1883. Vol. II, Coasting Trade. 4° Calcutta, 1884.

GOVERNMENT PRINTING PRESS.

„ List of Officers in the Survey Departments, corrected to 1st January 1884. flsc. Calcutta, 1884.

REVENUE & AGRICULTURAL DEPARTMENT.

„ List of publications and maps relating to Forest Administration in India, sent to the Edinburgh International Forestry Exhibition of 1884. 8° Pam. Calcutta, 1884.

HOME DEPARTMENT.

„ Registers of Original Observations in 1883, reduced and corrected. June to August 1883. 4° Calcutta, 1884.

METEOROLOGICAL REPORTER TO GOVERNMENT OF INDIA.

„ Report on the Administration of the Persian Gulf Political Residency and Muscat Political Agency for 1882-83. No. 191. 8° Calcutta, 1883.

FOREIGN DEPARTMENT.

„ Report on the Census of the Baroda Territories, 1881. flsc. Bombay, 1883.

REVENUE AND AGRICULTURAL DEPARTMENT.

MADRAS.—Report on the Administration of the Madras Presidency for 1882-83. flsc. Madras, 1883.

MADRAS GOVERNMENT.

N.-W. PROVINCES.—Statistical, descriptive and historical account of the North-Western Provinces of India. Vol. IX. 8° Allahabad, 1883.

GOVERNMENT OF THE NORTH-WESTERN PROVINCES.

PUNJAB.—IBBETSON, DENZIL CHARLES JELF.—Report on the Census of the Punjab, taken on the 17th of February 1881. Vols. I—III. 4° Lahore, 1883.

REVENUE & AGRICULTURAL DEPARTMENT.

„ Report on the Administration of the Punjab and its Dependencies for 1882-83. flsc. Lahore, 1884.

PUNJAB GOVERNMENT.

TRANSACTIONS, PROCEEDINGS, &c., OF SOCIETIES, SURVEYS, &c.

Titles of Books. *Donors.*

BERLIN.—Annales de la Société Géologique de Belgique. Tome IX. 8° Berlin, 1881-1882.
THE SOCIETY.

BOMBAY.—Journal of the Bombay Branch of the Royal Asiatic Society. Vol. XVI, No. 42. 8° Bombay, 1884.
THE SOCIETY.

BRUSSELS.—Annales de la Société Royale Malacologique de Belgique. 3me Série, Tome II. 8° Bruxelles, 1882.
THE SOCIETY.

" Procès-Verbaux des Séances de la Société Royale Malacologique de Belgique. Tome XI. pp. 155—266, and Vol. XII, pp. 1—108. 8° Bruxelles, 1882-1883.
THE SOCIETY.

" Bulletin de la Société Royale Belge de Géographie. Année VII, No. 5. 8° Bruxelles, 1883.
THE SOCIETY.

BUDAPEST.—Földtani Közlöny. Kötet XIII, füzet 4—6. 8° Budapest, 1883.
THE INSTITUTE.

" Mittheilungen aus dem Jahrbuche der Kön. Ungarischen Geologischen Anstalt. Band VI, heft. 5—6. 8° Budapest, 1883.
THE INSTITUTE.

CALCUTTA.—Journal of the Asiatic Society of Bengal. New Series, Vol. LII, Pt. I, Nos. 3—4; and Pt. II, Nos. 2—4. 8° Calcutta, 1883-1884.
THE SOCIETY.

" Proceedings of the Asiatic Society of Bengal. No. IX. 8° Calcutta, 1883.
THE SOCIETY.

" Mallet, F. R.—Descriptive catalogue of the collection of Minerals in the Geological Museum, Calcutta. 8° Calcutta, 1883.
GEOLOGICAL SURVEY OF INDIA.

" Memoirs of the Geological Survey of India. Vol. XX, Nos. 1—2. 8° Calcutta, 1883.
GEOLOGICAL SURVEY OF INDIA.

" Palæontologia Indica. Series XIV, Vol. I, pt. 4. 4° Calcutta, 1883.
GEOLOGICAL SURVEY OF INDIA.

" Popular Guides to the geological collections in the Indian Museum, Calcutta. Nos. 1—5. 8° Calcutta, 1879-1883.
GEOLOGICAL SURVEY OF INDIA.

" Records of the Geological Survey of India. Vol. XVII, Part 1. 8° Calcutta, 1884.
GEOLOGICAL SURVEY OF INDIA.

CAMBRIDGE.—Proceedings of the Cambridge Philosophical Society. Vols. I and II. 8° Cambridge, 1866-1876.
THE SOCIETY.

