MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

INDIA.

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VOL. X.

PUBLISHED BY ORDER OF HIS EXCELLENCY THE GOVERNOR GENERAL OF INDIA
IN COUNCIL,

UNDER THE DIRECTION OF

THOMAS OLDHAM, LL.D.,

Fellow of the Royal and Geological Societies of London; Member of the Royal Irish Academy;
Hon. Mem. of the Leop-Carol. Academy of Natural Sciences; of the Isis, Dresden;
of the Roy. Geol. Soc. of Cornwall; Corr. Mem. of Zool. Soc., Lond., &c., &c.

SUPERINTENDENT OF THE GEOLOGICAL SURVEY OF INDIA.

CALCUTTA:

PRINTED FOR THE GOVERNMENT OF INDIA.

SOLD AT THE

GEOLOGICAL SURVEY OFFICE,
OFFICE OF SUPERINTENDENT OF GOVERNMENT PRINTING
AND BY ALL BOOKSELLERS;
LONDON: TRÜBNER & CO.

MDCCCLXXIII.

CALCUTTA:
OFFICE OF SUPERINTENDENT OF GOVERNMENT PRINTING.
1873.

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ERRATA.

Page 17, line 22, *omit* "and population."

Page 17, line 30, *for* 2,483,861 *read* 550,266.

Page 17, line 30, *for* 4,340,806 *read* 2,407,211.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

On the Geology of parts of the MADRAS *and* NORTH ARCOT *Districts lying north of the Palar River, and included in Sheet* 78 *of the Indian Atlas, by* R. BRUCE FOOTE, F. G. S., *Geological Survey of India.*

CONTENTS.

CHAPTER I.—GENERAL SKETCH OF THE AREA.

The shape of the area here described is rather irregular, its boundaries being, to the south, the Palar river; on the east, the sea; on the north, a line commencing at the sea ten miles northward of Pulicat, crossing the lagoon diagonally to Meddpolliam, and continued in a sinuous line through the places noted below* as far as Naggery. To the west the boundary is another sinuous line running south-south-east from Naggery to Arconum, and thence south-west till it strikes the Palar river a little east of Arcot.

The extent of the area thus defined is about 2,600 square miles.

The general features of this area are those of a gently undulating inclined plane sloping gradually down to the sea, but broken through in several places by wide, shallow, river-valleys.

Hills.

Only the north-west and south-east parts are hilly, the former being occupied by the Sattavedu and Alicoor hills, while the latter, or south-east part of the area, is traversed by several ridges of low hills running parallel with the coast for about twenty miles, at a distance of eight or ten miles inland. A smaller set of parallel ridges occurs around and north of Chingleput. To the north of these are several detached and isolated hills, as the Goodoovanchary, Vendaloor, and Mullapode hills, and the small groups of hills at Cuddapary choultry and Palaveram. Besides these are a few rocky hills of trifling elevation scattered about among those just mentioned, as the Paliacaranei hills and St. Thomas' Mount. None of the hills above mentioned attain to an elevation much exceeding 700 feet above sea-level.

Rivers.

The principal rivers draining this area are the Palar in the south, the Corteliar and Naggery rivers conjointly in the central parts, and the Narnaveram river in the northern, all falling into the Bay of Bengal.

Of the smaller streams falling directly into the sea, two only, the Adyar (or Sydrapettah) and the Cuum (or Triplicane), are worthy of separate mention, and both of these fall into the sea south of Fort St. George.

* The boundary of the north side of the area runs from Meddpolliam to Cummumbaucum and Kolladum, thence round the Sattavedu hills to Corywale and Vembaucum; it then runs round the north side of the Alicoor hills, and along the north side of the alluvial valley stretching up to Naggery.

Lagoons.

Of lagoons and backwaters there are several good examples, as the Pulicat lake, the Ennore and Covelong backwaters, all of which are salt-water lagoons, but much influenced by heavy rains, which fall generally during the north-east monsoon. Unless the flood-water breaches the sandbars thrown up by the surf across their openings into the sea, the water in the lagoons loses its salt character, so much as to cause a nearly total destruction of the estuarine fauna generally found in them.*

Absence of forests.

No forests occur anywhere within the limits above specified, but some large patches and many strips of scrub-jungle occur on and among the Sadras hills, which furnish a great part of the firewood used in Madras. The Alicoor and Sattavedu hills are also covered in great measure by low brushwood jungle. The accompanying long section from Naggery Nose to the sea near Palaveram, (Plate A,) gives a good idea of the gradual rise of the ground and of the manner in which the several great alluvial valleys divide the area occupied by the older rocks into bands and patches by masking great part of their surfaces.

The various geological formations met with in the area under consideration, may be conveniently classed, according to their relative geological ages, in a tabular arrangement as below :—

1.	Recent or quaternary deposits.	Blown sands. Alluvia, marine and fluviatile. Laterite and Conjeveram gravels.
2.	Tertiary ?	Gritty sandstones (? Cuddalore sandstones).
3.	Secondary	(Cretaceous ?). Jurassic, Rajmahal plant beds.
4.	Sub-metamorphic ? ...	Kadapá group.
5.	Metamorphic	Gneissic series, (including intrusive trappean rocks).

* This has happened from time to time in the case of the Covelong backwater, according to the statements of the natives living on its banks, owing to the insufficiency of the flood waters to breach the bars. This cannot again happen, now that it is connected by the coast canal with the estuary of the Adyar, the bar of which is opened every year.

Relative positions of alluvia.

Of these formations the blown sands and marine alluvium occupy the seaboard, and the fluviatile alluvium the valleys of the larger rivers.

Laterite.

The members of the lateritic series occupy the greater part of the surface of the higher tracts of land between the different alluvial valleys, and lie either on the Cuddalore series, or the Rajmahal series, or the metamorphic rocks.

Cuddalore rocks.

The rocks referred provisionally to the Cuddalore sandstone series are seen only to a limited extent in a few sections in the northern part of the area.

Rajmahal beds.

The Rajmahal series, generally overlaid and obscured by the lateritic formations, occupies a broad belt of country forming the central part of the area.

Metamorphic rocks.

The metamorphic rocks occupy the area westward of the limits of the various sedimentary rock-series; also a considerable tract of country between the coast alluvium and the central sedimentary region from which the sedimentary rocks have been removed by denudation. Besides this, there are several small inliers of the gneissic rocks which protrude through the sedimentary rock area like so many islands.

These various formations will be considered in the order of their age and stratigraphical position, beginning with the uppermost and youngest, *i. e.*, those belonging to the recent or quaternary periods.

Before, however, entering upon the description of the several formations, it will be well to draw attention to the labours of different geologists who had studied the geology of the Madras districts at different times before it was systematically worked out by the Geological Survey of India.

Chapter II.—Previous Observers and Publications.

Very little had been recorded about the geological structure of the country around Madras up to the time when it was taken up by the Geological Survey of India. The earliest observations published appear to be those contained in Dr. Heyne's Tracts on India.*

Dr. Heyne.

In Tract No. I, (p. 2,) speaking of the soil of the Carnatic, he especially dwells on the sterility caused by saline impregnations. The occurrence of marine shells at different places some distance inland at varying depths below the surface is also mentioned.

In Tract XXI, entitled "Remarks on Mahavellypooram," (or Mahamalaipúram), the rocks in which the famous temples of that place (better known to Europeans as the "Seven Pagodas") are carved, are described as all granite. Dr. Heyne speculates in this tract on the question of the existence at this place in former ages of an important city, alleged by Hindu legends to have been engulfed in the sea. He regards this legend as an unfounded myth, although the geological evidence of continuous encroachment of the sea all along the Coromandel Coast favors the credibility of the legend in question.†

In his "remarks on the geology of the country between Tellicherry and Madras" published in the transactions of the Geological Society of London (Vol. V, p. 329,) Mr. Babington propounded very briefly the hypothesis of the submergence of the plains of the Carnatic below the sea at some former geological epoch, and in support quoted the occurrence in a well section at Madras of recent marine shells in clay at a considerable depth below the surface. This paper was read on the 15th January 1819.

Babington, 1819.

* See "Tracts, Historical and Statistical, on India," by Benjamin Heyne, M. D., F. L. S., London: 1814.

† This question will be again referred to when considering the coast alluvium.

The next writer in point of time was Dr. Benza, of the Madras Medical Service. In a paper he published in the Madras Journal of Literature and Science for July 1836, Dr. Benza remarks that 'granite' is the lowest rock in the Madras plain, and occurs intermixed with pegmatite at the Marmalong bridge, and on the Guindy race course. By granite, Dr. Benza must have meant the more compact beds of hornblendic and felspathic gneiss. He further notices the occurrence of garnetiferous gneiss at Palaveram, also the formation of Kaolin by the decomposition of the pegmatite. The hornblende slate and rock* at St. Thomas' Mount and Palaveram are stated to be overlying the fundamental granite. Borings for water near Madras, Dr. Benza justly considers unlikely to be successful.

Dr. Benza.

With reference to laterite he remarks that conglomeratic laterite, either undisintegrated or detrital, extends nearly over the whole plains. He further points out the occurrence of the detrital laterite in two geological positions, 1*stly*, as loose, round pebbles scattered all over the surface; 2*ndly*, as a substratum to the soil often many feet thick, with undecomposed pieces of compact conglomerate; the detritus being derived from the present conglomerate.

He mentions the occurrence of dykes of 'basaltic hornblende' trap between Palaveram and Trimatoor.

The occurrence of 'marine organic exuviæ' in the clayey stratum underlying the Madras sands is also recorded by Dr. Benza, whose remarks, though very brief, are generally judicious, and show that he was a good observer.

In the same number of the Madras Journal (July, 1836), with Dr. Benza's paper appeared a valuable Memoir "On the geological position and association of the laterite or iron clay formation of India with a description of that rock

Mr. Robert Cole.

* The 'hornblende rock' is merely a very compact variety of hornblendic gneiss.

as it is found at the Red Hills near Madras" by Robert Cole, Esq., of the Madras Medical Service. In this paper Mr. Cole proved very satisfactorily that the laterite of the Red Hills is conglomeratic and of sedimentary origin, therefore neither a rock resulting from decomposition of older rocks in situ, like the red lithomargic earth on the Nilghiris described by Dr. Benza, nor a trappean rock, nor in any way associated with trappean phenomena. After enumerating the principal writers who had at that time written on the subject of laterite, Mr. Cole described very correctly the mode of occurrence of the laterite at the Red Hills. The vermicular and cellular cavities and their effect on the texture of the weathered conglomerate masses, and the stratified structure of these, are clearly pointed out. He mentions picking out of the laterite fragments, both angular and rounded, of white quartz, of very compact red sandstone,* and of white, granular, friable disintegrating sandstone. The variety of appearances presented by the laterite are next described, from the heavy deep red ferruginous conglomerate to the crumbling semi-lithomargic variety and the mere gravels.

Mr. Cole then enters into a speculation of the cause of the absence of organic remains from the laterite, showing that it does not afford any evidence in favor of the hypothesis of a trappean origin. The probable sources of the enclosed fragments are pointed out; and the notes conclude with a notice of the economic uses and value of the laterite.

This paper shows clearly that the late Mr. Cole only needed the opportunity of acquiring larger experience in the applied sciences in order to have distinguished himself as a geologist.

Dr. J. Clark.

Two years after the publication of Mr. Cole's memoir, a paper 'On the laterite formation' appeared in the Madras Journal (October, 1838,) from the pen of Dr. John Clark, of the 13th Dragoons, but it contained no special

* Probably quartzite.

reference to the geology of the Madras district or of any part included within the range of this report.

Captain Newbold.

Captain Newbold's writings which come next in point of time contain but little information about the Madras district beyond his describing two sections through the marine alluvium at Madras; these descriptions will be found quoted at p. 16 of this report.

The 'Red Hills' near Madras were regarded by Captain Newbold as of the same geological age as the Pondicherry 'Red Hills.' He also considered the sandstones occurring westward of Poonamallee on the road to Sripermatoor, and certain other beds occurring at Permalnaigpett, as contemporaneous with the beds at Trivicary (Tiruvakkarei) near Pondicherry, which latter belong to the probably tertiary Cuddalore sandstone series of Mr. H. F. Blanford. But fossils discovered during the progress of the survey in shales conformable to the sandstones near Poonamallee show these beds to belong to the much older Rajmahal series. Captain Newbold was quite correct in supposing that these beds extended to the vicinity of Conjeveram.

Mr. T. G. Taylor.

In 1847 a memorandum was given in the Madras Journal by Mr. T. G. Taylor, then Government Astronomer at Madras, of the results of a boring executed on the beach near the Custom House in 1845. The value of this section is much diminished, because the thickness of the different strata is not given, but merely the depths reached on successive days by the boring instrument. The boring was only continued to a depth of 48 feet 3 inches, and did not penetrate the alluvium down to the gneiss, and gives, therefore, no information as to the total thickness of the alluvium under that part of Madras which is a point of importance and interest.

Greenough, 1854.

In 1854 appeared the first Geological Map of India constructed by Mr. G. B. Greenough, F. R. S. Unfortunately this map, though in many respects a highly meritorious work, was, from being constructed on very insufficient data, very faulty in many parts; and the illustration it gave of the country around Madras was quite erroneous.

Mr. A. Schlagintweit.

In 1856 the late Mr. Adolf Schlagintweit visited Sripermatoor and discovered remains of *Palæozamiæ* in the shales which there occur. He published a short notice in the Journal of the Bengal Asiatic Society for 1857* of the results of his trip through Southern India, and in it advanced the idea that the Sripermatoor shales and gritty sandstones and the Nágpúr plant-bearing beds were of the same geological age. He also regarded the post cretaceous gritty sandstones of Tiruvakkarei (Trivicary) as of the same age. Both these conclusions were singularly unhappy, because based on totally insufficient data.

Dr. A. Hunter.

Dr. Alexander Hunter, the Superintendent of the School of Arts in Madras, has published various lists of minerals collected by him in the neighbourhood of Chingle-put and other places in the Madras area, also one or two sketches of the country about Madras itself. These are drawn up so vaguely, as regards the indication of localities and distinction of the several geological formations met with, that they are of no scientific value. I have been unable to procure a detailed account of some borings in search of coal made under Dr. Hunter's superintendence in the neighbourhood of Sripermatoor.†

Mr. H. F. Blanford.

In a short paper published in the Madras Journal of Science and Literature (Vol. IV, New Series, p. 47), Mr. Henry F. Blanford, then of the Geological Survey of India, confirmed Mr. Schlagintweit's discovery of *Palæozamia* remains

* Journal Asiatic Society, Bengal, Vol. XXVI, p. 104.

† Dr. Hunter's lists of minerals will be found in a small volume of Reports on Greenough's Geological Map of India, (published by the Madras Government,) and in various Jury Reports on the several industrial exhibitions held in Madras. The sketches of the neighbourhood of Madras appeared in a Magazine published some years ago in connection with the Madras School of Arts.

in the Sripermatoor shales, and also noticed the occurrence of beds of gritty sandstone a few miles west of Poonamallee on the Madras-Arcot road. This sandstone was, however, referred by him to the Cuddalore sandstone series, and not to the 'Plant shale' series, to which, however, they are shown to belong by the plant remains discovered in them. This paper was read before the Madras Literary Society in 1858, and published, as above mentioned, in the year following.

Geological survey begun 1862. Mr. R. B. Foote.

In August 1862, the geological survey was begun by myself, and some of the results obtained were first made public in a paper published by the Madras Literary Journal 'On the occurrence of stone implements in lateritic formations in various parts of the Madras and North Arcot districts.'* To this paper were appended some 'Notes on the occurrence of stone implements in North Arcot district by William King, Esq., B. A., Geological Survey of India,' some of which have reference to places within, or immediately adjacent to, the Madras area.

Notes by Mr. W. King.

Mr. R. B. Foote.

In 1868, by permission of Dr. Oldham, F. R. S., Superintendent of the Geological Survey of India, I read a paper before the Geological Society of London 'On the distribution of stone implements in Southern India.'† In this various points bearing on the geology of the Madras area are discussed, and a theory advanced to explain the occurrence of stone implements at certain levels. This paper was illustrated by a diagram map showing roughly the area of country in the southern part of the Peninsula of India, which could be submerged by a subsidence of the land to a depth of 500 feet below its present level. One of the ideal sections given shows the relations of the different formations met with between the coast a little north of Madras and the Naggery Nose mountain.

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* See "Madras Journal of Literature and Science," October 1866 (third series, pt. 2). Some copies of this paper were struck off separately and circulated in June 1865.

† See Quarterly Journal, Geological Society, November 1868, Vol. XXIV.

An abstract of the contents of the present report was published in the first number of the Records of the Geological Survey of India for 1870, under the title of 'Notes on the geology of the neighbourhood of Madras, by R. Bruce Foote, Esq., F. G. S., Geological Survey of India.'

This concludes the list of papers bearing on the subject of the geology of the country around Madras to which I have had access. No attempt had been made to lay down the geological features of the area in question on a map, with the exception of what is shown on Greenough's Geological Map of India, and in this the country had been most inaccurately represented.

CHAPTER III.—SUB-AERIAL FORMATIONS.

a.—Blown sands.

The blown sands in this region are nowhere so well developed in distinct ridges as they are further south near Pondicherry and Porto Novo. They form a belt, from a quarter of a mile to a mile wide, of irregular sand-hillocks stretching all along the coast, but nowhere attaining to any great size. The largest observed southward of Madras were immediately south of Covelong, and some of these appeared to cover old ruined buildings. At Mahavalipooram they have encroached on the base of some of the Monolith temples at the southern end of the gneiss-ridge. At Padari, a small rock-hewn temple is so filled with sand that it cannot be entered.

South of Madras.

Only one inland ridge of sand was observed, and this occurs on the west side of the back water, a few miles north-west of Covelong.

The blown sands, which form a continuous ridge except where broken by the embouchures of the Corteliar at Ennore and Carangoly, and of the Narnaveram river at Pulicat,* offer no very striking features. They are generally low spread, varying in width from a few hundred yards to about a mile (a few miles north of Ennore).

The highest and most striking sandhills are those at Chintominicoil near Pulicat. The sands here have been raised by the wind in irregular mounds 40 or 50 feet high, and are rapidly covering a small pagoda which had been built there on a much lower sandhill. The north face of these hills is by far the steepest, which is in part owing to the presence of thickets of Cashew nut trees (*Anacardium occidentale*), the *Mundrimaram* of the Tamulians. This tree grows in great profusion on the sandhills in many other places, and when mixed with the wild screw-pine, or *Pandanus*, is very effective in staying the

* The bars of these two rivers were both closed when I visited them in August and October 1864, and hillocks of sand had been raised by the wind on them, as well as elsewhere along the coast.

inland advance of the moving sand. Of trailing plants, the *Spinifex squarrosus* and *Ipomea pes-capri* seem the most useful in fixing the surface of the sands.

Sandhills north of Ennore.

The very steep and well defined line of sandhills running northward from the Ennore backwater to Caulongy appears to owe its definite shape chiefly to the line of Cashew nut trees and Pandanus, which have either been planted, or have sprung up, along its inner boundary.

For about eight miles north of Chintominicoil the blown sands form but very small hillocks with the exception of three or four isolated sandhills of fair size which occur along the Pulicat sand-spit, and on one of which stand the Pulicat light-house and flagstaff.

Sandhills north of Pulicat.

Nearly three miles north of Coromandel at the village of Topa-lumpolliam the sandhills again rise to a height of from 15 to 30 feet, and are hedged in on the west side by scrubby jungle or by a growth of the Cashew tree and Pandanus.

The Palmyra palm (*Borassus flabelliformis*) and Casuarinas flourish on the blown sands, and thick plantations of the latter seem more effective than anything else in staying the movements of the loose sands.

Effects of *Casuarina* plantations.