" Transactions of the Cambridge Philosophical Society. Vols. IX to XI, Part 2. 4° Cambridge, *1851—1869.*
THE SOCIETY.

Titles of Books. *Donors.*

CAMBRIDGE, MASS.—Annual Report of the Curator of the Museum of Comparative Zoology at Harvard College for 1882-83. 8° Cambridge, Mass. 1883.

ALEX. AGASSIZ.

„ Bulletin of the Museum of Comparative Zoology. Vol. XI, Nos. 3—9. 8° Cambridge, Mass. 1883.

MUSEUM OF COMPARATIVE ZOOLOGY.

„ Memoirs of the Museum of Comparative Zoology. Vol. VIII, No. 2; and IX, No. 2. 4° Cambridge, Mass. 1883.

MUSEUM OF COMPARATIVE ZOOLOGY.

COPENHAGEN.—Mémoires de l'Académie Royale de Copenhague. 6me Série, Vol. II, Nos. 4—5. 4° Copengahen, 1883.

THE ACADEMY.

„ Oversigt over det Kongelige danske Videnskabernes Selskabs. No. 2. 8° Copenhagen, 1883.

THE ACADEMY.

DRESDEN.—Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gesellschaft Isis in Dresden. Juli bis December, 1883. 8° Dresden, 1884.

THE SOCIETY.

EDINBURGH.—Transactions of Royal Scottish Society of Arts. Vol. XI, Part 1. 8° Edinburgh, 1883.

THE SOCIETY.

GLASGOW.—Proceedings of the Philosophical Society of Glasgow. Vol. XIV. 8° Glasgow, 1883.

THE SOCIETY.

„ Transactions of the Geological Society of Glasgow. Vol. VII, Part 1. 8° Glasgow, 1883.

THE SOCIETY.

HALLE.—Nova Acta Academiae Caesareae Leopoldino-Carolinae Germanicae Naturae Curiosorum. Tomus XLIV. 4° Halle, 1883.

THE ACADEMY.

„ Leopoldina. Heft XVIII. 4° Halle, 1882.

THE ACADEMY.

LIVERPOOL.—Proceedings of the Liverpool Geological Society. Vol. IV, Part 5. 8° Liverpool, 1883.

THE SOCIETY.

LONDON.—Journal of the Society of Arts. Vol. XXXII, Nos. 1620—1632. 8° London, 1883-1884.

THE SOCIETY.

„ Mineralogical Magazine, and Journal of the Mineralogical Society of Great Britain and Ireland. Vol. V, Nos. 22—25. 8° London, 1882-1883.

„ Palæontographical Society's publications. Vols. XXXV—XXXVII. 4° London, 1881-1883.

„ Proceedings of the Royal Geographical Society. New Series, Vol. V, No. 12; and VI, No. 1. 8° London, 1883-1884.

THE SOCIETY.

„ Quarterly Journal of the Geological Society. Vol. XXXIX, No. 156. With list of Fellows for 1883. 8° London, 1883.

THE SOCIETY.

Titles of Books. *Donors.*

LONDON.—Report of the British Association for the Advancement of Science, for 1881 and 1882. 8° London, 1882-1883.

MADRID.—Boletin de la Sociedad Geografica de Madrid. Tomo XV, Nos. 4—6. 8° Madrid, 1883.

THE SOCIETY.

MANCHESTER.—Transactions of the Manchester Geological Society. Vol. XVII, Parts 11—12. 8° Manchester, 1883-1884.

THE SOCIETY.

MELBOURNE.—Geological Survey of Victoria. Report of Progress. No. VI. 8° Melbourne, 1880.

GOVERNMENT MINING DEPARTMENT, VICTORIA.

„ Report of the Inspector of Explosives to the Honourable the Minister of Mines, for the years 1880 and 1881. flsc. Melbourne, 1881-1882.

GOVERNMENT MINING DEPARTMENT, VICTORIA.

„ Reports of the Mining Surveyors and Registrars for quarter ending 30th September 1883. flsc. Melbourne, 1883.

GOVERNMENT MINING DEPARTMENT, VICTORIA.

MONTREAL.—Geological and Natural History Survey of Canada. Reports of Progress for 1880-81-82. 8° Montreal, 1883.

THE SURVEY.

„ MACOUN, JOHN.—Catalogue of Canadian plants. Part I. Polypetalæ. 8° Montreal, 1883.

THE SURVEY.

MUNICH.—Abhandlungen der Mathematisch-Physikalischen Classe der Königlich Bayerischen Akademie der Wissenschaften. Band XIV, Abth. 3. 4° München, 1883.

THE ACADEMY.

„ RADLKOFER, LUDWIG.—Ueber die Methoden in der botanischen Systematik insbesondere die anatomische methode. 4° München, 1883.

THE ACADEMY.

„ Sitzungsberichte der Mathematisch-Physikalischen Classe der K. B. Akademie der Wissenschaften. Heft 1 and 2. 8° München, 1883.

THE ACADEMY.

NEWCASTLE-UPON-TYNE.—Transactions of the North of England Institute of Mining and Mechanical Engineers. Vol. XXXIII, Parts 1—2. 8° Newcastle-upon-Tyne, 1883-1884.

THE INSTITUTE.

PARIS.—Bulletin de la Société Géologique de France. 3me Série, Vol. XII, Nos. 1—2. 8° Paris, 1883-1884.

THE SOCIETY.

PENZANCE.—Transactions of the Royal Geological Society of Cornwall. Vol. X, Part 5. 8° Penzance, 1883.

THE SOCIETY.

PHILADELPHIA.—Journal of the Franklin Institute. 3rd Series, Vol. LXXXVI, No. 6; and LXXXVII, Nos. 1—2. 8° Philadelphia, 1883-1884.

THE INSTITUTE.

„ Proceedings of the Academy of Natural Sciences. Part II. 8° Philadelphia, 1883.

THE ACADEMY.

Titles of Books. *Donors.*

PISA.—Atti della Societá Toscana di Scienze Naturali. Processi Verbali. Vol. IV, pp. 1—27. 8° Pisa, 1883.

THE SOCIETY.

ROME.—Atti della Accademia dei Lincei. Serie III, Transunti, Vol. VII, fasc., 15. 4° Roma, 1883.

THE ACADEMY.

SAINT PETERSBURG.—Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg. Tome XXVIII, No. 3. 4° St. Pétersbourg, 1883.

THE ACADEMY.

" Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg. Tome XXXI, Nos. 5—8. 4° St. Pétersbourg, 1883.

THE ACADEMY.

" Bulletins du Comité Géologique. Tome I and II, Parts 1—6. 8° St. Pétersbourg, 1883.

THE COMMITTEE.

" Mémoires du Comité Géologique. Vol. I, No. 1. 4° St. Pétersbourg. 1883.

THE COMMITTEE.

SALEM.—Bulletin of the Essex Institute. Vol. XIV, Nos. 7—12. 8° Salem, 1882.

THE INSTITUTE.

SYDNEY.—Annual Report of the Department of Mines, New South Wales, for 1882. 4° Sydney, 1883.

DEPARTMENT OF MINES, NEW SOUTH WALES.

TASMANIA.—Papers and Proceedings of the Royal Society of Tasmania for 1882. 8° Tasmania, 1883.

THE SOCIETY.

TORONTO.—Proceedings of the Canadian Institute. Vol. I, No. 5. 8° Toronto, 1883.

THE INSTITUTE.

VIENNA.—Verhandlungen der k.k. Geologischen Reichsanstalt. Nos. 14—18, (1883); and Nos. 1—3, (1884). 8° Wien, 1883-1884.

THE INSTITUTE.

WASHINGTON.—Catalogue of specimens added to the Cabinet of the United States Naval Academy in 1878 and 1881. 8° Washington, 1879 and 1881.

HOME DEPARTMENT.

" Preliminary Catalogue of the Minerals in the Cabinet of the United States Naval Academy, Annapolis. 8° Washington, 1877.

HOME DEPARTMENT.

" Regulations of the United States Geological Survey. 8° Washington, 1882.

HOME DEPARTMENT.

" Report of the United States Geological Exploration of the Fortieth Parallel. Vol. V, Botany. 4° Washington, 1871.

HOME DEPARTMENT.

" United States Geographical and Geological Survey. Contributions to North American Ethnology. Vol. III. 4° Washington, 1877.

HOME DEPARTMENT.

YOKOHAMA.—Mittheilungen der Deutschen Gesellschaft für Natur und Völkerkunde Ostasiens. Heft 30. 4° Yokohama, 1884.

THE SOCIETY.

Titles of Books *Donors.*

YOKOHAMA.—Transactions of the Asiatic Society of Japan. Vol. XI, parts 1—2; and XII, part I. 8° Yokohama, 1883.

THE SOCIETY.

MAPS.

DAHLL. TELLEF.—Geologisk kart over det Nordlige Norge. Kristiania, 1866—1879.