At Puludivakum (or Poodoovakam), where a very large plantation of *Casuarinas* has been made for the purpose of supplying Madras with firewood, I was informed by a very intelligent native in charge of the salt-pans, that the drifting of sand over the paddy-fields bordering the backwater had entirely ceased as the trees grew up, and that the cultivators had been very greatly benefited thereby. It is a well known fact that thick plantations of fir trees and other conifers have been found the only effective means of checking the destructive advance of the great sandhills of the Landes between Bordeaux and Bayonne in the south of France.

The most westerly accumulation of blown sands observed lies about seven miles north-west of Pulicat on the south shore of the Pulicat lake north of the village of Pungalum; it is of small extent, being only a mile and a half from east to west and about half a mile at its broadest part. From its more than usually reddish color, I am inclined to attribute its formation in part to the action of the south-west monsoon sweeping over the very sandy surface of the decomposing laterite grit beds lying to the south of it.

No blown sands, which were of sufficient size or extent to merit any notice, were seen along any of the rivers in the area now treated of.

b.—Soils.

The soils found within the area here treated of are almost invariably formed of the decomposed subsoil, moved about and redistributed by the action of the heavy rain-fall to such an extent that in many sections they present the appearance of truly sedimentary formations, and in fact constitute a link between the truly sedimentary and truly sub-aerial deposits. They are almost everywhere sandy or loamy, and on the gneissic and lateritic formations of varying shades of red color, the intensity depending on the percentage of iron they contain.

On the alluvial formations the soil is generally very pale, reddish or brownish-white in color, and consists most frequently of a nearly pure sand.

White soda soils were noticed along the eastern branch of the Adyar river, which rises in the great Nundiveram tank.

Regur (rigar), or true black-soil, not resulting from tank deposits, was observed in one place only near the Arconum railway junction; and there it covers but a small area.

Chapter IV.—The marine, estuarine, and fluviatile alluvia.

It is not possible to draw definite boundaries between these several varieties of alluvium where they come in contact, but their proper positions relatively to each other may be easily explained.

The marine and estuarine beds occur intercalated with each other along the coast, while the true fluviatile alluvia occupy the valleys of the larger rivers which traverse the Madras District, and appear to overlap the marine and estuarine beds near the present mouths of those rivers.

Deep bay of alluvium west of Poonamallee.

The marine and estuarine alluvia occur in a narrow belt running along the coast, and varying in width, southward of St. Thomé, from one to five miles. West of St. Thomé the alluvial belt widens greatly, running up in a deep bay to beyond Poonamallee cantonment, and there meeting the river alluvium by which the marine beds appear to be overlaid. Unfortunately no sections were found by which to determine exactly the westward limit of the marine formations. To the north-west by west of Madras (Black Town) this alluvial bay is bounded by the lateritic beds forming the so-called Red Hills, and the belt of alluvium narrows to about six miles, but immediately to the north it again widens out and attains its maximum width in the delta of the Corteliar and Narnaveram rivers.

Alluvial delta of Corteliar and Narnaveram rivers.

Here, as in the Poonamallee alluvial bay, there were no sections to show the westward extent of the marine and estuarine beds. The northern boundary of this delta extends north-eastward up to the southern end of the Pulicat lake, where the alluvium measures six miles in width. A very narrow belt of mixed estuarine and fluviatile alluvium stretches up the south-west side of the lake, while its bed and the islands by which it is cut off from the sea consist of marine and estuarine deposits. The outer or shore edge of this alluvial belt, as has been already shown, is fringed almost along its entire length by a line of blown sands of varying width and height.

a.—Marine and estuarine alluvium.

The strip of land lying along the coast southward from Madras as far as Sadras, offers undeniable evidence of a slight elevation of the land having taken place in comparatively recent times. The evidences of this elevatory movement consist in the presence of beds abounding in the remains of marine and estuarine shells of existing species at considerable distances from the coast. The whole of Madras appears to be built on such beds which have been laid open at various places in the excavation of wells. Thus, for example; the two well-sections, given by Captain Newbold in his Summary of the Geology of Southern India, sunk in 1832 at the Land Custom House, about three-fourths of a mile inland from the sea, reached a bed of black clay with marine shells at depths of 13 and 16 feet, and came upon the gneiss at depths of 51 feet 6 inches, and 55 feet respectively.

Marine strata underlying Madras.

Well sections in Madras.

The succession of formations shown in the deeper of the two wells was—

		ft.	in.
1.	Sand and clay....	3	0
2.	Light colored sand and clay	1	0
3.	Stiff clay	3	6
4.	River sand	5	6
5.	Black clay with sand and shells	20	0
6.	Blue clay with sand and lime and pieces of iron stone	12	6
7.	Granite and quartz rubble	0	6
8.	Clay and gravel mixed with broken granite, quartz, mica, &c.	9	0
	TOTAL ...	55	0

Mr. B. G. Babington, in a paper referred to at page 5, describes the following sequence of formations as occurring in a well-section sunk in Colonel Marshall's garden at a distance of two miles from the shore:—"From the surface for 5 feet there is a stratum of brown clay chiefly intermixed with sand. Then follows a stratum of bluish black clay, in which at the distance of 21 feet, there is a thin and scattered layer of large oyster shells which all lie in a horizontal position and between the laminæ composing the shell the black clay has penetrated, so that they split asunder with great facility. There are also shells of the cockle and other kinds. At the depth of 27 feet the springs of water began to gush; the stratum becomes softer and more and more mixed with silicious sand, still however of a dark slate black colour. This continues to 37 feet, the lowest point to which the well was dug, when lumps of what I suppose to be green martial earth were found intermixed with sand."

Shell-beds exposed near the Cenotaph.

Close to the Mylapúr tank on the Mount Road, marine shells in great quantity, and all of existing species, were obtained in sinking a well in the compound of Mr. Ainslie's house a little north of the Cenotaph. Again, in the Mowbray Road, about half a mile east of the former locality, Surgeon Major Porteous found numerous marine shells, all of living species, in a sub-fossil condition imbedded in black sandy clay. How far west of the Mylapúr tank the unequivocally marine beds of black fossiliferous clay may extend in this great bay could not be ascertained owing to the absence of sections of sufficient depth. In a well sunk not far from Munro bridge, pale-yellow sand was found at a depth of 30 feet underlying the bluish black or black stiff clay.

In Mylapúr.

South of Madras by the Coast Canal sections.

In a large well sunk about a quarter of a mile south of the Pagoda tank in Brodie's Road, the same black clay appeared full of comminuted fragments of shells. The canal from the Adyar to the Palar south of Sadras has in many places along its entire length been dug into these marine beds; the black or grey clay thrown up on the sides in great heaps is often full of marine shells. These fossil shells were observed in greatest quantity along the south coast canal from its opening into the Adyar to the bridge south-east of Guindy Park. A little to the south-east of Onatoor on the west side of the backwater they are again extremely abundant. The shells are also very numerous in the brine pits in the dry bed of the backwater at the salt works near Covelong, and again in those sunk a little to the north-west of Seven Pagodas. These shells are generally found in good condition, and occasionally retain faint traces of polish and color; they are, however, often very brittle and difficult to preserve.

At the time when these beds were forming, the sea must have extended westward very nearly to the Palaveram hills.

Islands of gneiss in the alluvial plain.

When the marine deposits now described were being formed several small islands of gneiss stood up in the shallow sea, which now appear as outliers of the great metamorphic area breaking slightly the monotony of the alluvial country. Several of these are noteworthy—Three more especially.

1*st*.—The outlier on which stand the famous Seven Pagodas, the Mahabali or Mahavalipuram or Mahamalaipuram of the Hindus. (*)

2*ndly*.—The island of gneiss at Padari,—a village not marked on the atlas maps,—three miles north of Seven Pagodas.

3*rdly*.—An outlier of gneiss surrounded by a belt of lateritic deposits in the great Puliacarany flat, and about four miles south-east of St. Thomas' Mount.

These will be described in detail when treating of the metamorphic rocks.

The Covelong back-water.

The Covelong backwater is not now in reality the great sheet of salt-water one would be inclined to believe from looking at the maps. At the time of the survey of that part of the Madras District in August (1862), although both openings at the Covelong and the Madras ends were closed by high sand bars, by far the greater part of the area marked on the map was a dry sandy plain overgrown with *Salicornaria*, &c., with only here and there a few large puddles.

The broad channel between Covelong town and the rocky island to the west was dry, all but a running stream about a yard across. This

* A complete account of this remarkable spot will be found in a volume, edited for the Madras Government, and entitled 'Descriptive and Historical papers relating to the Seven Pagodas, on the Coromandel Coast', edited by Captain M. W. Carr. M. S. C.

is in great part due to the drainage effected by the canal which runs right through the length of the backwater, and for which, excepting for a couple of miles near Covelong, the channel had to be excavated to a depth of several feet. From enquiries made of the natives in various villages along the backwater, it was ascertained that it is only after very heavy monsoons that the landwater accumulates sufficiently to fill the bed of this remarkable lagoon.

The following list shows the shells occurring most frequently in the marine and estuarine beds at Madras:—

Pelecypoda.	Gasteropoda.
Ostrea, several species.	*Potamides telescopium.*
Placuna.	,, *fluviatile.*
Arca.	*Oliva, sp.*
Cytherea castanea.	*Natica.*
Tellina.	*Murex.*

These shell beds are the principal source of the finer sort of chunam for which Madras is celebrated.

Marine and estuarine alluvia north of Madras.

That the elevatory action which upraised the marine and estuarine beds south of Madras also affected those to the north cannot be doubted, although no positive proofs in the shape of fossil remains were met with anywhere north of Madras. The alluvium, as seen on the surface and in the few river sections, is almost entirely sandy, rarely clayey. But sections are so rare and of such slight depth that it is impossible to pretend to anything like a satisfactory acquaintance with the formations. Even well-sections, which in other parts of the country afford some little help, are here useless, as, from the mode of sinking, the sides cannot be seen to a depth of more than 2 feet or a yard, because, owing to the friable nature of the strata sunk through, the wells have to be built up at the top as the lower part sinks with the progress of excavation. In smaller wells the sides are kept from falling in by means of earthen-ware tubbing, *i. e.*, large cylinders of earthen-ware from 3 to $4\frac{1}{2}$ feet in diameter, but only 10 inches to a foot deep, are allowed to sink in the excavation as it proceeds, and others added from above till the requisite depth be attained.

The country on the west side of the Ennore-Pulicat backwater is a dead flat of sandy clay, rather swampy in some places, but generally dry and overgrown with *Salsolæ,* which extend about a mile inland.

Pulicat lake.

Further north, the bed of the Pulicat lake is composed of fluvio-marine beds, abounding most especially in remains of *Potamides fluviatile* and *Cytherea castanea.* The surface is seen at low water to consist in most places of a true greyish-white shell marl.

b.—The river alluvia.

These are of more interest than the unquestionably marine alluvium along the coast, as their peculiar distribution indicates that at some past period, but within the human era, the courses pursued by various of the principal rivers within the north-east portion of the area of sheet 78 differed considerably from their present courses. Thus, it will be seen on looking at the map that the Palar river, or a great branch of it, once flowed into the sea not, as at present, a few miles south of Sadras, but between fifty and sixty miles further north, probably near to the present embouchure of the Corteliar river.

The old valley of the Palar.

The broad alluvial valley which extends from the sea up to the banks of the present Palar river, six miles east of the town of Arcot, is altogether disproportioned to the size of the Corteliar river, which now flows through it, and it is evident that some very much larger river was instrumental in the deposition of the extensive alluvial formations occupying the valley in question. The alluvial accumulations further down the present valley of the Palar are equally out of proportion to the magnitude of the river now debouching at Sadras.

A stream now connected with the Palar near Arcot by means of a channel which is crossed by the Arconum-Conjeveram tramway at Pulloor, bears the Sanscrit name of Virdachara nuddee, or Old Milk-river, and is regarded by the natives as the old Palar, the Tamil name Palar also signifying 'milk-river.'

When the change in the course of the river took place is not known, but from the above fact it probably happened at no very remote period, even historically considered. The probable cause of the change, if a natural one, was the silting up of the old river valley, which raised the river sufficiently during some great flood to find its way through and across a dam of gneiss rocks, still in part remaining opposite Mavamunglum and Maundoor, when the fall of the land surface being more rapid in an easterly direction than in the old bed, the latter was permanently abandoned, or only filled during the very highest floods, while the main river joined the valley of the Cheear river, which it followed to the sea.

Old valley of the Naggery river.

Another and in many respects similar change of course has taken place in the Naggery river. This river has cut through a neck of gneissic rock and trap dykes (about half a mile in width) at a point lying two and half miles east-south-east of the town of Naggery, and abandoned the broad alluvial valley which stretches eastward along the foot of the Naggery mountain towards the Nagloperam range. Before its change of course the Naggery river undoubtedly joined the Narnaveram river a little to the south of Nagloperam village.*

The Vaddagar, an old branch of the Palar.

The alluvial valley now occupied by the Conjeveram river or Vaddagar can similarly be regarded only as an abandoned arm of the Palar proper;—abandoned, because silted up.

The Palar alluvium.

The alluvium of the Palar is generally nothing but a coarse, gritty, dusty sand, and rarely consists of gravel; both are made up almost entirely of the débris of the coarse-grained granitoid rocks occurring so largely in the North Arcot

* I have been unable as yet to ascertain whether the natives recognize this alluvial valley as an abandoned river course, and have given it any name in reference to that fact as in the case of the old Palar.

District. It rarely contains beds of loam and still more rarely of clay. The latter formation was observed only between Chingleput and the sea in two or three places, where the ground was in consequence very swampy. Between Sadras and the village of Perumbaukum (two and half miles west of Sadras) the clay is of dark-greyish black color, and near the bank of a deep but narrow branch of the river shows the characters of true regur, or cotton soil.

Alluvium of the old Palar.

The description of the alluvium of the Palar river applies equally well to that of the old Palar valley, through the deposits of which the present Corteliar river, after draining the great Covrepauk tank, merely cuts its way, very rarely forming any deposit itself.

Alluvium of the Corteliar.

The deposits of the Corteliar river are easily distinguishable from the coarse sandy alluvium of the old Palar, which is of pale drab colour in general, whereas the Corteliar has deposited but a very narrow belt of reddish loam or loamy sands on the sloping sides of the old and rather deep bed. The principal deposition of such loamy alluvium has taken place between Illeputandalum and Tukkoolum (Tukkool of Atlas sheet).

Junction of the old Palar and Poonamallee alluvia.

On the east side of the bridge by which the Arconum-Conjeveram tramway crosses the river, the relative position and the small extent of the true Corteliar alluvium can be especially well seen. Following the course of the valley seawards in a north-east direction, the alluvium will be found to surround several outliers of lateritic rocks near the Trivellore railway station, while a narrow strip of alluvium follows the course of the Cuum or Madras river and joins the alluvium of the old Palar with the sandy alluvium of the Poonamallee bay.*

* The branch stream which runs from the Cuum river into the great Chumbrumbaucum tank is of artificial origin.

The coarse sandy character of the old Palar alluvium is generally persistent all the way to the junction with that of the Narnaveram river; but where it approaches the edge of the lateritic deposits, or has been influenced by small streams rising on the higher lateritic grounds, the sand is frequently clayey, *e. g.*, near Metnavilly, &c. Nearly in the centre of the valley north-eastward of Trivellore town and along the banks of the small stream between Vulloor and Cummacumbade, the bare surface consists of very unctuous whitish sandy clay with numerous small quicksands; but whether this is the surface of a true clay-bed, or merely a local deposit of clayey matter washed up during the inundations of the stream in question, could not be safely decided, no good sections being obtainable in that neighbourhood.

Clayey sands.

The small cliffs forming the banks of the Corteliar river between Cavilloor and Singacoopum ford show the following section opposite Kuravayal:—

	Ft.		Ft.
Sand	3	to	4
Dark coloured regur-like clay	7	to	9
TOTAL ...	10	to	13

Further down the river opposite Chooroopaucum and also west of Munarswamy Covil, small deposits of dark reddish brown loam occur in the midst of the sands and are exposed in the river-side cliffs. Two and a half miles north of the last-named place, considerable infiltrations of ferruginous matter have cemented parts of the sands together into not very compact masses bearing a slight resemblance to very sandy laterite. Such material may be seen turned out of two or three small tanks recently dug near Mettawhy and Vellary.

Reddish loam.

Ferruginous infiltration.

The alluvium of the Narnaveram river is almost purely sand, occasionally mixed with quartzite pebbles, or small boulders derived from the adjoining

Narnaveram river alluvium.

lateritic formations. Eastward of the Nellore high road where the lateritic grits become but very slightly ferruginous, and the alluvial sands so abound in lateritic pellets as often to assume a reddish color, the distinction between the two formations becomes anything but easy, and in the absence of sections is often quite a matter of guess-work.

Poonamallee-Madras alluvial bay.

The mineral character of the Poonamallee-Madras alluvial bay is very simple. Near the sea and inland in a westerly direction, so far as Poonamallee, it consists generally of pure fine light drab sand. Westward of Poonamallee, the fine sand, mixed, near the banks of the Cuum, with a considerable proportion of clay, passes near Trimalchy and Chittagauda into the coarse gritty dusty sand of the old Palar alluvium, which here contains (locally) a considerable proportion of washed-up laterite pellets.

The junction of the two alluvia through the valley south of Permalpett has been already pointed out.

The junction line of the coarse fluvial sands and the fine marine sand, trends north-eastward as far as the great tank at Ayapakkam (Ayappalicum of the map), which village stands on a bank of the coarse sand raised 10 or 12 feet above the general level of the alluvial plain, and abutting against the slope of the lateritic formations.

Between the villages of Nuttum and Anakaputur (Anacotore of map) to the south of Poonamallee is a considerable spread of black soil undistinguishable from cotton soil, but which was formed no doubt at the bottom of the great Pammal tank, which formerly occupied several square miles of country in the valley of the Adyar.

Organic remains in alluvium.

The only organic remains anywhere observed in the alluvial deposits proved to belong to existing animals, and were very sparingly met with. They consisted of the shells of Helices and of other fresh-water mollusca.

It will be observed on reference to the map, that the Corteliar to the north of Tripassore does not continue to flow in the alluvial valley of the old Palar, but forces its way between two rather elevated spreads of lateritic conglomerate near Pundi (Boondy of Atlas sheet). It is uncertain whether this passage was forced by the waters of the united Corteliar and Naggery rivers, or whether it had already been made by the Old Palar. There is no distinct evidence on the subject, but the probability is, the passage was forced by the old Palar river after it had silted up its valley in the narrower part lying between Trivellore and Nemaly to a height sufficient for its waters to flow into what was undoubtedly an old valley formed by denudation during the period of elevation which raised the implement-bearing laterite to its present position.

The direction in which the Corteliar here flows seems to indicate that it was then the more important stream, instead of bringing down as at present a much less amount of water than the Naggery river; this points to the inference that the Naggery river at that period still flowed into the Narnaveram river, the passage through the narrow gneiss ridge three miles north-north-west of Nellatoor mentioned before (page 21) not having been formed till a later period.

Between Pundi (Boondy) and Villapaucum, the Corteliar has, during its floods, deposited a good deal of reddish loam on its banks, but as it flows in a rather deep channel, this newer alluvium never attains to the same general level as the older, more gritty or sandy and paler Palar deposits.

The Narnaveram river alluvium.

Like the Corteliar, the Narnaveram river flows in a deep bed, and appears to be far more active in eroding the old alluvium than in depositing the material derived from its higher reaches.

Were it not that great part of the water of all the rivers in this part of the Carnatic is drawn off by side channels during freshes, and the highly turbid waters allowed to settle their sediment in tanks, almost every part of the sediment they bring from inland would be carried into the backwaters or out to sea to be scattered up and down the coast according to the set of the great periodical coast-currents.

The great quantity of water drawn from the rivers for irrigation purposes must materially retard the scouring action by which these rivers deepen their beds, which would otherwise probably soon become so deep as to be useless for ordinary irrigation purposes. Such a state of things on a large scale was taking place in the Coleroon river, when the Government stepped in and built the anicut, or dam, across the river at the head of the (Seringham) Sri Rungum island, near Trichinopoly.

The positions of the various alluvial valleys are clearly shown in the long section accompanying this report (Pl. A).

Chapter V.—The Lateritic Formations.

Of the various formations classed together as 'lateritic,' the most important and most striking in appearance is the laterite proper, a ferruginous clay of a peculiar character. The other formations associated with it are gravels and sands, both generally more or less ferruginous.

Definition of the name laterite.

The name 'laterite' has unfortunately been extended to other rocks of somewhat similar aspect, but of very different origin from the truly sedimentary ferruginous clay of the western coast, to which the name was first applied by Dr. Francis Buchanan.*

Much confusion has arisen from this loose application of names, the true sedimentary laterite being frequently confounded with a red tufaceous clay associated with lavas in volcanic regions† and also with a peculiar indurated ferruginous clay found chiefly on the summits of the highest mountains in Southern India, *e. g.*, the Nilghiris and Shervaroys, and resulting from the decomposition of hornblendic and other ferruginous rocks in very damp climates.

True laterite a sedimentary rock.

To avoid such confusion the term 'laterite' is, in this report, applied only to a truly sedimentary rock of (in all probability) marine origin.

Although no organic remains have been found in the laterite of the Coromandel Coast, nor, so far as I know, in the corresponding formation on the Western Coast of India, to show whether it was a marine or fresh-water formation, there can yet be little or no doubt of its being of marine origin, if the position of the several laterite areas along the coast, from Tanjore northward nearly to Ongole in Nellore District,

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* See "Journey from Madras through Mysore, Canara and Malabar" (London, 1807, 3 vols.), Vol. II, pp. 436 and 440.

† See Lyell's "Elements of Geology," 6th Edition, page 590.

be considered. The several patches in which the laterite there occurs are manifestly but the remains of one continuous formation cut across by the eroding action of the larger rivers as the land was gradually rising above the sea. The parallelism of this band of laterite with the coast on one side, and with the general strike of the high ground of the peninsula on the other, is most marked.

To suppose this laterite to have been deposited in a fresh-water or brackish lagoon involves the conception of a barrier of extraordinary length and breadth to be sufficient to exclude the sea and to retain the waters brought down by numerous rivers along a line several hundred miles in length. Moreover, the fresh and brackish water deposits which have been formed in the lagoons now existing in no way resemble the lateritic formations.

Its lithological characters.

The typical laterite of Buchanan may be described as an impure red sandy clay, as a rule very largely impregnated with iron in the form of brown hæmatite, and remarkable for its tendency to form concretionary conglomeratic masses, abounding in vesicular and vermicular cavities, which are generally filled with a lighter-colored soft lithomargic clay. When freshly quarried the mass is often soft enough to be cut with an axe or spade and trimmed into shapes convenient for building purposes; but under atmospheric influences it soon hardens, and after a time becomes coated with a hard ferruginous glaze. The softer clay occupying the vermicular cavities communicating with the surface will then generally be found to have been washed out, giving the surface of the rock a very rough porous appearance. It is this scabrous looking rock to which the Tamil people have given the name of '*shuri kal*' or 'itch-stone.'

In many parts of the Peninsula this rock is largely quarried for building purposes and forms a substitute for bricks,—a use which appears to have suggested the name to Dr. Buchanan, who adopted the latin word '*later*,' a brick, as the root for the new name he coined.

Varieties of laterite.

A variety of laterite occasionally met with in association with the typical rock consists of an aggregation of round pellets, 'pisolitic gravel,' of brown hæmatite united together by a ferruginous argillaceous cement. This variety also possesses the quality of hardening on exposure into a useful building stone.

The laterite is generally a conglomeratic rock enclosing pebbles and fragments of other rocks.

Associated with the typical laterite, and very often passing into similar conglomerate, are beds of loose lateritic gravel, which again very often pass into compact red sandy clay or sandy loam, throughout which lateritic pellets are scattered in greater or lesser quantity. The passage is generally gradual, but in some few cases the change of character takes place within a distance of a few feet.

The intermediate forms, the unconsolidated gravels, and compacted red sands, occupy the larger parts of the lateritic formation area, but are much less striking features, both topographically and geologically, than the conglomerate beds.

The typical conglomeratic laterite may be best studied in the neighbourhood of Madras, and the largest and most accessible development of it is at the 'Red Hills,' about seven miles north-west of Madras; but other equally typical beds of laterite are exposed at various other places in the Madras District, and will be referred to separately further on.

Absence of fossils.

No organic remains, either animal or vegetable, have been found as yet in the lateritic series, excepting some pieces of silicified wood, washed up out of older formations, as the Rajmahal and Cuddalore series. In certain lateritic gravels

Implements of chipped stone.

and conglomerates, however, at various places in the Madras District and adjoining parts of the North Arcot District, chipped stone-implements of human manufacture are found imbedded, proving that man had set foot in the Peninsula prior to the formation of the gravels and conglomerates in question. These gravels and conglomerates form the upper part of the laterite series, which is therefore referred to the Quaternary or Recent Period. Some of the principal localities yielding these implements will be found described at the end of this chapter.

Although they occupy in the aggregate an area of several hundred square miles, the lateritic formations are generally of but small thickness, often merely a few inches in depth, but still they give so much character to the surface which they cover that they are deserving of more attention than would be accorded to formations of less individuality in mineral and structural character.

The lateritic formations generally rest unconformably upon much older fossiliferous rocks of the same general age as the Rajmahal rocks of Bengal and of some of the Oolitic rocks in Kutch. But in many places the Rajmahal rocks are overlapped by the lateritic formations, which then rest directly on the metamorphic rocks (gneiss).

a.—Conglomerates, Gravels, &c.

Typical laterite at the Red Hills.

The conglomerates being the most interesting and important members of the whole series deserve to be first described. The Red Hills conglomeratic laterite, which, as before mentioned, is quite typical, occurs in several detached patches, the largest being at the northern end of the great tank around the village of Narraincoopum, where the ancient builders of the so-called Korumbar rings, availed themselves of the material so abundantly at hand to construct a great number of their rings and enclosed kistvaens. The laterite here shows to perfection its peculiar dark glazed cellular surface in the weathered blocks, while the freshly quarried masses show their clayey character and the vermicular and cellular cavities filled with sand or sandy clay. The undoubtedly conglomeratic nature of this rock is proved by the not unfrequent occurrence of rounded quartzite pebbles imbedded in the solid mass. Other large patches of an identical laterite occur at the village of Madaveram (the native name of the red Hills) and to the northwest along the banks of the Corteliar River, where it is seen capping cliffs of coarse friable brownish grit of undeterminable age, provisionally referred to the Cuddalore series.

The appearance of the laterite-spreads at, and north of, the Red Hills recalled to mind very vividly the laterite occurring at Vellum in the Tanjore District, the uncovered beds presenting on the surface the appearance of low reefs of rock on a coast. Between the above patches of typical laterite-conglomerate the surface is covered either by lateritic gravel or by the lateritic sands.

On the top of the cliffs, on the right bank of the Corteliar, the laterite contains numerous stone-implements, some still imbedded in the compact tough rock, others lying loose, having been weathered out.

Increase of coarseness of conglomerates as traced to the west.

If we proceed westward from that part of the country, we find a gradual and steady increase in the size of the quartzite pebbles in the conglomerate beds till the source whence they were derived is reached; and this source is found in the enormously coarse conglomerate beds of 'Rajmahal' age, situated in the Alicoor and Sattavedu hills.

With the increase of coarseness in the conglomerate, the typical character of the laterite is lost, for it can no longer be shaped by mere cutting into building stones of convenient size, and has lost the singular vermicular branching tubes and most of its concretionary structure. In extreme cases the ferruginous material forms but a very sparingly distributed cement.

Conglomerates near Avadi.

South and south-west of the Red Hills tank, typical laterite conglomerate occurs in patches of different sizes at various places, especially to the north of the Avadi railway station.

South of the Cuum river, on the principal laterite area, small patches only occur, except around and to the south-west of the great Chumbrumbaucum (Sembarampakkam) tank. On the north and south sides of this huge tank large areas, each several square miles in extent, are almost entirely covered by the conglomerate, the latter being largely exposed on the higher grounds. Very few quartzite pebbles of large size are here seen, and the laterite is as typical as at the Red Hills.

Near Chumbrumbaucum tank.

A very good display of the laterite occurs still further south-west near Irumbedu and near Sripermatoor. The most southerly laterite-spread of any magnitude in this part of the Madras District occurs at and around Oragidam (Woodagurm of Atlas sheet), eight miles south of Sripermatoor. South-westward of Sripermatoor the laterite already shows a marked increase in the size and number of the quartzite pebbles it encloses. It may be well seen at Tirumungalum, at Kandur, and on the high ground south-west of Arryapaucum.

Near Irumbedu and Sripermatoor.

Near Oragidam.

A small but very easily accessible patch of laterite conglomerate occurs on the south side of the Cuum immediately opposite the Trivellore railway station, and, being largely quarried as a road material, furnishes many fresh sections.

Near Trivellore station.

The outlying area of laterite lying between Tripassore and the Corteliar belongs to the very coarsely conglomeratic variety, the enclosed pebbles and boulders being often of large size, as well as extremely numerous. Of the same character are the more elevated laterite beds occurring on the small table-land lying between the Corteliar and the south-east extremity of the Alicoor hills.

Near Tripassore.

The lateritic formations lying on the north and south sides of the Naggery river valley are yet more shingly in character, but the included shingles, though large,

Coarse shingly conglomerate.

but rarely reach a size sufficient to merit the name of boulders. In these there is also the same decrease in the size of the pebbles, with little of the lateritic cement visible on the surface. In the well-sections the cement sometimes becomes apparent, and occasionally also forms blocks exposed on the surface or in rain channels.

Near Chinnamapett station and Catramatoor.

Frequently the position only of the shingle bed, and the occurrence of stone implements, indicate the real age. Such is the case with regard to the shingle beds south of Catramatoor near the Chinnamapett railway station, and with those (three in number) east of Tukkoolum.

"Boulder beds" near and around Alicoor and Sattavedu hills.

A very great part of the lateritic formations lying both between the Corteliar and Narnaveram rivers, and to the north of the latter, consists of the extraordinarily coarse conglomerate referred to above. The coarseness of these conglomerates, which is often so great as almost to merit the appellation of 'boulder beds,' seems to increase with their proximity to the older conglomerates of the Rajmahal system, which compose the main mass of the Sattavedu and Alicoor hills. The difficulty of distinguishing between the series of conglomerates when weathered need not again be touched upon.

Coarse conglomerate near Sattavedu.

The most extraordinarily coarse example of true conglomerate was noticed in a well-section a little north-west of Callapanaidoopettah near Sattavedu. Here the bed is fully 12 feet thick, and consists of very large rounded masses of quartzite cemented together with true lateritic cement. Towards the middle and base of the section several small beds of typical laterite are intercalated, contrasting strongly with the coarse conglomerate. The real base of the section was covered by the water in the well.

Conglomerate south of the Narnaveram river.

South of the Narnaveram river is an immensely coarse laterite shingle occurring at Benaloor and Goompolliam, and stretching up to the foot of the

Alicoor hills and into the valleys opening out of them. In an easterly direction, similar shingle re-appears at intervals at Cutchoor (quite as coarse as at Benaloor) all along the northern slope of the high ground and as far as Vadamadiri (Waramderry of map), where it is well displayed, especially on the north-west side of the great tank. Here numerous small blocks of laterite occur with the loose quartzite pebbles on the surface. South of the great tank the shingly character is exchanged for a more sandy one, but re-appears on the high ground west of Vingul and north of Chumbode and south of Meyyur. The plateau on the top of the high ground west of the Chumbode hill is chiefly covered with massive, or gravelly, laterite which extends west to the small scarps at Cunjalum near Nelway.

Shingle conglomerate near Chumbode.

Very fine examples of less coarse conglomerate frequently approaching the above in character occur at various places. To the north of the Narnaveram river very good examples are to be seen at Junglepilly, and again about two miles to the south-eastward near Sinjeagraram (Chingeagrin of map). At both these localities the laterite forms small scarps of some extent, rising abruptly to a height of about 30 feet above the alluvium of the Narnaveram valley. The laterite weathers almost black and is very vermicular in parts. To the west this typical conglomerate graduates into a coarse shingle of quartzite, not consolidated on the surface, but with pellets of laterite mixed with the sand lying in the interstices between the quartzite pebbles. Whether the shingle is merely the result of the weathering out of the cement of a very coarse conglomerate or a true unaltered shingle bed could not be ascertained in the absence of sections.

Conglomerates north of the Narnaveram river.

Near Sinjeagraram and Junglepilly.

Fine beds of typical or nearly typical laterite occur to the north-east of Junglepilly at various places, *e.g.*, the south end of Caradepootoor tank, at Boodoor, south of

At Caradepootoor.

Sattavedu, at Seervedu (Seerwaydoo), at Amerambode (Amerumbardoo of map) very largely.

The whole of the high ground north of the last village is covered with generally massive laterite. The village of Maderapaucum stands on a large spread of very dark laterite rock. Very large sheets of it may be seen protruding over the surface all round Paundavaucum and again at Cunnumbaucum. To the south-south-east and east of Amerumbode the massive laterite occurs largely at Colanur, Pulloor, and thence along the high ground to Ingawarpolliam, where it forms a spread nearly two miles in width, and passes eastward into the gritty or clayey variety, which extends several miles further eastward, and then itself passes into sands mixed with lateritic pellets.

Manjakaranei outlier.

A very interesting outlier of the Red Hills typical laterite lies about two miles north-north-west of Yermootapolliam, where the Corteliar river trends north prior to crossing the Madras—Nellore high road. The outlier consists of a small tabular hill steeply scarped on all sides but the east; it is close to the village of Manjakaranei and above 50 feet high above the alluvium. The summit of the hill is composed of typical laterite, with numerous included fragments of quartzite, passing down into vermicularly cellular rather clayey grits with a few lateritic lumps. These again appear to graduate into coarse, mottled, and rather friable grits, which become increasingly white and pure as they descend. The grits contain no fragments of quartzite. Several stone implements of not very good workmanship were picked up at the foot of the hill in the laterite débris, and one in a little rain-gully on the west side of the hill just below the top. These had evidently been weathered out of the massive laterite and had fallen down.

Cuddalore grits.

It has already been pointed out that the greater part of the lateritic formations are of less compact character than the conglomerates just described, which in the southern parts of the area, more especially, occur but in detached and scattered patches, mostly of small size. These gravel and sand beds may be best seen on the higher grounds to the north and west of Sripermatoor, where they probably obtain their maximum thickness, which, however, is in all probability but small and cannot be estimated at much more than 20 feet. The upper part of these sands is frequently pure, or mixed only with laterite pellets in very varying proportion. When pure, it often shows no signs whatever of bedding; as, for example, at Illupur (six miles north of Sripermatoor), where the pure reddish sand attains a thickness of more than 5 feet, as shown in a small sand-pit.

In a section offered by the banks of a small nullah about two miles to the north-east of Illupur and a little south-east of Coopoor village, the red sandy soil is distinctly bedded, the bedding being shown by layers of laterite pellets. The bedding here has a slight south-easterly dip.

Difficulty of distinguishing the upper part of the shales from overlying clayey beds.

The lower part of the sands is sometimes rather clayey and charged with kunkur in pipe-like concretions, and it then often becomes very difficult to distinguish between them and the underlying shales of the Sripermatoor series, the upper beds of which are rarely fossiliferous, and are much broken up at the top and filled with infiltrated kunkur concretions.

Presence of quartzite pebbles in lateritic sand a distinctive sign.

It is often also hard to distinguish between these non-compact lateritic deposits, when they rest upon, or approach close to, metamorphic rocks, and the reddish sandy soils formed by the decay of the latter. In color and texture they are often quite undistinguishable to the naked eye; but careful searching will generally solve the difficulty by discovery in the true lateritic sands of water-worn fragments of quartzite derived indirectly from the great quartzite beds of the Kadapá series, which cannot of course occur in sands formed from the weathering of the gneissic rocks underlying them. In several places these unconsolidated sands contain rounded pebbles and masses of quartzite of various colors and sizes:—for example, in a new well-section seen at Ulandur, five miles north-west of Sripermatoor, pale sands full of large pebbles and small boulders of quartzite of pale-drab, whitish, purplish and brown colors (mixed in this case with rounded fragments of gneiss and mica-schist and some débris of the plant-shales) occur, which pass up into the red lateritic sand. Occasionally small portions of the sand have been cemented together, apparently by subsequent infiltration of calciferous water, into flaggy cakes, parts of which are sometimes rather concretionary in structure and consist of very impure sandy marl. Many of these may be seen in a rain-gully south of the Madras—Arcot road, opposite Tirumungalum. Also on the high grounds east of Manoor (three miles north-north-east of Sripermatoor), and scattered over the fields south of Wallaveram and northwards of that village near the tank at Paduvalur (Pullilore of the Atlas sheet).

Sandy marl concretions formed by infiltrations.

Westward of the high ground near Tirumungalum (four miles south-west of Sripermatoor), the lateritic character of the sands ceases, and the surface of the country is covered by pale sandy or gritty pebble and shingle beds. As the exact relationship of these beds to the unquestionably lateritic formations is obscure and doubtful, they will be separately described.

The two small quasi-insular patches of lateritic formations lying east and south-east of Trivellore, consist almost entirely of the sandy varieties of laterite, but small sections of the massive variety are exposed in the case of the southern patch—close to the overflow (kalingula) of the large tank east of the town—and again in a small irrigation channel immediately south of the railway station.

Lateritic formations S. of the Corteliar at Trivellore.

The central portion of the Red Hills laterite area is very sandy, and the massive rock or lateritic gravel only shows in a few localities, but in the western and southern parts of the area from Callicoopum and Mittanemali (Metnavilly of map) to Avadi, and thence on to close to the south-east of the Red Hills tank, the rising grounds are in many places covered with the massive or gravelly varieties.

Association of lateritic conglomerates and gravels.

Striking examples of the association of the laterite conglomerates and gravels may be seen in various places, *e. g.*, on the high ground between Yenkadu and Irumbedu (Vemgada and Yerrempoor of the Atlas sheet), three miles east of Sripermatoor. Here the surface all around Yenkadu village is quite purplish in color from the immense quantity of 'pisolitic laterite gravel,' which, further to the south-east near Irumbedu, has been cemented together into a hard and almost black lateritic conglomerate apparently very rich in iron. The same thing may also be well seen to the south of Puduperu (Poottoorpare of the Atlas sheet), where the high ground south of the old high road is capped with coarse laterite gravel partially cemented into a hard conglomerate.

It is by no means easy to explain the isolated occurrence of the laterite conglomerate spreads scattered over the Madras District. Some of the smaller patches, *e. g.*, the small oval patches capping the Vellacotta hill and the Munjakaranei hill, must be regarded as outliers separated from the main spreads by denuding forces of various kinds; and the outlines of these are invariably sharply defined. But many others cannot be ascribed entirely to the denuding effects of aqueous or atmospheric agency, but are due to the peculiar distribution of the sedimentary materials at the time of the formation of these deposits. It would appear, then, that the marine currents at work in those days, deposited in many places great masses of sand of mixed character,

Laterite gravels and conglomerates were possibly banks of magnetic iron sand.

a great part being pure silicious sand, but a great part also being ferruginous sand, probably magnetic iron sand, great abundance of which is at the present time constantly being carried out to sea at every fresh in the larger rivers rising on the metamorphic rocks. This may be seen any day on the beach of the Coromandel Coast, where the color of the sand is a true index of the quantity of the iron sand contained. Very frequently scores and sometimes many hundred square yards of the beach may be seen of dark black color, and consisting mainly of magnetic iron sand. This is the case to a very remarkable extent near Cape Comorin, and on the south coast of the Tinnivelly District. The black iron sand is often replaced by dark crimson garnet sand, but they are often also blended together, or arranged in irregular bands of patches with the common pale buff or drab quartz sand; producing altogether very striking and pleasing effects by the contrasts of color.