ROYAL UNIVERSITY, NORWAY.

Geological map of Learmouth. Melbourne, 1882.

COMMISSIONER FOR VICTORIA.

Geological map of the Ararat Gold Field. Melbourne, 1875.

COMMISSIONER FOR VICTORIA.

Geological map of the Ballarat Gold Field. Melbourne, 1874.

COMMISSIONER FOR VICTORIA.

Geological map of the Creswick Gold Field. Melbourne, 1880.

COMMISSIONER FOR VICTORIA.

Geological map of the Sandhurst Gold Field. Melbourne, 1873.

COMMISSIONER FOR VICTORIA.

Geological map of the Stawell Gold Field. Melbourne, 1878.

COMMISSIONER FOR VICTORIA.

Geological sketch-map of the Parish of Beechworth. Melbourne, 1871.

COMMISSIONER FOR VICTORIA.

Geological map of the districts of Hartley, Bowenfells, Wallerawang and Rydal. Sydney, 1875.

COMMISSIONER FOR NEW SOUTH WALES.

Geological map of the Forest Reefs Gold Field. Sydney, 1881.

COMMISSIONER FOR NEW SOUTH WALES.

Geological map of the town and environs of Young. Sydney, 1879.

COMMISSIONER FOR NEW SOUTH WALES.

Geological sketch-map of New South Wales, compiled from the original map of the late Revd. W. B. Clarke. By C. S. Wilkinson. Sydney, 1880.

COMMISSIONER FOR NEW SOUTH WALES.

Geological sketch-map of the Oberon district, by C. S. Wilkinson. Sydney, 1877.

COMMISSIONER FOR NEW SOUTH WALES.

Map of New South Wales, Australia, showing the localities of the principal minerals. Compiled by J. Tayler; revised and corrected to date by C. S. Wilkinson. Sydney. No date.

COMMISSIONER FOR NEW SOUTH WALES.

Plan showing where the diagrams have been taken, and the extent of the New South Wales Coal Field as far as at present examined by John Mackenzie. Sydney, 1879.

COMMISSIONER FOR NEW SOUTH WALES.

April 1st, 1884.

Government of India Central Printing Office.—No. 37 S. G S.—24-4-84.—720.

MEMOIRS

OF

THE GEOLOGICAL SURVEY OF INDIA.

PALÆONTOLOGIA INDICA.

(SER. I, III, V, VI, VIII.)—CRETACEOUS FAUNA OF SOUTHERN INDIA.

VOL. I. The Cephalopoda, by H. F. BLANFORD and F. STOLICZKA, pp. 216, pls. 94 (6 double).
The Belemnitidæ and Nautilidæ, by H. F. BLANFORD, pp. 1-40, pls. 25 (*out of print*).
The Ammonitidæ, by F. STOLICZKA, pp. 41-216, pls. 69 (6 double).

VOL. II. The Gastropoda, by F. STOLICZKA (1867-68), pp. xiii, 500, pls. 28 (10 parts) (*complete*).

VOL. III. The Pelecypoda, by F. STOLICZKA (1870-71), pp xxii, 537, pls. 50 (13 parts) (*complete*).

VOL. IV. The Brachiopoda, Ciliopoda, Echinodermata Corals, &c., by F. STOLICZKA (1872-73), pp. v, 202, pls. 29 (5 parts) (*complete*).

(SER. II, XI, XII.)—THE FOSSIL FLORA OF THE GONDWANA SYSTEM.

VOL. I, pp. xviii, 233, pls. 72 (*complete*).
„ pt. 1 (1863) (in six fasciculi, *Nos. 4, 5 & 6 out of print*) Rájmahál Group, Rájmahál Hills, by T. OLDHAM and J. MORRIS, pp. 52, pls. 35.
„ „ 2 (1877). *Same, continued*, by O. FEISTMANTEL, pp. 53-162, pls. 36-48.
„ „ 3 (1877). Plants from Golapilli, by O. FEISTMANTEL, pp. 163-190, pls. 8.
„ „ 4 (1879). Outliers on the Madras Coast, by O. FEISTMANTEL, pp. 191-234, pls. 16.

VOL. II, pp. xli, 115, pls. 26 (*complete*).
„ pt. 1 (1876). Jurassic Flora of Kach, by O. FEISTMANTEL, pp. 80, pls. 12.
„ „ 2 (1878). Flora of the Jabalpur Group, by O. FEISTMANTEL, pp. 81-105, pls. 14.