The Kistna, and such of its tributaries as flow through the great Deccan Trap area, also carry down large quantities of magnetic iron sand derived from the trappean rocks. It is evident that the same thing, and on a much larger scale, must take place over considerable areas under the sea, which, if elevated above sea level and exposed to atmospheric influences, might, in the course of ages, be oxidized; and according to the poverty or richness of the sands in iron, we might expect they would remain either simple sands or become sands with lateritic grains, lateritic gravels (formed by agglomeration of grains together, the cement being peroxide of iron), or, when pebbles existed, lateritic conglomerate. There are many reasons for supposing such processes to have actually taken place in the formation of the lateritic deposits before described; and the supposition that the ferruginous materials were originally deposited under water in the state of iron sand unequally distributed over the bed of the sea, greatly simplifies the explanation of the phenomena of the passage of sands into the most compact lateritic conglomerates, which may be seen in so many places over the area described.

Former western extension of lateritic formations.

That the lateritic formations once extended further west is certain, for débris of them occurs in various places at a considerable distance from the present boundaries. For example, numerous pebbles of quartzite with some lateritic gravel occur on the gneiss near Paliamungalum to the east of Arconum railway junction. On the north side of the Trittany river between Permaltoor and Maundoor, traces remain of the lateritic formations in the shape of quartzite pebbles, and a little laterite gravel, among which a very good stone implement was found.

Traces near Naggery.

Where the Naggery river leaves its old alluvial bed and turns to the south-east, a small patch of lateritic gravel occurs on the top of the gneiss. Three or four good implements were found here.

About a mile south of the village of Gungamoperam, and again close to the north end of the great tank at Panoor, small patches of lateritic conglomerate have been left after the removal of probably extensive beds, by erosion during and after the process of elevation, which raised the country to its present position.

Similarly, there are indications of the existence of laterite formations on the gneiss country near the sea, *e. g.*, at Tyhoor, where a couple of acres are covered with typical laterite, and near Tiruvanjeri and Madampakam, a few miles south of Palaveram, where lateritic gravel with quartzite fragments is rather common. The laterite near Guindy park is gravelly as a rule, and then very pisolitic in character. It contains small angular fragments of quartzite of drab color, which contrast strongly with the brownish purple of the pisolitic ferruginous gravel.

Near Palaveram, west of the Travellers' Bungalow, the laterite is less ferruginous than near Guindy, but approaches more to a conglomerate in its character; it contains a fair number of quartzite pebbles, and among them chipped implements. The first chipped quartzite implement discovered by me in India was found among the material turned out of a ballast-pit dug in the laterite gravel a little to the south of the Brigade parade-ground between Palaveram and St. Thomas' Mount.

(*b*).—*Conjeveram Gravels.*

The name of Conjeveram gravels has been proposed by me for a series of coarse gravels and shingles, covering a large tract of country to the north, north-west, and north-east of the large and well known town of Conjeveram. The relations of these shingle beds to the lateritic formations which overlie them, as well as to the underlying Rajmahal series, are obscure; and even should it eventually be established beyond a doubt that they (the shingles) belong to the lateritic period, yet will it be better to distinguish them by some local name on account of their great mineral dissimilarity to the typical lateritic formations.

Area of distribution.

The area occupied by these shingles and associated sandy beds is not very sharply defined on the east side. On the north or south, on the contrary, it is distinctly bounded by the edge of the old and new Palar and the Vuddagar alluvium, which meet together about three miles south-south-east of Covrepauk. The gritty character of these sands, even when very coarse, and the analogous superposition of the laterite where the two formations are in juxtaposition, suggest the idea that these gravels and sands might be stratigraphically equivalents of the gritty sandstones (Cuddalore sandstones), so largely developed in the Yermootapolliam and Munjakarinei sections. This view seems favored by the fact that these Conjeveram gravels lie much nearer to what must have been the old coast line of the lateritic sea, and, therefore, are necessarily much coarser than deposits showing a more deep sea character.

Want of good sections.

Unfortunately no section I am acquainted with throws much light on the subject, for in none do the gravels appear clearly exposed in contact with the Rajmahal beds or with the true laterite; nor have I found any section showing the Cuddalore sandstones and Rajmahal beds in contact:—nor have any fossils yet been found in the Conjeveram gravels by which to distinguish them from, or to assign them unhesitatingly to, either of the two series of rocks. The mineral character of the gravels is very uniform on the whole, consisting mainly of quartzite pebbles of various colors, rarely larger than a man's fist; associated with these are pebbles of gneiss, quartz, and débris of decomposing granitic rocks of all kinds.

Absence of fossils.

Sandy beds; the gravel series.

The sandy beds are generally reddish in color, with lateritic pellets occasionally becoming slightly clayey and moderately compact, *e. g.*, near Shevtamodoo and to the east of Nelliangolam; both places lying near the banks of the Palar river. Typical examples of the gravels may be studied on the sides of the Tennary tank off-flow channel north of Devaroyempakkam; on the rising grounds north of Great Conjeveram in a very ruinous bowry at Ingepaucum three miles north of the town. In the northern madaghoo (off-flow channel) of the large tank at Corree the white gritty Conjeveram gravels rest conformably on white friable grits. The white grits of the Vidaloor tank madaghoo are likewise conformably overlaid by the somewhat lateritic gravels.

Sections at Ingepaucum,

Corree, Vidaloor.

Damul.

In a section in a new well being dug about one and a half mile east by north of the Pagoda at Damul (eight miles west-north-west of Conjeveram) the beds observed were greyish-red, gritty coarse sand, slightly lateritic, $3\frac{1}{2}$ feet in thickness, lying on obscurely bedded friable gritty felspar gravel, exposed to about 10 feet in depth.

The same feature of lateritic gritty sand resting on whitish grits is also shown in the channel leading from the Onatoor tank to the Damul tank. The most westerly occurrence of a formation referable to the lateritic series is a small bed of intensely red gritty sand with laterite pellets and quartzite pebbles at Maramungalum, at the junction of the old and new Palar alluvia.

Onatoor.

Red gritty sands at Maramungalum.

The gravels are especially well developed near Parundoor and Vellatoor to the north-north-east of the Corree section. In a new channel leading northward into the Parundoor tank, the pale gravels, which contain a bed of lateritic gravel from 6 inches to 2 feet thick, rest on the eroded surface of a bed of clayey, pebbly, reddish mottled grit. The thickness of the grit is not shown. In mineral character the grit is strikingly like that occurring at Devaroyempakkam south-east of Tennary. One or two rather doubtful stone implements were found near the Parundoor tank kalingula, and a considerable number were obtained on the surface of the gravel beds between Ackeramperam and Singilpadi.

Parundoor.

Between Singilpadi and Puddoor the sandy beds are well shown, and in the shallow valley extending eastward from Surebaucum to the head of the Tennary tank the gravels are also admirably exhibited on the surface. Between Surebaucum and Puddoor they are rather unusually lateritic for that part of the country.

In the Surebaucum valley.

(c).—*Stone Implements in the Laterite.*

Many of the chipped stone implements found within the limits of the Madras area having been discovered *in situ*, it will be as well to give a fuller account of the sections in which they were found.

The section in which the first discovery of implements *in situ* was made occurs on the north side of the Corteliar river in the valley of a nullah falling into that river

Attrampakkam nullah sections.

at the village of Attrampakkam in the Trivellore taluq. In the upper part of the shallow valley through which the nullah flows is a large tank, near the village of Numbaucum, which on several occasions has burst its bund and thereby given rise to the formation of large and deep gullies leading down to the bed of the nullah. In these gullies the laterite beds in which the implements were found are extremely well exposed.

Close to the kalingula or waste-weir of the tank stands an old pagoda in ruins, just below which, at the deepest part of the gully, the following section is exposed :—

	Ft.	In.		Ft.	In.
a.—Soil and made ground	6	0	to	0	0
b.—Lateritic conglomerate with layers of quartzite pebbles ...	1	6	„	3	0
c.—Sandy clay with quartzite pebbles and kunkur in strings ...	5	6	„	6	6
d.—Lateritic conglomerate full of quartzite pebbles ...	3	0	„	0	8
e.—Grey shales (plant shales) with ferruginous stains ...	1	6	„	0	0

The annexed cut is a rough sketch of this section :—

Fig. 1.—Sketch of section in bank of stream at north end of Numbaucum tank.

A few yards to the west of the ruined pagoda these beds are exposed in a shallower gully down to the top of *d*. Here sticking in the sandy clay bed *c* a few inches above the top of *d* I found a well made hatchet-shaped implement. This implement appeared to be truly *in situ*, about

10 or 11 feet below the true surface. Further east in another breach gully the following section was measured :—

	Ft.	In.		Ft.	In.
a.—Soil	2	0	to	3	0
b.—Clay with laterite pebbles and a little kunkur ...	3	6	„	4	0
c.—Pebbly laterite conglomerate	1	6	„	0	0
d.—Kunkury clay (base not exposed)	2	0	„	0	0

First implement *in situ* discovered by Mr. King.

In the bed *c* an implement most unequivocally *in situ* was discovered by my colleague Mr. King, who accompanied me when examining these sections.

This implement was almost entirely imbedded in the hard conglomerate, from which it required considerable force to extract it.

Fifteen or twenty yards further down the gully another large hatchet-shaped implement * was found by me lying *in situ* on the here exposed top surface of the bed *c*, fully 6 feet below the general surface. This gully section and some others opening into it show in several places two distinct beds of lateritic conglomerate divided by sandy clay corresponding with the bed *c* of the pagoda gully section ; in other places the sandy clay is absent, and but one bed of laterite seen.

About half a mile eastward of the place where the last mentioned two implements were found, and a little below the junction of the kalingula gully with the main nullah, the following series of beds was measured in the bank of a small nullah coming from the south :— (Fig. 2.)

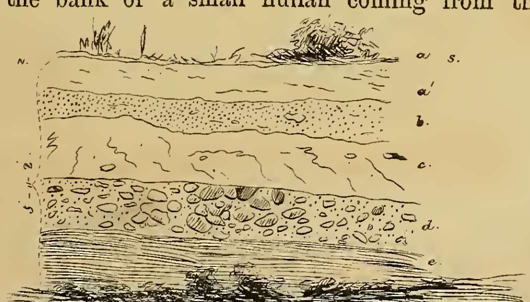

Fig. 2.—Section of stream bank, near tank.

* Two figures of this implement are given in Plates XII and XII *a* accompanying my paper published in the Madras Literary Journal, October, 1866.

		Ft.	In.
a.—Vegetable soil	... ...	0	2 to 3
á. Loamy sand	... ...	0	10
b. Lateritic gravel	... ...	0	9
c. Clayey sand with kunkur and a few pebbles of kunkur and laterite	... ...	1	4
d. Lateritic couglomerate with implements	... ...	1	2
e. Plant shales with kunkur infiltrations (base not exposed)	...		

On the face of the bed *d* a large and rather water-worn implement was well exposed, but the non-exposed side was so firmly impacted as to require several blows from a heavy hammer to detach it. Two other implements were extracted from the same bed a few yards to the northward. These also were firmly imbedded in the hard and tough conglomerate. Another fine but considerably water-worn implement was found by me in the side of a small gully coming from the north in to the Attrampakkam nullah. This implement occurred at a place about half a mile east of Nelway village, in a bed of very hard lateritic conglomerate at a depth of 3 feet from the top of the bed. This bed is not cut through by the gully, so its thickness was not ascertained. From the extreme hardness of the laterite the extraction of this implement * was effected only with considerable labour.

On the high ground a mile north-east of this gully several implements were found weathered out of the rocky laterite, other implements were also found on the surface of other laterite-covered areas further to the north-east, south-west, and west, near the villages of Deandivakkam, Tumbul, and Panur † respectively.

On other laterite spreads, lying both north and south of the Narnaveram river, large numbers of implements were found, and in some cases chiselled out of the hard conglomerate rock. The implements

* Two figures of this fine implement are given in Plates VI and VI*a* accompanying my paper in the Madras Literary Journal, October, 1866.

† A large village west of the Alicoor hills indicated, but not named, in sheet 78.

found lying on the surface had doubtlessly been weathered out of the rock they rested on, for they in every case presented precisely the same color and degree of weathering as the accompanying scattered pebbles, whose being weathered out from the conglomerates could not reasonably be doubted.

The places at which quartzite implements were found imbedded *in situ* and had to be chiselled out of the laterite were, on the north side of the Narnaveram river, seven in number, of which three are especially worth mentioning; they are, 1*stly*,—Caradepootoor (six miles south by east of Sattavedu), where a large spread of coarse lateritic conglomerate is exposed at the north end of the tank. Among the coarse quartzite shingle here cemented into a very typical conglomerate I found several implements. 2*ndly*.—Amerumbode (Amerumbardoo of the map) where an implement was found imbedded in hard clayey laterite fully 3 feet below the surface of the bed, which itself was overlaid by several feet of red sandy loam.

Implements found *in situ* at Caradepootoor.

Amerumbode.

Scattered through the scrubby jungle between this place and Maderapaucum to the north are many "Kurumbar rings," or circular enclosures of large rough blocks, of laterite in this case. Some of these contain kistvaens made of cut blocks of the same laterite. These ancient burying places* stand on the same bed of laterite as the implement found at Amerumbode was found imbedded in.

The third locality north of the Narnaveram river, to which I wish to draw attention, occurs near the village of Cunnumbaucum, six miles north by east of Amerumbode. A large show of very typical laterite conglomerate is there met with on the south side of the large tank, and in this I discovered

Cunnumbaucum.

* See a paper by Sir Walter Elliot, K. C. S. I., read at the Norwich Meeting of the International Congress for Prehistoric Archæology, and published in its volume of Transactions.

a small quartzite implement of nearly oval shape imbedded in the hard and undisturbed rock. Only a little of the edge of one side of this implement projected over the tolerably level surface of the rock, which was so hard that it took me not much less than half an hour to chisel it out.*

On Manjakaranei outlier.

To return south of the Narnaveram river, there is a rather remarkable outlier of 'Cuddalore' grits at Manjakaranei (Manjacarnay of map) capped by laterite conglomerate; here again implements were met with, though not *in situ*, but about one and half mile to the south-east on the greatly weathered surface of the laterite conglomerate capping the grit cliffs overhanging the Corteliar river (see page 42) I found several well made and well preserved implements lying among quartzite pebbles evidently weathered out from the mass of the laterite. Several others I found imbedded, and chiselled them out of parts of the rock, which were hard and unweathered.

On top of the cliffs south of the Corteliar river.

Theory that the implements are not of same age as the laterite.

It has been suggested that the implements found here and at other places had not been deposited originally at the same time as the quartzite shingle and other pebbles of gneiss and quartz, &c., found in the ferruginous clay mass of the laterite, but that they had been subsequently dropped on the surface of the laterite when uncompacted, and those found impacted in exposed surfaces of the rock had become so impacted by subsequent consolidation of the whole bed, and that those found loose on the weathered surface of the rock could not be considered as having been weathered out of it, but as merely lying accidentally on the surface, and therefore altogether younger than the laterite.

* This implement is figured in a paper read by me to the International Congress for Prehistoric Archæology held at Norwich in 1868, and published in the volume of their Transactions.

Objections to that theory.

There appear to me several objections to this suggestion:—*Firstly.*—In this part of the Peninsula chipped stone implements have as yet never been found excepting in, or on, lateritic formations, or in their immediate neighbourhood, at such levels that it is evident whence they were washed down. None occurs in, or on the surface of, the various younger alluvia, in some of which they would surely have been found had the implement-makers lived later than the laterite period. Considering how many outliers and separate areas of lateritic conglomerate are scattered over the Madras area, in, or on the surface of, most of which quartzite implements have been found, and often in large numbers, it is remarkable that none have as yet been found in the younger formations separating the several outliers and areas of the laterite.

Secondly.—The color or stain derived from the matrix and the general condition of the surface of the quartzite shingle found, often in large quantities, lying loose on the surface of the laterite beds, perfectly agrees, as far as my own observation goes, with the color and surface condition, *i. e.*, degree and nature of weathering of the implements found lying equally loose on the surface. Now, it is highly unlikely that the large quantity of quartzite shingle met with on the surface of the laterite in very many places should have been deposited there by the same accidental causes which, it was suggested, had brought the implements into the positions in which they were found, and yet, as above stated, the external characters of the gravel and implements admit of no distinction. I cannot, therefore, help thinking that the implements were deposited contemporaneously with the upper part of the laterite formation.

Thirdly.—The evidence of the section at Amerumbode (quoted a few pages back) in which an implement was found imbedded in the laterite fully 3 feet below the surface of the bed, is completely opposed to the idea of the implements belonging to a later and younger age.

Dr. Oldham and Mr. King were inclined to regard the Attrampakkam implement beds as younger than the typical laterite as seen at the Red Hills and elsewhere, and to be really only a washed-up and reconsolidated formation. It appears to me that there is no sufficient evidence for arriving at this conclusion, and unfortunately there are no sections by which to prove or disprove it. The difference in lithological characters between the low-lying beds close to the nullah and the high-level beds at Cunjalum, just north of the valley, and of their northern extension near Chungonum (where also implements were found *in situ* in laterite identical in appearance and relative position with the typical spreads at the Red Hills, &c.), is not of sufficient importance to afford any real distinction, while, for aught that is known to the contrary, the two sets of beds may be really continuous, though masked by superficial deposits. It is a very common phenomenon for the laterite beds to have accommodated themselves to the inequalities of the surface they were deposited on. This may be seen in hundred of places on a small scale. On a far larger scale than would be requisite to account for the extension of the laterite from the high grounds at Cunjalum down into and across the Attrampakkam valley, may this be seen to be the case in the Ingawarpolliam nullah valley five or six miles east of Sattavedu. The same phenomenon has been described as of common occurrence in the laterite district of Bancoorah in S. W. Bengal.* The perfectly unbroken and unworn condition of a large number of the implements is a very strong argument against their having been washed out of older formations.

Implements made of quartzite only.

All the implements found within the Madras area were made of quartzite, and so many show waterworn sides of old pebbles that it is very probable that all, or nearly all, were made from large pebbles or small boulders, such as occur in innu-

* See Report on the geological structure and physical features of the districts of Bancoorah, Midnapoor, and Orissa; Memoirs of the Geological Survey of India, Vol. I, p. 270.

merable quantity in the conglomerates of the Sattavedu and Alicoor hills. These hills and many of the isolated gneiss hills to the south and south-east must have stood up as islands in the laterite sea.

Elevation at which implements have been found connected with lateritic beds.

From the elevations at which the remains of the lateritic formations are found together with implements on the flanks of the Alicoor hills and elsewhere, there appears reason to believe that during the latter part of the laterite-period the Peninsula of India was depressed some 500—600 feet below its present level. That this has been the case I am the more inclined to believe from having studied the distribution of the lateritic beds, containing implements of human manufacture, northward of the Madras area in the Nellore and Kistna districts.

In the papers on the distribution of stone implements in Southern India read before the Geological Society of London in 1868, I entered fully into the subject, and therefore quote the following passages:—

"The highest elevation of the implement-bearing beds which has been accurately measured is 370 feet above mean sea-level at Madras; this is at Kircumbaddy, on the north side of the Soornamookey valley. I am indebted for this measurement to Mr. W. R. Robinson, C. E., of the Madras Railway, a gentleman who took great interest in the discovery of the stone implements, and himself made a large collection of them from this locality.

"The next highest measured elevation is that of the lateritic débris occurring on the elevated ground near the Arconum railway junction, which attains a height of upwards of 300 feet above the sea-level.

"During my last visit to the Alicoor hills, in August 1865, I found several implements lying on the much-weathered surface of the laterite, a considerable distance up the slope of the hills north-north-west of Naiken-polliam, at an elevation which I believe considerably exceeds that of the foregoing cases. Unfortunately I had no instruments with me at the time to make an exact measurement, so had to content myself with an estimate of the elevation, for which, however, the circumstances were very favourable.

" At a distance of three miles from where I found the implements is a station of the Great Trigonometrical Survey of India, marked on the map as the Nemilly hill, which has an elevation of 367 feet above sea-level. This Nemilly hill is perfectly overlooked from the spot at which I obtained the implements in question, which must, therefore, be at a considerably greater elevation, and probably lies between 500 and 600 feet above sea-level.

" That the implements here found were really derived from the underlying lateritic conglomerate I have no doubt, as they were deeply stained of the purplish-brown colour, which characterizes the conglomerate and its débris at this place. The implements were much water-worn and very smooth, as if they had not been long exposed to the roughening action of the atmosphere. The spot at which I found these implements lies but little below what was probably the uppermost limit of the laterite; for on ascending further up the hill all lateritic débris is soon lost sight of, and the surface consists only of a weathered crust of the jurassic conglomerates, which are of drab and grey colours, and in this district very free from ferruginous matter.

" The other indications of the former greater extension of the laterite deposits, occurring further to the north, which have been alluded to, are met with in the northern-half of the Nellore district, in the shape of lateritic débris, occurring in scattered patches over the general surface of the country, but at much higher levels than the alluvia of the existing streams, which are exclusively confined to the generally deep and narrow valleys.

" The first of these patches that I had the opportunity of examining lies to the south and south-east of the small town of Pamur, where a broad tongue of high ground extends eastward from the foot of the Byrawudi mountain, between the small rivers which unite to form the Munair. This elevated water-shed is covered in many places with enormously large gravel, a perfect boulder-gravel, of quartzite; in other places the gravel is of an ordinary character; but in both cases much ferruginous matter, in the form of pellets of clayey brown hæmatite, accompanies the gravels, on the surface of which implements were found occasionally. In all these cases the implements bore the strongest resemblance in point of stain, or possible adherence of ferruginous matter, to the patch of gravel or débris on which they occurred; and I have no doubt that they were weathered out of the underlying gravels.

"A careful examination of these gravels, which are well exposed in the sides of various deep rain-gullies of recent formations, would, I firmly believe, lead to the discovery of implements still imbedded *in situ* and well reward any explorer. It was not in my power to give these deposits more than a very cursory examination, which I greatly regretted, as it is not unlikely that some organic remains might be found in the loamy beds which are here and there included. The gravels especially deserving of examination are those near Cumbaldinna, eight miles east-south-east of Pamur, and others further to the east and south-east at Ranamuddagoo and Sullawarpully. The westernmost point in this region at which I found implements was at the foot of the Vaimpaud hill, six or seven miles south of Pamur, where a great accumulation of the boulder-gravel is piled around the hill like a talus. This gravel-bed lies at a very considerable elevation above the general level of the country, which in its turn is shown, by the long succession of rapids and falls in the rivers, to rise quickly after the flats of the sea-coast have been left behind. Comparing the level of this spot with that of the Soondy hills, which are 900 feet high, and with some of the intermediate hills, it may be safely estimated at nearly 600 feet above the sea-level.

"A second area showing this peculiar lateritic gravel with implements occurs about twenty-five miles north-west of Pamur, near the village of Nundanawanum. The laterite sea evidently made a deep bay here, and has left considerable traces of its presence in the form of gravels and dark-red sandy clays, which extend right up to the foot of the Vellaconda mountains. The country here at the headwaters of the Palair river is much flatter, and probably less elevated, than that around Pamur. I obtained several well-shaped implements from the surface of a gravelly clay south of the village of Ramiahpully."

* * * * * *

"With the lateritic formations now described, it will, I believe, be found necessary to include the great talus-like banks of boulder-gravel occurring along the base of the Vella Condas and the Naggery mountains, which are well seen, in the case of the former, at the east end of the Dorenál Pass, and at the town of Udayaghiri. In the case of the Naggery mountains there is a splendid gravel-bank along the south flank of the Naggery mountain itself. In this latter case I observed the quartzite boulder shingle to be extensively stained of dark red-brown purple, which indicates that the stone had been weathered in the presence of ferruginous matter of extraneous origin, the quantity of iron, in any shape, in the quartzite being in general extremely small. This ferruginous matter I believe to have been the lateritic cement by which this shingle was partly cemented into a conglomerate precisely the same as that now seen around the flanks of the Alicoor hills. The presence of such a ferruginous cement at high levels in places where no ferruginous matter was derivable from the higher grounds, as in the case of the Alicoor hills, near Naikenpolliam, nor from the substance of the enclosed materials, may, I think, be explained by supposing that the highly agitated waters of the laterite sea carried much ferruginous matter in suspension—a supposition which is not in the least degree hazardous when we consider the immense quantities of magnetic iron and highly ferruginous hornblende-rock which are now, as they must have been then, carried into the sea by every freshet in the rivers.

"The highest level to which the shingle-bank is piled up, along the southern flank of the Naggery mountains, accords well with the level which I suppose to have been the uppermost limit of the laterite sea around the Alicoor hills, and which I estimate to have been rather over 500 feet above sea-level."

The total absence of organic remains from the lateritic formations renders it very difficult to arrive at any satisfactory conclusion as to the circumstances existing during their deposition over such wide-spread areas.

There is good reason to suppose that the lateritic conglomerates and sands of the Madras region were deposited at the bottom of a shallow sea studded with mountainous islands in the straits, between which flowed currents of great rapidity and strength. The sea flowed far up among the quartzite and gneiss mountains of Naggery, Trippetty, and Calastry, and still further north it formed a deep bay up the valley of the Pennair, while, as already observed, the Sattavedu and Alicoor hills, and the highest points of the scattered gneiss hills southward of Madras (*e. g.*, the Palaveram, Vendaloor, Chingleput, and Pirukari Kunam hills), exceeding 500 feet in height, alone stood up as islands in the laterite sea at the period of greatest depression.

In a westerly direction the laterite sea probably broke against a generally low gneiss coast trending in a north-north-east direction from near Covrepauk to the neighbourhood of Naggery Nose.

The islands forming at present the Sattavedu and Alicoor hills were very probably inhabited or visited by the people who manufactured the implements which now remain as the only record of their existence. Of the fauna and flora of these islands and the mainland no remains have yet been discovered, and there are, therefore, no indications of the climate then prevailing nor any means of further correlating the relative age of the lateritic formations with that of other formations.

While many of the implements found in connection with the laterite show strong marks of attrition from having been water borne,—others, as before mentioned, are so perfectly fresh in their chipped surfaces, and have their sharp thin edges so unbroken, that it is evident they cannot have been drifted any considerable distance, and thus recourse must be had to some other agency—that of strong currents—to explain their presence at great distances from the *terra firma* of the period.

The carrying power of ice being inadmissible in a region so near the equator, the only hypothesis which remains is that of direct human agency, but how such human agency may have worked can only be guessed at. It is a pure speculation whether the implement-makers went to sea in canoes or in catamarans or log-rafts such as are in daily use on the Coromandel Coast, and from off which the implements were accidentally lost in deep water, or whether they only ranged over the laterite when in condition of flats exposed at low tide and then occasionally from some cause or other left implements behind. There can be no doubt, however, that as the land rose out of the sea the implement-makers would spread themselves over the newly-formed surface and follow the retiring waters, and possibly navigate them after their rude fashion.

From the position of the implements in the upper parts of the lateritic formations, it is most probable that they were deposited there towards the close of the laterite period, when the sea had already become very shallow. As with the ascent of the land the implement-men could advance more and more eastward, it may not unreasonably be inferred that the date of deposition of the unrolled implements will to a certain extent directly coincide with their distance from the old land surface. The further east they occur, the younger they would then be.

Bearing upon this point is an interesting discovery made by my colleague Mr. King (in 1863) of a spot at which, or very close to which, implements appear to have been manufactured in considerable numbers. To quote his own description from his notes, the spot 'lies towards the north end and on the west side of a rocky ridge two miles and three quarters north by east of Cupedoo. The flat ground at the foot of the ridge, and extending nearly to the stream flowing southward to the Narnaveram river, is formed by a deposit of lateritic sand, gravel, and breccia partly overgrown with scrubby jungle. Sub-angular and rounded fragments of quartzite are frequent on the undisturbed surface, but, as far as I could see, there are no implements. This general level of the ground is, however broken by a shallow depression, the result of the scouring out, or denudation, of an extensive patch of the lateritic deposit down to the underlying gneissic or crystalline rocks.

The thickness of the deposit is very variable owing to the irregular surface of the rocky ground on which it rests, but it may be taken on an average as between 1 and 3 feet. Numerous fragments of quartzite were lying on this denuded surface, as was the case on the adjacent level ground ; but in addition to these were plenty of flakes and implements (of which I picked up ten), besides a number of imperfect and broken specimens. The weapons brought away are very well made and trimmed to a more regular shape than the generality of those which we have found. The specimens referred to as imperfect suggest the idea that they had been discarded or left unfinished, for some of them have the whole of one side uniformly chipped, while the other side is trimmed only for a short distance from the edge, leaving a ragged lump, which only requires knocking off to make the implement symmetrical as to its sides. Another example, illustrating incomplete manufacture, presents nearly three quarters of the plane edge reduced by repeated chipping to a pretty regular straight line, while the rest is decidedly a wavy line, the result, it would seem, of preliminary dressing.

'The implements, many of which I left on the ground, lie scattered irregularly over the denuded area; but I was struck by the more frequent occurrence of these as well as of chips around some low hummocks of gneiss rising out of the surrounding ferruginous gravel and laterite on the northern side of the denuded area. I noted three of these hummocks of protruding rock at short distances from each other, and beside these were evidences of stone chipping.'

The unworn condition of the majority of the implements, therefore, proves plainly they could not have been drifted from any great distance. This, combined with the remarkable collocation of so many implements, both finished and unfinished, together with large numbers of the latter, points strongly to the conclusion that the implement-folks had carried on their work on that very spot or at only a slight distance from it.

For other details concerning the occurrence of the implements in this part of the Madras country, and for further archæological speculations on the subject, the reader is referred to the three papers before quoted.

Chapter VI.—The Cuddalore series.

The rocks referred to this series offer no fossil remains of any kind whatever by which to establish their geological age, and it is on stratigraphical evidence only that they are separated both from the underlying Rajmahal rocks and the overlying laterite.

As already pointed out in the introductory chapter, these rocks are exposed only to a limited extent in a few sections lying in or near the banks of the Corteliar river, a little west of the ford crossed by the Madras-Nellore high road. In all these sections the mineral characters of the rocks are the same, *viz.*, friable, white, and red mottled grit overlying a friable quartzose grit of buffy-white and brown colors becoming whiter downwards.

Sections on the Corteliar.

The best section occurs on the western scarp of a low hill lying immediately south of the village of Yerumeivettipaleiyam (Yermootapolliam of sheet 78) on the right bank of the Corteliar river.

The section here seen presents the following succession of beds: —

Lateritic conglomerate	3 ft. to 4 ft.
Mottled grits	6
Quartzose grit of buffy-white and brown colors, becoming whiter and coarser grained downwards; very friable; beds divided by thin partings of kunkur.	30—40
Dip 2°-3° S. E. to S. E. by S.	

The same succession of beds may also be traced all along the line of cliffs commencing about ¾ of a mile east-north-east of Yerumeivettipaleiyam and running north for about three-fourths of a mile along the right bank of the river, and rising sheer for 50 to 60 feet and upwards above the water. The base of this fine section is unfortunately obscured by a talus of fallen masses, and the river here forms a deep perennial pool, nor is there any section that I am acquainted with where these rocks may be seen in contact with the Rajmahal rocks.

Manjakaranei section.

The same succession of beds is displayed, but less clearly, in the small outlying hill at Manjakaranei, with this difference that the capping bed of laterite appears to pass down gradually into vermicularly cellular clayey grits, with a few lateritic lumps. These grits again appear to graduate into the coarse, mottled, friable grits, which themselves become purer and whiter the deeper they go. This outlier forms a small island in the alluvium of the Corteliar and Narnaveram river delta. The height of this hill is about 50 feet above the surrounding fields. The thickness of the true laterite is about 4 or 5 feet at the utmost.

Whether the vermicularly cellular clayey grits into which the laterite apparently passes really belong to the laterite series or to the Cuddalore series has yet to be decided. In this section the laterite appears to belong to the Cuddalore series, and so also does the laterite on top of the line of cliffs along the Corteliar, but in the Yerumeivetti-paleiyam section there is no apparent downward passage into the mottled grits. As in the case of the Tanjore area of Cuddalore rocks, (*) the want of conformity between them and the capping bed of laterite is more apparent in the great breadth of the overlap, or westward extension of the laterite over the adjacent gneiss region, than by a positive and distinct discrepancy in the position of the respective strata visible in any particular section; so in the case of the laterite and Cuddalore series, in the part of the Madras district just described, does the wide extension of the laterite on all sides far beyond the utmost extent of the Cuddalore rocks prove the existence of an overlap and of a real unconformity.

(*) See Memoirs, Geological Survey of India, Vol. IV, Part 2, p. 42.

Chapter VII.—Cretaceous Rocks.

The presence of any representatives of the cretaceous era within the limits of the Madras area has not as yet been established, but it is not impossible that such may yet be found among the rocks of undetermined age underlying the lateritic formations to the north-west of Madras.

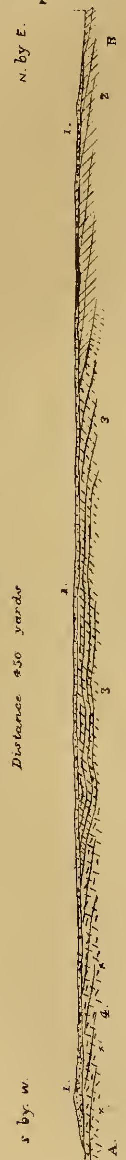

Fig. 3.—Section on the Kambamkal channel.
1, Lateritic gravel: 2, Plant shales: 3, Sandy grits and shales: 4, Grits, * Fossiliferous blocks.

Certain blocks of gritty sandstone containing fossil shells different from the marine fossils of the Rajmahal beds near Sripermatoor were found near that place resting loosely on the surface of a rather similar gritty bed underlying the plant shales. The facies of the fossil shells from the grit blocks inclines more to that of the cretaceous than of the jurassic marine fossils, so it may not be amiss to describe the mode of occurrence of the blocks in this section of the report.

The annexed section shows the position occupied by these blocks relatively to the underlying Rajmahal beds as exposed in the Kambamkal channel (a feeder from the Palar river of the great Sripermatoor tank), about half a mile west of the Public Works Department bungalow.

The section is a very unsatisfactory one, the contact of the loose blocks and underlying grit being obscured by the mud and water of the channel in which only they are exposed. The blocks found in the banks of the channel had their upper sides enveloped in the gritty, clayey, lateritic gravel, in which some smaller lumps occupy a higher level, some $3\frac{1}{2}$ to 4 feet above the surface of the grit bed No. 4. In color these blocks are grey or greenish-grey, and they are formed of gritty detritus of granitic rocks; in this respect and to some extent in color they resemble the underlying Rajmahal grit bed. The grit is considerably indurated. The number of blocks is not large, and some have been built into a retaining wall to a waste-weir for the channel. Of those exposed in the section, some eight or ten only in number, I broke up all but two or three in search of fossils, of which a considerable number was obtained. The fossils were *Ammonites* (four or five species), *Belemnites, Nautilus? Pleurotomaria,* two or three species, &c. No similar blocks were seen anywhere else. They are true water-borne boulders (the largest measuring less than half a cubic yard in its solid contents), but whence they come could not be ascertained; nothing resembling them was to be found on the higher grounds to the west and north, though specially searched. Probably these grit boulders were derived from some formation which was all but entirely removed by denudation prior to the commencement of the lateritic period.

Other boulders of gneissic rocks of, in some cases, larger size occur in the lateritic gravel of this place.

Chapter VIII.—Jurassic Rocks.

The Rajmahal Series.

The name of the "Rajmahal" rocks having been given by Dr. Oldham and applied by other members of the Geological Survey of India to a certain group of beds in the Rajmahal hills in Bengal, it cannot be a misnomer to apply the same name to a series of rocks in the Madras Presidency, which contain fossils specifically identical with those typical of the Bengal rocks. The interest which attaches to these rocks is enhanced very greatly by the fact that they have equivalents also in Cutch, where their association with beds containing unequivocally Jurassic *Ammonites* and other marine fossils, after having been long suspected in consequence of the researches of Colonel Grant,* has been conclusively established by the recent labours of Messrs. W. T. Blanford and A. B. Wynne of the Geological Survey of India.

The existence of these rocks in the Carnatic as a distinct formation was first ascertained in the Trichinopoly district near Ootatoor, where fronds of *Palæozamiæ* were first discovered by Mr. Charles Oldham. Since then they have been traced northward to beyond Nellore, occurring in a number of detached patches, which, except in the neighbourhood of Madras, are of very small size.

The boundary of the very irregular area over which these rocks extend in the north-east quarter of sheet 78 of the 'Indian Atlas' stretches northward from close to the north bank of the Palar river, about four miles west of Conjeveram, to the western extremity of the southern part of the Alicoor hills. Thence it follows the westerly base of those hills and of the Sattavedu hills. At the northern extremity of the latter group of hills the boundary bends, and trends south along their eastern flank down to

* Trans. Geological Society, London, 2nd Series, Vol. V, p. 289. Mr. Blanford's observations are recorded in the Memoirs of the Geological Survey of India, Vol VI, p. 17, and Mr. Wynne's in his Report on the Geology of Kutch in Vol. IX of the Memoirs.

the banks of the Narnaveram river (roughly speaking). If the boundary be continued thence to Poondamallee, and across the Apoor hill to the bank of the Palar, it would enclose all the localities where the Rajmahal rocks are known to appear, with the exception of one or two doubtful spots, which will be hereafter alluded to separately. The area thus described includes nearly (if not more than) 1,000 square miles, but it is only over a small part of this that the jurassic beds are to be found exposed, for, as a glance at the map will show, several hundred square miles of the area is covered up by younger formations.

By these superimposed formations the Rajmahal rocks are superficially divided into numerous areas, the four largest of which are the Sattavedu hills area, the Alicoor hills area, the Pyanoor area, and the Sripermatoor area, each of which includes several small and closely adjacent outliers.

Owing to the entire absence of really good sections, the exact stratigraphical relations of the several detached patches can only be regarded as approximately ascertained. No real and natural division has been found to exist among the members of this series except in lithological characters, and even these furnish a division into two groups, which is only partly true, and which is adopted only provisionally for greater convenience in describing the whole series.

Series divided into two groups.

The division of the series into two groups which is now proposed is fairly suited to the geographical positions and topographical features of the several distinct areas formed by these rocks, as will be shown in the sequel. The first of the two groups consists of the upper members of the series which are best represented in the Sattavedu hills, where also they were first studied by Mr. King, of the Geological Survey of India, who first proposed to call the great conglomerates occurring so largely in that quarter the 'Sattavedu conglomerates.'

Sattavedu group.

The upper group of the Rajmahal series includes the upper and larger part of the conglomerates, and consists almost entirely of such conglomerates, and may advantageously be called the Sattavedu group.