VOL. III, pp. xi, 64 + 149, pls. 80 (9 double) (I-XXXI + I A—XLVII A) (*complete*).
„ pt. 1 (1879). The Flora of the Talchir-Karharbári beds, by O. FEISTMANTEL, pp. 48, pls. 27 (5 double).
„ „ 1 (Supple.) (1881), pp. 49-64, pls. xxviii—xxxi (1 double).
„ „ 2 (1880). Flora of the Damuda and Panchet Divisions, by O. FEISTMANTEL, pp. 77, pls. 18 (1 double).
„ „ 3 (1881). The same (concluded), pp. 78-149, pls. 31 (2 double) (XVII A—XLVII A).

VOL. IV, pt. 1 (1882). Fossil Flora of the South Rewah Gondwana basin, by O. FEISTMANTEL, pp. 42, pls. 21.

(SER. IX.)—JURASSIC FAUNA OF KACH.

VOL. I (1873-76). The Cephalopoda, by W. WAAGEN, pp. i, 247, pls. 60 (6 double) (*complete*).

(SER. IV.)—INDIAN PRETERTIARY VERTEBRATA.

VOL. I, pt. 1 (1865). The Vertebrate Fossils from the Panchet rocks, by T. H. HUXLEY, pp. 24, pls. 6.
„ „ 2 (1878). The Vertebrate Fossils of the Kota-Maleri Group, by SIR P. DE M. GREY EGERTON and L. C. MIALL, pp. 23, pls. 4.
„ „ 3 (1879). Reptilia and Batrachia, by R. LYDEKKER, pp. 36, pls. 6.

(SER. X.)—INDIAN TERTIARY AND POST-TERTIARY VERTEBRATA.

VOL. I, pp. xxx, 300, pls. 50 (*complete*).
„ pt. 1 (1874). Rhinoceros deccanensis, by R. B. FOOTE, pp. 18, pls. 3.
„ „ 2 (1877). Molar teeth and other remains of Mammalia, by R. LYDEKKER, pp. 69 (19-87), pls. 7 (iv-x).
„ „ 3 (1878). Crania of Ruminants, by R. LYDEKKER, pp. 84 (88-171), pls. 18 (xi-xxviii).
„ „ 4 (1880). *Supplement to pt. 3, pp. 10 (172-181), pls. 3 (XXI A, B, XXIII A).*
„ „ 5 (1880). Siwalik and Narbada Proboscidia, pp. 119 (182-300), pls. 19 (xxix-xlvi), 35 bis.

[See page 2 of Cover.]

MEMOIRS

OF

THE GEOLOGICAL SURVEY OF INDIA.

VOL. I. Royal 8vo, pp. 309, 1859 (*out of print*).
VOL. II. Royal 8vo, pp. 341, 1859 (*out of print*).
VOL. III. Royal 8vo, pp. 438. Pt. 1, 1863 (*out of print*). Pt. 2, 1864 (*price* 2 Rs.): On the Sub-Himalayan Ranges between the Ganges and Sutlej.
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.): 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.): 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.): 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.): 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.): Karharbári 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, 1873 (*price* 3 Rs.): Geology of Madras.—Sátpúra 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 Dúars. Pt. 2, 1876 (*price* 3 Rs.): Salt-region of Kohát, Trans-Indus: pp. 230.
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: pp. 95.
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 Hutar 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.): Mánbhúm and Singhbhúm. Pt. 3, 1881 (*price* 2 Rs.): Pránhita-Godávari Valley.
VOL. XIX. Royal 8vo, pp. 242. Pt. 1, 1882 (*price* 2 Rs.): The Cachar Earthquake of 1869. Pt. 2, 1882 (*price* 1 Re.): Thermal Springs of India. Pt. 3, 1883 (*price* 1 Re.): A catalogue of Indian Earthquakes. Pt. 4, 1883 (*price* 1 Re.): Geology of parts of Manipur and the Naga Hills.
VOL. XX. Royal 8vo, pp. 240, Pt. 1, 1883 (*price* Rs. 2-8): Geology of Madura and Tinnevelly. Pt. 2, 1883 (*price* Rs. 2-8): Geological Notes on the Hills in the neighbourhood of the Sind and Punjab Frontier between Quetta and Dera Ghazi Khan.
VOL. XXII. Royal 8vo, pp. 344 (1883). The Geology of Kashmir, Chamba, and Khagán.

The price fixed for these publications is 5 Rs. (10s.) each volume.

Manual of the Geology of India, 2 Vols. and Map (*out of print*). Pt. III (Economic Geology), *price* 5 Rs. (10s.)