The second group contains the underlying members of the series, the upper part of which is a shale formation occupying everywhere apparently the same horizon as do the Sripermatoor shales.

Sripermatoor group.

As these shales are also the most important member of the lower division of the Rajmahal rocks, a more appropriate name could not well be given to the lower division than to call it the Sripermatoor group.

Definition of the four principal areas.

Sattavedu area.

Of the four principal areas before named, the most northerly, *i. e.*, the area occupied by the Sattavedu hills, is occupied by great beds of compact conglomerate mixed with a few beds of coarse sandstone.

Alicoor area.

The northern-central, or Alicoor area, shows a series of compact conglomerates with a few small beds of sandstone resting on non-compact conglomerates, with included beds of clayey grits and sandstone and sandy shales, which latter pass into true shales and shaley clays in the eastern part of the area.

Pyanoor area.

The southern-central, or Pyanoor area, includes the various formations of the Rajmahal series lying within the angle formed by the junction of the Naggery and Corteliar rivers. The prevailing rocks here are friable shales and sandstones, and uncompacted conglomerates and boulder-beds, all of which apparently belong to the lower or Sripermatoor group.

Sripermatoor area.

The southernmost of the four areas is occupied mainly by an important shale formation resting on gritty sandstone. These shales are distinguished as the Sripermatoor shales from the small town of that name at which they were first met with. The southern part of this (Sripermatoor) area is occupied by a series of grits, sandstones and sandy clays whose exact relation to the Sripermatoor shales is not quite clear.

The rocks occurring in the small outlying areas lying westward of a line drawn from the great Tennary tank to the south-east end of the Alicoor hills all apparently belong to the lower part of the Sripermatoor group, while those lying eastward of this line, both north and south of the Corteliar, seem to be representatives of the Sripermatoor shales or other younger members of the series.

(a).—The Sattavedu area.

This area is limited to the extent of the Sattavedu hills, a series of moderately elevated rounded hill ridges lying on the borders of the North Arcot and Madras District. The main mass of the hills is made up of immense beds of compact conglomerate of extreme coarseness, intercalated with a few beds of sandstone and grit. These conglomerate beds were once continuous with those in the Alicoor hills, though now separated by the alluvial valley of the Narnaveram river.

Absence of lower group beds from Sattavedu area.

The western and northern parts of the Sattavedu area were not examined by me, but by Mr. King; hence I cannot speak very decidedly about them; but I incline to think that either the whole of the beds occurring in the Sattavedu hills belong to the upper or Sattavedu group, or else that the beds belonging to the Sripermatoor group, occur only at the very base of the series forming the Sattavedu hills. The reason for arriving at this conclusion lies in the fact that the continuation of the beds occurring on the north-east side of the Alicoor hills, (which belong unquestionably to the Sattavedu group,) in the direction of their strike so as to join the corresponding beds at the south extremity of the Sattavedu hills, leaves no space for the filling in the Sripermatoor group beds of the western side of the Alicoor hills. An additional reason for considering all the beds north of the Narnaveram river to belong to the Sattavedu group is, that even the lowermost conglomerate beds east of Nagloperam are compacted together with a hard and generally ferruginous cementing material, which is quite unlike the perfectly loose, or very slightly compacted, conglomerates of the Sripermatoor group.

The conglomerate beds occurring on the east and south sides of the Sattavedu hills were formed by the cementing together of very coarse quartzite shingle with a cement generally of great hardness, and either ferrugino-argillaceous, or calcareo-silicious, in composition. The rocks are very rarely seen in these parts of the hills owing to the immense amount of débris caused by the weathering of the conglomerate beds.

In the corresponding beds in the Alicoor hills, rolled fragments of granite, syenite, and more rarely of quartz, occur among the included shingle, and become more numerous in a southerly direction.

In the south-east part of the Sattavedu hills between Sirgulpilly and Sattavedu village none but conglomerate beds were observed, and these all showed a dip to the south or south-east. These extremely coarse conglomerates, where not weathered, all exhibited a dark, generally purplish chocolate-brown, ferruginous matrix, which latter, however, was much less in quantity than the included pebbles of quartzite. Not a trace of organic remains was found in these coarse formations.

Sirgulpilly section.

No good sections of these coarse beds occur on the east and south sides of the hills; the best is to be met with in the deep long valley or ravine, north of Sirgulpilly; here three great conglomerate beds at least crop out, their strike being nearly at right angles to the axis of the valley. They appear at some distance from each other,* and indicate a thickness of beds of several

* The bottom of the ravine is so rugged with small water-courses and brushwood that I was unable to pace the distances between the several outcrops, but they are probably about 100 yards apart from each other.

hundred feet, for they are both over- and under-laid by other conglomerate beds of equal or greater thickness. The dip is, as nearly as can be ascertained on the extremely rugged surfaces, which are only exposed for a few square feet, about 18°. What may be the nature of the beds intermediate between these projecting outcrops of very coarse conglomerate, I cannot pretend to say, so entirely is the true surface obscured by the débris of the conglomerates, but I am inclined to think these spaces must be occupied by other conglomerates less coarse and cemented by a less compact material.

At the head of a smaller ravine opening into the Narnaveram river valley about one and a half mile north-west of Sirgulpilly, a fair section of one of these immensely coarse conglomerate beds may be seen. The face of the section is 16 or 20 feet deep, and shows thousands of projecting pebbles, few smaller than a man's fist and many larger than a cocoanut, all impacted in a brownish-red ferruginous cement, and apparently without any stratification. At the top of the section, which appears to have been made in the hope of finding sandstones fit for quarrying, the true surface of the bed is exposed for a few square yards, and here the cementing material appears spread over the pebbles very smoothly. This hard dark chocolate-red matrix has been one source of the ferruginous pellets, of which much of the true laterite of the neighbourhood is composed. The surface of this conglomerate bed shows a dip of 10°—12° to south-south-east.

The structure of the northern end of the Sattavedu hills was investigated by Mr. King, who found them to consist of thick beds of very coarse conglomerate with many intercalated beds of sandstone of red and reddish-brown color. The beds are exposed in steep cliffs in the narrow valleys among the hills, one of which cliffs attains a height of 150 feet. These sandstones proved unfossiliferous, though very carefully examined. The shingle enclosed in the conglomerate consists only of quartzite.

Ralah section.

Further south, and about two and a half miles north-east of Ralah, are sections in the valleys showing coarse, brown, ferruginous conglomerate and (locally) breccia resting on nearly horizontal quartzite beds of the Kaddapá system. In one gully there is a cliff section 70 to 80 feet high, showing an immensely coarse conglomerate dipping north-west at an angle of 5°. The bedding is distinctly shown by lines of larger pebbles and rounded blocks of quartzite.

Red sandstones with plant remains.

In the central part of the hills, Mr. King found that red sandstones had been quarried in shallow pits on the side of a hill lying south of the road leading from Carnaveram to Sattavedu village. These sandstones are described in Mr. King's notes as of deep-red, purplish-red, reddish-yellow and yellow colors, compact and fine grained in texture, but soft and friable. Interlaminated with the compact sandstone are thin layers of crumbly sand containing drifted plant remains. These plant remains proved to be chiefly fragments of reed-like stalks and of ferns, amongst which was part of a *Dictyopteris ?*

Tettoo section.

Close to the village of Tettoo (not marked in the map) which stands at the narrowest part of the valley opening out a little south of the Sattavedu Trigonometrical Station, sandstones occur in the bed of the stream, and are quarried there for large blocks. The rock is a bright red, compact, but soft sandstone, showing little or no lamination, and containing a few smooth quartzite pebbles. Mr. King found the red sandstone unfossiliferous, but succeeded in extracting some fragmentary plant remains from a yellower sandstone of a less uniform texture, which occurs in thin layers among the bright red variety. The general appearance and texture of the sandstones at this place reminded Mr. King of similar sandstones, belonging, however, to the much younger Cuddalore series (tertiary?) exposed in a quarry a little distance north of Verdachellum in South Arcot. The dip of the sandstones at Tettoo is between 5° and 10° north, but at other places the beds roll about a good deal, *e. g.*, on the western face of the ridge north of the stream the beds dip west-south-west 5°—10°.

The general dip of the beds of conglomerate and sandstone in the northern parts of the Sattavedu hills Mr. King found to be north or north-west. To the south of this valley, however, the dip and strike of the beds change to the east and south-east.

Vembaucum section.

Eastward of the village of Vembaucum thick beds of coarse conglomerate are exposed along the ridges, and are seen to dip east at a low angle.

At the southern end of the Sattavedu hills, their structure is more plainly seen, their surfaces being here less obscured by débris of weathered rock.

Section at south-western extremity of the hills.

In the ridge forming the south-western extremity of the group of hills, very coarse and sometimes ferruginous conglomerates appear above a considerable talus of débris. The upper part of the ridge is composed of similar beds of conglomerate with interbedded irregular layers of yellow and red sandstone and cherty claystone, all capped by an extremely coarse conglomerate of rounded or sub-angular fragments of quartzite. Mr. King could not find any fossils in any of these beds.

The next ridge further east also consists of similar beds. Many of the sandstones are pale-yellow cherty claystones, in which Mr. King found traces of fragmentary plant remains. These were chiefly fragments of stems, but no leaves occurred among them. The cementing material in several of the conglomerate beds is a similar cherty, clayey sandstone. These conglomerates form the greater part of the mass of this part of the hills.

Sirgulpilly section.

At the south end of the ridge are some small quarries, which have been opened for the sake of getting at the sandstones. In one of these, on the east side of the ridge, Mr. King found dark, purple, coarse friable sandstones, out of which long troughs were being cut. On the west side of the ridge are white and grey, and white and purple, mottled, sandstones with ferruginous and jaspery concretions.

The general dip of the beds over these two ridges is from 10°—20° east.

Sattavedu section.

Of the intercalated beds of sandstone mentioned above (p. 68), only one is seen on the east side of the Sattavedu hills, about a mile south-east of the village of Sattavedu, where compact, greyish, buffy, or reddish sandstones appear, and

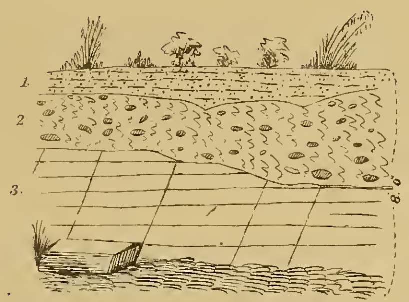

Fig. 4.—Section near Sattavedu.
1, Red soil; 2, Lateritic conglomerate; 3, Sandstone.

are exposed in a small quarry a few score yards off the new high road. The sandstones, which are thin-bedded and contain numerous irregular calcareous laminæ, dip south by east at an angle of about 7°—10° (?).

The annexed rough sketch shows one side of one of the small pits made to quarry the stone for building and other domestic purposes, for which it seems very well adapted. Only a few extremely obscure and doubtful traces of fossil plants were observed in one block of the sandstone.

From the great quantity of the superincumbent lateritic formations added to the very jungly surface of the country, the relations of this sandstone to the conglomerates forming the mass of the Sattavedu hills to the westward could not be traced out, but it may reasonably be regarded as a younger and overlying member of the series.

Eastward of these quarries no outcrop of Rajmahal beds was met with anywhere northward of the Narnaveram river.

(b).—The Alicoor area.

The Alicoor area embraces the Alicoor hills, the Naikenpolliam hills,* and the small outlying areas of Rajmahal rocks lying north of the Naggery river and the Corteliar, and includes deposits belonging to both the Sattavedu and Sripermatoor groups.

It has already been mentioned (page 66), that the north-eastern part of the Alicoor hills is occupied by great conglomerate beds, with sandstones belonging to the Sattavedu group, and formerly continuous with the beds occurring at the south end of the Sattavedu hills.

These conglomerate beds give the hills the peculiar form they present when seen from the south, when they resemble a rude saw, the steep side of the teeth corresponding with the scarps formed by the outcrops of the conglomerate beds which dip towards the east at an angle of 25°—30°.

Hard conglomerates.

Owing to the extraordinary amount of débris covering the flanks of these hills and the thickness of the scrub jungle, it was found impracticable to ascertain where the change in the character of these conglomerates from compactly cemented

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* The Naikenpolliam hills are really nothing more than the southern part of the Alicoor hills, but are by some of the natives dignified with a separate name.

to soft friable sandstone rock (including quartzite pebbles) commences, but the change will most probably be found to have taken place on the west side of the valley lying north-west of Hodson's Pettah. The friable sandstone conglomerates appear to underlie the hard ferruginous beds, in fact they must do so unless they have been thrown down by some great fault, of the existence of which no evidence was observed.

Non-compact conglomerates.

The conglomerate beds north and north-east of Alicoor village consist of precisely similar materials, and are covered up similarly in most places by débris. It is only at the summits of the ridges that the true surfaces can be readily seen, and they are then generally so rough that the common clinometer is of no use in ascertaining the true dip.

Sattavedu beds in the Alicoor hills.

The most westerly outcrop of the compact conglomerate occurs about two miles due north of Hodson's Pettah, and between that and the east foot of the hills, at least eight or nine other conglomerate beds crop out, several of them forming considerable scarps.

Alicoor conglomerate beds.

The central beds are the thickest and form the highest ridges of the whole group of hills north of Alicoor.

The highest ridge divides in two near the centre of the group, and a deep narrow valley is formed opening south near Alicoor, the general disposition of the ridges being in reality considerably different from what is shown in the map. The scarp forming the western ridge of the fork is the outcrop of what appears to be the fourth great bed of conglomerate section (p. 76). Bed No. 5 appears on the east side of the valley intervening between the west and east ridges, and gives rise to fine vertical naked cliffs showing a thickness of unmixed conglomerate of not less than 70 or 80 feet. Bed No. 6, which forms the eastern and principal ridge, is of lesser magnitude, but the bed overlying it (No. 7) is exposed in a very fine cliff, at the head of a large ravine opening eastward, to a depth of fully 100 feet. The head of this ravine is very remarkable, as presenting unmistakeable evidence of having been excavated by marine action.

Cave section.

The conglomerate bed has been eaten into by surf action so much that a perfect amphitheatre 200—300 yards across and of about the same depth has been formed, surrounded by truly vertical cliffs. These cliffs are highest at the apex of the curve, the dip of the bed being down the valley (eastward). On the south of the amphitheatre a cave of some magnitude has been formed by the undermining of the cliff. The shape of the cave in plan is that of a shallow crescent, the chord of the arc measuring about 230 feet and the greatest depth being about 65 feet.

The greatest height of the arched opening cannot be much under 30 feet, which decreases to 4 or 5 feet at the back of the cave, the floor rising also in the same direction.

Both floor and roof consist of the conglomerate, and are not covered by any incrustation. At the back of the cave is a perfectly loose accumulation of grey calcareous dust, 1 or 2 feet thick, consisting apparently of decomposed bat's dung and ashes. It contains nothing but some dead snail shells of the species common in the neighbourhood. A small quantity of deliciously clear and cool water drips from the roof at the west end, and is collected in chatties by the goat herds frequenting the valley. The waters of the small stream falling over the cliffs just above the cave, when in flood, must scour the greater part of the floor, and this alone is sufficient to account for the absence of any accumulation of soil, &c., in the cave, but the stream drains too small an area ever to have been large enough to have had much influence, if any, in enlarging the cave.

Another similar but much smaller cave occurs in the next overlying conglomerate bed a few hundred yards further down the ravine.

When viewed from the top of the highest ridge, the outcrops of these conglomerate beds are seen distinctly striking north by east to north-north-east, and, if continued across the Narnaveram river, would join the most south-westerly conglomerate beds of the Sattavedu hills.

In the lofty cliff opposite the cave two small lenticular masses of sandstone are exposed; they appear to be 3 or 4 feet thick, but are inaccessible.

About one and a half or two miles north of Alicoor the only other bed of sandstone in the Alicoor hills belonging to this series was observed. The bed is exposed in a small pit on the west side of the valley about 200 feet over the valley, and is quarried for building stone, which it yields of a fair quality. The sandstone is fine grained and compact, white with concretionary purple bands, precisely like one of the sandstones exposed in the quarries in the spur of the Sattavedu hills before described (p. 71). This sandstone rests on a coarse conglomerate containing a considerably larger quantity of granite and syenite shingle in addition to the quartzite-shingle, than is the case in the other conglomerate beds lying further north. The dip of the beds at this place is diminishing as they trend round to the south-west, the dip here being about 5° south-east, while a couple of hundred yards north, the same beds have a dip of 12° south-east, and about one-half of a mile north, the dip is from 25° to 39° east-south-east.

Varieties of cementing material.

The cementing material in the different conglomerate beds varies a good deal in different parts of one and the same bed; it is sometimes ferrugino-silicious like laterite, at other places it is calcareous; at others again calcareo-silicious, or simply arenaceous, the two latter varieties being perhaps the most common on the Alicoor hills.

The junction of the Sattavedu group and Sripermatoor group is unfortunately nowhere exposed owing to the prodigious accumulations of conglomerate débris lying on the hill side, and covering the valleys to a considerable depth.

Excepting the small quarry just described and a very shallow and not very satisfactory section in the stream formed by the off-flow of the waters of the Alicoor tank, I could find no sections in the whole of the series of valleys branching out of the Alicoor valley. I am quite unable, therefore, to give any satisfactory explanation of the relative positions of the two groups of formations. As before stated, there is no evidence of any kind opposing the idea that the compact conglomerate rested conformably on the uncompacted beds (seen cropping out on the western slopes of the water), and have only been removed by extensive denudation.

Alicoor tank section.

The small amount of evidence furnished by the little section below the kalingula of the Alicoor tank is favorable to this view, the beds exposed being both of them soft and uncompacted. The two beds here seen are a soft clayey grit, mottled white and brown, and underlaid by a moderately coarse bed of uncompacted quartzite shingle conglomerate. The two small sections here given will help to explain the apparent structure of this group of hills. Figs. 5 and 6.

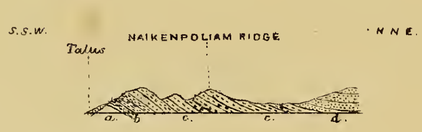

Fig. 5.—Ideal section from *Chinnareddypolliam* to *Hodson's Pettah* hill.
a, Gneiss; *b*, Runs of quartzite bed; *c*, Sripermatoor group; *d*, Sattavedu group.

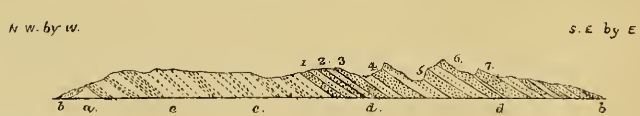

Fig. 6.—Section across the Alicoor hills, from north-west by west to south-east by east.
a, Gneiss; *c*, Sripermatoor group; *d*, Sattavedu group; *e*, talus. Nos. 1—7. Conglomerate beds.

Beds of the Sripermatoor group.

Only one section was met with on the west side of the Alicoor hills northward of the Alicoor valley which divides them from the southern part of Naikenpolliam hills. This section occurs about one and a half mile north-east of Cullumbaucum in a deep rain gully which has cut into the side of the hill to a depth of 20 or 30 feet, and exposes a very ill-compacted sandy clayey matrix full of large boulders of quartzite and various granitic rocks, of the kinds which occur below the quartzite plateaux of the Naggery mountains. Were it not that such boulder beds with unconsolidated matrices occur in several places further south, and underlie beds unequivocally belonging to the Sripermatoor series, one would be inclined to regard this as merely the highly-weathered surface of more compact conglomerates. No trace of bedding could be seen in this bed, which could hardly be expected, as the rush of water requisite to move boulders, many of which weigh 1, 2, or 3 cwt. and upwards, must have been so violent as to heap everything together in the utmost confusion. Similar, but less extraordinarily coarse, conglomerate beds would, to judge from the débris occurring all over this part of the Alicoor hills and over the greater part of the Naikenpolliam hills, appear to constitute the main part of the uncompacted beds assigned to the Sripermatoor series. Other beds of finer texture are unquestionably associated with the conglomerates, but the débris of the latter effectually conceals everything excepting in a very small number of sections.

Cullumbaucum section.

So thoroughly does this débris obscure the slopes of the hills that not a single section occurs on the west side of Alicoor hills and on the west and south sides of the Naikenpolliam hills in which the base of the Sripermatoor group is seen in contact with the underlying gneissic rocks. Only in one section is the gneiss seen within a few feet of the conglomerates, and this occurs immediately east of the village of Suroperam, where the gneiss is exposed *in situ* at a height of 100 to 150 feet above the general level of the adjoining plain. The rock is here a fine grained micaceous

Suroperam section.

schist striking north by east, with a dip of 75° to 85° west by north. The schist is much weathered and traversed by a yet more decomposed dyke of trap which has a nearly due east-west course. A very few feet above this section occurs probably the junction of the two rocks, where there is a slight shelf or terrace on the hill side.

It will be seen on reference to the map that the lowest part of the Sattavedu group occurring on the west side of the Sattavedu hills rests on a small outlier of quartzite belonging to the Kaddapá system; whether such an outlier exists under the beds forming the western and south-western sides of the Rajmahal area in the Alicoor area is a question yet to be decided. The facts which suggest the possibility of such outlier of quartzites having been left when the great denudation of the Kaddapá rocks had taken place previous to the commencement of the Rajmahal era, are the presence of several groups of huge masses of quartzite at levels apparently coincident with the junction of the Rajmahal rocks with the underlying gneissic rocks. These groups of blocks occur along the southern side of the Naikenpolliam hills; the first group occupies a considerable area of ground on the west side of the rounded hill lying between Illatoor and Naikenpolliam.

Probable outlier of quartzite of the Kaddapá system.

The immense number and size of the quartzite blocks lying close together at this spot, and their angular condition, suggest the idea that they are but the ruins of a bed of quartzite broken up, but not entirely removed by denudation. Several acres of ground are here thickly strewn with these large blocks, so thickly, in some parts, that it is easy to walk along the tops of them for several yards at a time. Hundreds of these blocks must exceed half a ton in weight, and many are yet larger in size. They appear to be all of one variety of quartzite, namely, an intensely hard compact variety of grey and white colors in bands, and including bands of large pebbles of an older quartzite and of jasper. The largest block observed

Illatoor bed.

could not weigh less than 4 or 5 tons at the lowest estimate, was quite angular, and not very much weathered.

About three quarters of a mile south-east of the above described boulder bed, an enormous solitary mass of quartzite protrudes from the side of the same hill, but at a greater elevation above the valley. It is of the same variety of quartzite, partly dense, partly conglomeratic in structure, and, though now broken into several pieces, once evidently formed a single block of great size. The cubical dimensions of the uncovered part cannot measure less than 20 or 30 cubic yards. The strike of the bedding shown in this block is north-north-east 5° east, south-south-west 5° west; the dip 70° west-north-west 5° north.

Naikenpolliam blocks.

Crossing hence to the east side of the Naikenpolliam valley, another series of enormous blocks occurs on the top of a small spur coming close down to the east side of the principal stream in the valley and to the head of the tank shown in the map, but which now exists no longer. The greater number of the blocks here dip to the north, at low but varying angles, but some of the largest have been thrown about confusedly in all directions. The blocks at this place, even more than elsewhere, appear to form the remnants of a continuous bed of quartzite, and I fancied I could make out the line of outcrop encircling the point of the spur which falls away steeply to the south, the strike of the bedding in some large blocks being east and west; the blocks also are certainly less broken up here than near Illatoor, and are generally rather square in shape.

Great block near Chinnareddypolliam.

Half a mile south-east of this last group of quartzite blocks another solitary block of the same variety of quartzite stands up in a field just at the foot of the hill east of Chinnareddypolliam. In shape it is a rude elliptical cone, about 10 feet high from the surface of ground, and upwards of 60 feet in circumference at the base. The dip of the bedding is vertical, the strike nearly north and south; it has, therefore, evidently been moved from its original position, but here, as in all the other cases, the base is concealed by the quartzite shingle débris, and it is impossible to tell what the mass may be resting upon.

The included pebbles of the conglomeratic bands in this huge block consist of quartzite, quartz, and red and black jasper, with a few examples of red felspathic and yellow syenite with much pistacite. On the east side of the hill above this block others of similar quartzite occur, not very rarely, but higher on the slope. From a little distance these appear to belong to the outcrop of a bed dipping north or north by west; several huge masses have that dip, but others equally large are dipping in every possible direction.

Woterpolliam block.

The last mass of quartzite of extraordinary size was observed about a mile north-west by north of Woterpolliam at the south side of the valley running up into the central parts of the Naikenpolliam hills. It is of larger size than any of the foregoing, and perched up so that the dip of its bedding is nearly vertical.

Rain theory.
Ice theory.

If these huge masses be really the ruins of quartzite beds pre-existing on those spots, it is very easy to comprehend their present positions; but if they have been brought there from distant points, no mechanical power saving that of floating ice would appear sufficient to have transported them from distances of many miles.

Ice theory inapplicable.

The supposition, however, that these blocks have been brought by floating ice seems inadmissible in presence of the very mild, if not tropical, climate indicated by the fossil remains of *Palæozamiæ* found imbedded in some of the lowest beds of the Rajmahal formation.

There is much less difficulty in supposing that these blocks are really the remains of a thin bed of quartzite, partially broken up by the destruction of the underlying much softer gneissic rocks; the larger masses being left nearly in their original position, or shifted only to little distances, and that the other materials of the conglomerates, which appear to include them, were heaped over and around them at some subsequent period of subsidence.

With reference to this, some importance seems to attach to the fact that blocks of gneissic rocks of great size only begin to be included in the Rajmahal conglomerates to the southward of the country where these great quartzite masses are met with.

If these blocks be considered as the ruins *in situ* of a bed of quartzite, it is the most southerly extension of the Kaddapá series known.

Many examples of the inclusion of great blocks and boulders of gneiss in the conglomerate beds of the same age underlying the cretaceous rocks in Trichinopoly district, are cited in Mr. H. F. Blanford's report on the Cretaceous rocks (Memoirs, Geological Survey of India, vol. IV, pp. 40 and 47).

Higher beds.

Overlying these blocks, which apparently represent the base of the lower group of the Rajmahal rocks, is a series of very coarse conglomerates with intercalated friable sandstones and clayey grits, and higher up in the series sandy shales also appear in thin layers. The whole series is by no means known, owing to the paucity of sections penetrating the thick layer of débris which everywhere covers the surface of the hills to a depth very often of two or three yards or more.

Naikenpolliam section.

Only four sections were seen along the southern slopes of the Naikenpolliam ridge from east of Panoor to the most southerly extremity close to Chinnareddypolliam, in which the débris was penetrated. The first of these occurs at the south-west corner of the Naikenpolliam ridge, and about three quarters of a mile south-south-west of the Trigonometrical Station shown in the map. The section, which lies about a mile north-west of Naikenpolliam, is seen in a large and deep rain-gully forming the head of a small stream flowing west into the Naggery river.

The succession of beds seen here in a section of between 25 and 30 feet in vertical height is the following:—

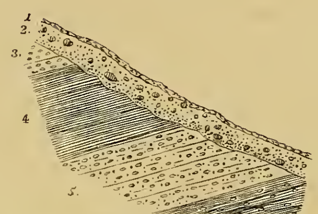

Fig. 7.—Sketch Section near Naikenpolliam.

1. Débris 1 ft. to 2 ft. (very unusually thin).
2. Lateritic gravel 5 ft. to 7 ft.
3. Pebbly sandstones (friable).
4. Shaly sandstones with thin layers of clay and clayey grits.
5. Friable sandstones, buff and drab colored, with very regular layers of pebbles.
6. Clayey grits (buff and drab) with layers of shingle, less regular than those in No. 5.

A side gully about 20 or 25 feet lower down the slope shows 10 or 12 feet of very coarse clayey grit, much stained by iron infiltrated from the overlying laterite. Enclosed in the clayey grit is much coarse quartzite shingle; all the pebbles also seen in the overlying beds were of quartzite. The dip of these beds is apparently between north by east and north-east, the inclination to the horizon being less than 30°.

No fossils were obtained from any of these beds on being hurriedly inspected in 1864, but on revisiting them in 1865 and examining them very carefully, a considerable number of specimens of fossil plant remains was obtained from bed No. 4. All the plant remains were fragmentary, like those obtained near Sripermatoor, and belonged to four or five genera, *viz.*, *Tæniopteris*, *Dictyopteris*, *Palæozamia*, and *Pterophyllum*, with grass-like stalks resembling *Poacites*. Specimens of *Tæniopteris* were found in the greatest numbers, but chiefly in the clayey layers, which are very soft, and on drying these crumbled away into small pieces. This bed No. 4 is probably the lowest of the fine grained formations in the Sripermatoor rocks in the Alicoor area, and apparently occurs very low down in the series near its base.

Section north-east of Naikenpolliam.

The next section occurs on the east side of the Naikenpolliam valley, about three quarters of a mile north-east of the village, in a large rain-gully beginning high up the side of the hill. The layer of the débris is only just cut through, and nothing is seen but very coarse quartzite shingle with small boulders of the same rock imbedded in soft, gritty, clayey, granitic detritus, of mottled grey and red color. The relative position of the bed is not shown in this section.

Section east by north of Naikenpolliam.

About one quarter of a mile south from the above section the side of the hill is scored by a double gully, the eastern arm of which cuts well through the detritus and gives the following section, of which a sketch is annexed:—

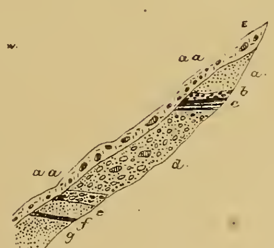

Fig. 8.—Section east by north of Naikenpolliam.

		Ft.	In.
ax.	Rubble with dark-brown earthy matrix.		
a.	Fine friable-brown sandstones with very few small quartzite pebbles	6	0
b.	Friable grit with pebbles of quartzite and syenite	1	6
c.	Fine shaly grit	1	6

d.	Very coarse shingle of quartzite and syenite in a soft gritty matrix	18 to 20
e. g.	Fine drab-brown friable sandstones with one small bed (8 to 10 inches) of quartzite and syenite pebbles near the top (*f*)? ... only the upper part of *g* is shown in sketch.	20 to 25

Below this in the lower part of the gully the detritus is not cut through. The beds dip north-north-west at an angle of 25° to 30°. No fossils were seen in any of these beds.

Chinnareddypolliam section.

If the side of the hill be followed still for a few hundred yards further south, another rain-gully will be found close to the great quartzite rock at Chinnareddypolliam. The superficial layer of débris is hardly penetrated, and when seen by me, only 2 or 3 square feet were clear, and showed tremendously coarse quartzite shingle in a soft matrix of grey clay containing much granitic grit. The loose masses in the gully are of very large size, many weighing 2 to 3 cwt. and perfectly rounded.

Section on south ridge.

Eastward of the ridge on which the three last described sections occur, only a single one was found on the slope of the Naikenpolliam hills. This solitary section occurs on the south side of the head of the south fork of the Mallyreddypolliam nullah, and only about half a mile eastward of the first section in the Naikenpolliam valley. The rocks exposed in the south ridge section are cut into to a depth of nearly 4 feet, and are seen to consist of a bed of rather small pebbles included in a friable sandy grit, of buffish-brown color, but mottled with white where felspathic débris is abundant. Excepting the quartzite pebbles all the materials are of granitic origin. The bedding which is indistinct shows a northerly dip of 15° to 20°. The superficial débris is here only a yard thick, but on the north side of the north fork of the nullahs it is upwards of 8 feet in depth.

From the position of the Naikenpolliam ridge relative to the hills north of Alicoor, it might be expected that the compact conglomerate beds which form the latter would be found capping the ridge; they are not seen on the ridge however, and have either been denuded away or have changed their character from being exposed to influences which prevented the hardening of the matrix of the conglomerate beds.

The gneissic rocks, though not seen in positive contact with the base of these sedimentary rocks, approach very closely to it at the southern extremity of the ridge close to Woterpolliam. Between the south end of the ridge and the Connicoma tank (which stands on the edge of the Naggery river alluvium) the whole area is occupied by the highly granitoid gneiss. The gneiss is best seen in a deep gully worn by rain torrents on the slope close to Woterpolliam village.

Beds lying south of Naikenpolliam ridge.

The beds which have now to be described, *i. e.*, those seen between the eastern part of the Naikenpolliam ridge and the Naggery river, are all at a considerably lower level with reference to the general elevation of the country than are those just described.

It will be seen on inspecting the map, that this tract of country is divided by three quasi-peninsulas of lateritic formations, with three intervening spreads of Rajmahal rocks, which occupy the lower grounds, and are chiefly exposed in or close to the beds of the principal streams.

The quasi-peninsulas of lateritic formations are really low broad backed spurs, branching off from the Naikenpolliam hills and rising 50 feet and upwards above the general levels of the intermediate valleys.

Sections at Woterpolliam.

The most westerly of the three valleys is that in which the village of Woterpolliam stands. The Sripermatoor rocks are but badly seen in this valley owing to the immense mass of shingle débris rolled down from the higher lying conglomerate beds belonging both to the same series and the lateritic formations.

When visited by me in 1864, and again in 1865, the wells, which afford the only sections existing there, were full to overflowing after the south-west monsoon. The material turned out of those near Woterpolliam was coarse quartzite shingle, with pale-drab sandy grit. Near the south end of the valley, close to the Connicoma tank, pale-buff sand had been thrown out of a small newly sunk well.

Conjibuddy section.

In the next or central valley, several sections were met with in the banks of the large nullah which feeds the Conjibuddy tank, and in the dry season many of the wells would probably give good sections, as they are deep and not walled up. The most southerly of these sections occurs at Conjibuddy at the west end of the tank bund, which was breached some years age, and the ground below the breach excavated by the escaping waters to a depth of from 12 to 15 feet. The lowest rocks seen here are coarse pebbly sandstones rather friable; these are seen only in the bed of the channel, and not more than one foot and a half in thickness of the beds is exposed.

The included pebbles consist of granitic rocks, quartzite, and occasionally of blackish, dark-grey and purplish clay-slate. The matrix is drab-grey or greenish-grey in colour. The sandstones dip 15°-20° east-south-east. Resting on these pebbly sandstones is a very coarse boulder bed containing very large rounded masses of decomposing syenite, and also of quartzite with occasional smaller fragments of slate. Of the two former, many of the boulders must weigh from 2 to 3 and 4 cwt., with others diminishing from that size down to mere pebbles. The largest piece of clay-slate observed weighed about 7 or 8 lbs., and was of purple color. On the top of the boulder-bed, which is from 4 to 5 feet thick, lies a bed of rubble, apparently the reconstructed surface of the boulder bed, which has a thickness of about a yard, and is in its turn covered by about 3 feet of débris of shingly laterite.

Mullyreddypolliam section.

Further north near Mullyreddypolliam another good section occurs in the banks of the muddagoo or off-flow channel. The annexed diagram sketch gives a correct idea of this section, which shows the following formations :—

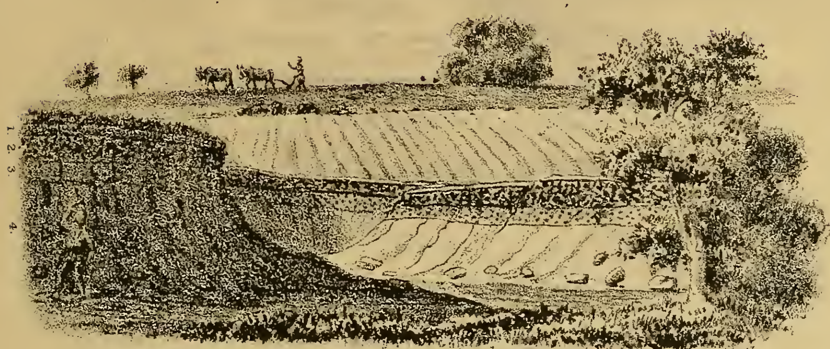

Fig. 9.—Sketch section near Mullyreddypolliam.

		Ft. In.	Ft. In.
Conformable.	1. Soil	1 0	
	2. Laterite gravel	2 6 to	4 0
	3. Pale gravel	2 0 „	3 0
	4. Pebbly boulder bed with friable sandstone matrix. Fragments of slate and red syenite very numerous.	6 0 „	8 0 exposed.

The relative position of this boulder-bed, and the beds forming the eastern end of Naikenpolliam ridge, lying immediately to the north, cannot be made out owing to the immense accumulation of talus mixed with shingly laterite beds.

This boulder-bed is again exposed higher up the same nullah, a little above its entrance into the Mullyreddypolliam tank, and 6 to 7 feet of the bed clearly shown. Many specimens of shingle of pistacite rock were here noticed, all extremely decomposed and crumbling.

Fossil wood at Ramanjeri.

Moderately compact, grey, gritty sandstone with numerous quartzite pebbles has been turned out of a well dug a little to the west of Ramanjeri. This stone contains numerous small white layers of chips of silicified (?) exogenous wood, and occasionally small pieces of trunks or large branches showing the rings of growth very distinctly. Not a trace of a recognizable leaf was noticed among the layers of chips, though very carefully sought for.

Sections at Motapolliam.

The valley lying east of the Conjibuddy laterite ridge, and spreading into a broad alluvial flat near the junction of the Naggery river and the Corteliar at Kistnapooram, presents no sections whatever but such as have been formed by digging wells. In the lower parts of the valley I found these quite full of water, and had only the turned out material to look to for information as to the underlying beds; but north-east of Motapolliam (the village lying west of the large tank shown in the map), where the ground begins to rise rapidly, and the water stands at a much lower level in the well, some useful sections were found.

Toombul tank.

The materials thrown out of the Toombul tank on to the bund consist of the friable brown grit, enclosing quartzite and granitic (decayed) pebbles.

Motapolliam sections.

Friable, buff-brown sandstone has been turned up in digging a well about three quarters of a mile north-north-west of Toombul, and in this I found two or three unrecognizable vegetable impressions. These beds probably agree in position with the pebbly sandstone at Ramanjeri and Conjibuddy in the Conjibuddy valley, and they are covered by a coarse conglomerate of quartzite and decaying granite shingle in a gritty loose matrix. The conglomerate is exposed in many wells north of Motapolliam, lying rather higher than the village itself. Following the gradual rise of the ground north-east of Motapolliam from a large well in which this conglomerate occurs for about 200 yards north-east by east, another well will be found yielding the annexed section :—

Buff-drab, friable, fine grained grits of granitic débris with a few small quartzite pebbles in laminæ. Grits slightly false-bedded		8 feet.
Slightly ferruginous gritty shales		2 "
	Total	10 feet.

The real dip of these beds is 1°—1½° north, and they unquestionably overlie the conglomerate bed just described. A few hundred yards further up, another well section shows white, and slightly ferruginous sandy shales, resting on friable buff sandstones, both dipping north by east at 2°—2½°.

Still further up the slope in a northerly direction, and a few feet below the watershed, which is capped with lateritic gravel, a small section occurs, in which yellow, slightly sandy, fine shales are seen dipping north at a low angle, while a few hundred yards across the watershed, very similar white and yellowish shales appear in the bank of the Kullaur (the Alicoor nullah), dipping north likewise at a low angle, and to all appearances representing the yellow shales seen south of the watershed. There can be little doubt but that these upper shales form the upper part of a continuous and unbroken series overlying the Motapolliam coarse conglomerate. There is equally good reason for believing that the white shales in the Kullaur are true representatives of the Sripermatoor shales, with which they agree very closely in lithological character. These white shales extend east from the Kullaur to the valleys of the Attrampakkam, Odapei, and Meyyur (Myoor) nullahs. Westward they were traced in the banks of the Kullaur to about a mile south-east of Alicoor.

The shales in the four villages first mentioned present few features of interest, as they are but poorly fossiliferous. In character they are very constant, white or yellowish shales with a few partings of slightly ferruginous soft clayey sandstone. The beds roll about a good deal, but at low angles, rarely, if ever, exceeding 7° or 8°. There are many sections of the shales in the banks of the Kullaur, and on the south side of the nullah a little south-west of Nungumbaukum, (Numbaucum of map), the shales form a small vertical cliff about 12 feet high, capped by 4 feet of laterite gravel. Further down the nullah about half a mile from the Corteliar, the southern bank of the Kullaur shows a small scarp of shales, in the base of which may be seen numerous large and small pebbles of quartzite and weathered trap. The trap is identical in appearance with that found by Mr. King in dykes in rocks of the Kaddapá series north of Nagloperam. This is the only case in which these shales were observed to include anything larger than grains of grit or a few small gritty laminæ.

Conglomerate bed in the shales near Pundi.

The banks of the Attrampakkam nullah offer very similar sections, which show the rolling about of the shales, and also the great erosion which the surface of the formation underwent, before the deposition of the laterite.

Attrampakkam sections.

The hollows formed by that erosion are now filled with lateritic shingle conglomerate containing numerous stone implements.

The upper part of the shales is freeer from ferruginous sandy partings, and, as a rule, also from iron-stains, excepting of course from such as proceed from infiltration of ferriferous water from the overlying laterite. The shale beds here proved but very sparingly fossiliferous. In one of the reddish-brown friable sandstone layers occurring in the shales about half a mile north-west of Attrampakkam village, the cast of a small shell, resembling a *Lucina*, was found with a few obscure impressions of plants. These were the only organic remains found in the Attrampakkam nullah sections. The shales in the Kullaur yielded only a fragment of an *Ammonite* with some obscure and indeterminable plant remains, found at Nungumbaukum.

In the valley of the nullah falling into the Corteliar at Odapei (Odipee of sheet 78) the shales show everywhere the same whitish color variegated by a few thin ferruginous, or sandstone, partings of brown, yellow, red and purple tints.

Odapei section.

The beds roll similarly to all points of the compass at low angles, so that none of the sections cut through to the underlying rocks, whatever they may be.

Opposite the village of Odapei, a little above the junction of the nullah with the Corteliar, is a small cliff about 16 feet high, about 12 feet of which is made up of white shales, with three or four partings of slightly ferruginous sandstone, each 4 to 6 inches thick. The shales are capped by lateritic gravel and soil 3 to 5 feet in thickness. This is the most important section of the shales in this small valley. Several others of lesser magnitude occur further north near Govindarajapuram and Mylapur. In the valley of the Meyyur nullah the shales are only seen in a few spots where the surface has been cleanly swept by heavy rains, and no points of any interest whatever were noticed. Fossils appear to be rare in these shales, for I found none at all in the two localities just named.

South of the Corteliar, following the line of the western boundary of the several lateritic areas, slight indications of shaly beds of yellowish white color were observed among débris thrown out of tank bottoms in several places—the first close to the Choultry standing at the edge of the alluvium about two miles south of Kallikuppam (Calicoopum of map); here the shell débris was mixed with tesselated concretionary clay-ironstone.

Doubtful outliers south of Corteliar.

At Kallikuppam.

Two miles further south along the edge of the boundary, débris of whitish shales, here and there iron stained, is seen in the bund of a small tank lying a little distance north-west of Mittanemalei village (Metnavilly of Atlas sheet).

At Mittanemalei.

Following the boundary which now trends north-westward, a small section (in a newly excavated well) may be found beside a group of trees standing on the rising ground south of Pilyur (Pilwoor of map). Buff-colored friable sandstone, with small ferruginous concretions, is here exposed below the lateritic gravels. The lithological characters of this sandstone are not characteristic enough to pronounce it decidedly to belong to the Rajmahal system in the absence of fossils, but it has more similarity to many of the friable sandstones just described of unquestionable Rajmahal age than to the gritty sandstones of the Cuddalore series.

At Pilyur.

Of similarly doubtful character is the gritty friable sandstone of greyish-white color with slight traces of shale which has been thrown up during the building of the village tank of Tirumullavayal (Trimullavoil of map) about one mile and three quarters north-east of Avadi railway station. Here the general appearance of the rock, the shales excepted, is more like the grit beds of the Cuddalore series, *e. g.*, in the cliffs along the Corteliar at Yermootapolliam. The real affinity can only be settled by the discovery of fossils of distinctive character. Similar buff shaly sandstones and grits show at various points along the railway cuttings near Avadi station, but only to a very small extent because of the turfing of the slopes. In lithological character they bear strong resemblance to certain sandstones and shales occurring at Coopoor a few miles to the south-west, which will be described further on.

At Tirumullavayal.

(*c.*)—*The Pyanoor area.*

The shape of this area, which lies south of the Naggery river, is extremely irregular, because the greater part of the surface is obscured by a continuous bed of shingly laterite conglomerate, which only leaves exposed a narrow belt of Rajmahal rocks skirting along the alluvium of the Naggery and Corteliar valley. West and south-west of Pyanoor this belt widens considerably.

Two important outliers occur to the west of this area, the one along the boundary of the Naggery river alluvium at its junction with the Trittany river alluvium, the other a little further south along the boundary of the metamorphic rocks.

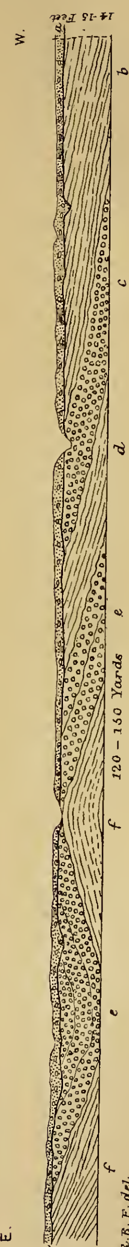

Fig. 10.—South bank of Naggery river, at Chittapuram, North Arcot.

The formations occurring in the Pyanoor area all belong to the Sripermatoor group, and form a series of friable sandstones, sandy shales, pebble and boulder-beds. Hardly any sections are available but such as are afforded by wells, and as these are almost invariably lined with walls, the information obtainable is very limited, and it is impossible to correlate the various formations of different parts of the area with any degree of certainty.

The general dip of the whole series is easterly, at varying low angles, but local exceptions to this general dip were met with in several cases.

Chittapuram section.

The most important section in this part of the country occurs in the small outlier at Chittapuram on the banks of the Naggery river. The section occurs in the south bank of the river, which forms a low cliff about 14 to 15 feet high and about one quarter of a mile long. (Fig. 10).

The succession of beds here exposed is—

a.—Laterite and quartzite shingle bed.

á.—Quartzite shingle enclosed in sand.

b.—Gritty friable sandstone with shaly and kunkury-layers—the gritty parts much false-bedded.

c.—Quartzite-shingle bed enclosed in sandy clay.

d.—Friable sandstones with plant remains. (*Tæniopteris*).

e.—Coarse-shingle bed—matrix of sandy clay.

f.—Clayey light brown grit with bands of sandstone. (*Dictyopteris*).

g.—Boulder-bed.

N. B.—The fossils were obtained from the corresponding beds on the north bank of the river.

The north side of the river shows the same section on a smaller scale and much obscured by slips of the overlying loamy alluvium of the Naggery river. On the south of the river I got no recognizable plant remains, but on the northern side I obtained from the bed corresponding to *d* several specimens, of a small but a broad leaf resembling *Tænio-pteris*, and from *f*, fragments of fronds of *Dictyopteris* and *Palæozamia ?*

South of Chittapuram, at about a mile distance, are several wells belonging to a little hamlet, Gollypully, (not shown in the map,) from which a moderately compact conglomerate has been thrown out. This conglomerate contains pebbles of quartzite, granite, syenite, (of various colors,) pistacite and slate, beside a good deal of white and partly dusty kunkur.

Cavitpooram pebble beds.

At Cavitpooram the same conglomerate reappears in wells sunk in the high ground north of the village, and has here been compacted by the infiltration of a small quantity of calcareous matter, and constitutes a rock of fair consistency, which is but rarely the case among the rocks belonging to the Rajmahal system lying southward of the Alicoor hills.

Here also fragments of slate are of no uncommon occurrence, the commonest colors being purple and greenish-grey. Great heaps of this conglomerate may be seen near two large wells lying one quarter of a mile north of the village.

The same or an extremely similar conglomerate appears also at Attiput (Oxapet of map), one and a half mile east-north-east of Cavitpooram (properly Kavedupooram), and at Kunjamuttur on the western boundary of the Pyanoor area.

From the perfect similarity of mineral character, and especially from the presence of pebbles of slate, I incline to consider this Cavitpooram conglomerate to be the same as that occurring at the base of the Conjipuddy section. The Cavitpooram conglomerate apparently lies higher in the series than the beds exposed in the Chittapuram section, for the latter have a southerly dip and the former occupies a very much higher level.

Pyanoor section.

Near Pyanoor a very coarse boulder-bed occurs, and is exposed in several wells, and also in the off-flow channel at the north end of the great tank. The bed is well exposed to a depth of 12 to 15 feet, and is of varying coarseness; the included fragments varying in size from ordinary pebbles to rounded masses 4 to 5 and even 9 feet in diameter. The larger masses are all granitic or syenitic; the largest noticed consisted of very coarse reddish syenite, highly felspathic, and so greatly decomposed as to be easily crumbled with the hammer, other smaller masses so much so as to fall to pieces altogether from a slight kick. The quartzite boulders noticed in this section were all small.

Section near Trevatankadu.

In a well section between Pyanoor tank and the large Pagoda at Trevatankadu (Trevatangul) the section exposed consisted of—

		Ft.	In.
1.	Soil	1	6
2.	Débris with a few laterite pellets and masses (rounded) of quartzite and granite	2	3 feet
3.	Friable drab sandstone with quartzite lumps passing into	5	6 feet exposed above water.
4.	Boulder-bed full of large boulders of quartzite and granite		

One well rounded mass of granite rock which stuck out of the side of the old well could not have been less than one and a half cubic yard.

In another large walled well, a few hundred yards westward, a thickness of 8 or 9 feet of the boulder-bed could be seen below the base of the wall. Here the masses of granite were still very large; one and a half to two feet in diameter being a common size. The quartzite boulders did not exceed a large man's head in size; many were smaller, and with them are mixed up large pebbles of brownish-purple slate. The matrix enclosing these boulders and pebbles is a buffy-brown friable sandstone.

Proceeding south-west from Trevatankadu, the boulder-bed changes its character somewhat, the large boulders become less numerous, and the bedding of the sandstone matrix is recognizable.

The bedding rolls very much, and as the sections seen are only in the vertical sides of the wells and bowries, it is difficult to determine the direction of the general dip, but it is most probably to the eastward.

Veerapooram section.

Still further west at the village of Veerapooram, the boulder-bed reappears in a well section diminished in thickness and underlaid by friable sandstone, both dipping eastward at an angle of from 20 to 25 degrees.

Friable sandstone of precisely similar character is seen in well sections north of Pyanoor. In two new well sections occurring about a

Section north of Pyanoor.

mile north of the village brownish-buff friable sandstone and greyish, or buffy-brown, gritty sandstones were seen at the base of the lining wall at a depth of between 20 and 30 feet from the surface, with occasional clayey partings and a few small quartzite boulders enclosed. In the more westerly of the two wells which are of large size (from 25 to 30 feet in diameter), the beds appear to dip about 6° towards a point lying between east by south and east-south-east. The lining walls prevented my ascertaining exactly the thickness of the superincumbent lateritic shingle beds, which is here very considerable. Whether this sandstone under- or over-lies the Pyanoor conglomerate is not shown in these sections. In another well three quarters of a mile north-north-west of Tiruvatankadu (Trevatangul of map), the same sandstones contain thin layers of broken branches and twigs of silicified wood of white color and very brittle, identical in appearance with the fossil wood found at Ramanjeri.

Tyloor section.

Very friable micaceous sandstones are exposed in a new well immediately north of the village of Tyloor (Tydoor of map). Here two fragmentary specimens were found, one of a *Palæozamia,* the other of part of a coniferous tree, and with them two distorted and unrecognizable casts of conchiferous bivalves. Though ill preserved and obscured from the coarse and friable nature of the matrix, these specimens were quite sufficiently clear to preclude all doubt as to the relative age of the rock with which they were associated.

Waroor section.

Chinnamapett section.

The friable sandstones are of a buffy-brown color, (the color paler where the rock is shaly) and have an easterly dip of 6° to 8°. Further south, sandstones and shales of identical lithologic character occur at the north end of the Waroor tank. A quarter of a mile to the west, these beds have been cut through in digging a well for the Railway Inspector's bungalow at Chinnamapett station.

Syenitic boulders at Pyanoor.

At Narnaveram.

Indications of the continuation of the boulder-bed, or beds, may be traced all round the base of the high ground north and north-north-east of Pyanoor by the presence of scattered syenitic boulders weathered out of the friable matrix, especially near Narnaveram (Naineveram of Atlas Sheets), where masses of flaggy syenite of whitish, pink, and dark-red color are very numerous on the surface as well as large rounded masses of quartzite, although very large quantities of the former have been trimmed into flags and largely used in the lining walls of the numerous very large circular wells in that neighbourhood. Stone fences of these syenitic flags and of quartzite boulders are very characteristic features round the villages adjoining these boulder-beds.

At Attiput.

At the village of Attiput (Oxapet of map) very large quantities of these syenitic boulders appear to have been raised in digging large wells, which are very numerous all round the village, and applied to building purposes for walls of all kinds. The same thing is seen at

At Kinjamuttoor.

Kinjamuttoor on the western edge of this rather elevated plateau. At this place, as at Attiput, these boulders appear associated with a bed of friable grey, or drab, sandstone full of small quartzite pebbles, with others of jasper and slate. The few wells which remain unwalled were at the time of my visit so full of water that I could not ascertain the real position of the exposed boulder-bed relatively to the Cavitpooram conglomerate.

At Chinnamapett.

To the south of Pyanoor indications of the continuation of the boulder-beds occur on the high ground south of the railway near Catramatoor (close to the Chinnamapett station), where occasional rounded blocks of granite and syenite protrude among the débris of lateritic formation by which the surface of country is almost universally obscured.

In the railway section a little north of Chinnamapett station the boulder-bed is exposed, but not sufficiently to show its relations to the underlying sandstones and shales. The boulders here consist chiefly of quartzite and are unusually small in size, few, if any, attaining one foot in diameter. At Moshoor numerous large rounded blocks of very granitoid gneiss occur, which from their position appear to have been once included in the friable sandstones which were deposited over this part of the country and in great part again removed by denudation. Traces of very friable micaceous sandstone appear to occur in a well immediately south of Moshoor village resting on the decayed gneiss, but the well being full to overflowing at the time of examination this could not be positively verified. These rounded blocks or boulders, many of which must be nearly a ton in weight, appear to be derived from the underlying pistacite gneiss, and to have been formed by the action of surf on the ancient gneiss shore. Pebbly sandstone beds belonging to the Sripermatoor group may be seen in a well section south-east of Moshoor on the high ground beyond the nullah flowing out of the Sripermatoor tank; these beds from their position were evidently once continuous with others which have been denuded from off the Moshoor gneiss. The section in the well (which is close to an old indigo vat) shows the following strata:—

Moshoor section.

	Ft. In.	Ft. In.
Reddish loam	3 0	
Coarse lateritic gravel	1 0 to	1 4
Gritty pebble beds with shaly partings alternating ...	9 0 to	10 0
Sandstone conglomerate with some strings of quartzite pebbles	2 0	
	15 0 to	11 4

The direction of the dip of the beds is about 16° south of east.

Between this well section and the high ground near Catramatoor great boulders of granite appear on the surface protruding through the lateritic gravel, some of such size as to suggest the idea of their being surf worn pinnacles of the underlying granitic rock. Similar masses appear in various places along the junction of the highly granitoid gneissic rock with the Rajmahal formations southward towards Tukkolum. Near Tukkolum the rock is a granite, or highly altered quartzo-felspathic micaceous gneiss, of rather coarse grain. Many of the isolated blocks have been used to form 'Kurumbar rings', a considerable number of which occur on the north bank of the Corteliar.

Two boulder-beds have been met with south of the Corteliar and will be described further on, but there is generally a well marked decrease of size in a south-east and a south direction of the separate constituent parts of all the rocks belonging to the Rajmahal system.

Naggery Coopum section.

Friable sandstones are exposed in an old ruinous well a few hundred yards south-east of Naggery Coopum, a hamlet of recent origin about two and a half miles north of Tukkolum, to a depth of 7 to 9 feet and capped by about 4 feet of granitic débris and lateritic quartzite gravel. The sandstone includes layers of quartzite pebbles and is in part conglomeratic.

(d).—*The Sripermatoor area.*

Included in this area are the Rajmahal rocks occurring immediately around the village of Sripermatoor, and several outlying outcrops of beds belonging to the same system, and lying south of the Corteliar river.

Two series of rocks.

The Sripermatoor area itself is occupied by two series of rocks whose exact relative position is not satisfactorily determined, owing to the want of sections, of sufficient magnitude, to show the two series in contact.

Their relative positions.

One of these two series, which includes the typical plant-shale beds of Sripermatoor, and some underlying gritty sandstones, occupies the northern part of the area, while the southern part is occupied by a series of grey clays, reddish or purplish gritty sandstones, and buff sandy shales, very unlike in color to the white shales and grits occurring further north.

The principal outliers, four in number, of the Sripermatoor area, occur along the outer edges of the lateritic deposits which lie round the north end of the area.

Northern half of area.

The lithological character of the beds in the northern half of the area is very uniform throughout the basin-like series of shallow valleys they occupy.

The base of this series cannot be said to be known, as no sections occur in which the underlying rocks (most likely the gneiss) are seen in contact with the Sripermatoor beds. The probability is, that the gritty sandstones are the base, though not seen, resting on the gneiss.

Vellakotta section.

The best section of the series in the northern part of the area occurs on the flank of a little hillock six miles south of Sripermatoor, and half a mile south-west of Vellakotta village, a sketch of which is given in Fig. 11 and shows the following strata:

		Ft.	Ft.
1.	Laterite conglomerate	10 to	
2.	Plant shales	8 „	10
3.	Friable, gritty sandstone...	10 „	12
4.	Gritty shales...	2 „	3
5.	Sandstones (gritty)	Base not seen.	

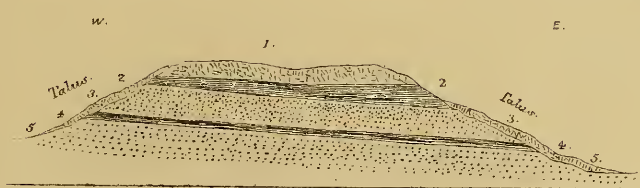

Fig. 11.—Section of Vellakotta hill.

Kambamkal channel section.

Another good section is to be seen in the Kambamkal, a channel* running into the Sripermatoor tank, about half a mile west of the Department of Public Works Bungalow at that place. In this section† the beds exposed are—

1. Lateritic sand with implements.
2. Plant shales, pure, white, and compact.
3. Coarse yellowish grits, with shaly partings and much false-bedded, very friable.
4. Micaceous sandy shales.
5. White and greenish-grey gritty sandstones,—friable.

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* See Fig. 3, p. 61, which is a diagram sketch of the section in question.

† A very handsome piece of silicified exogenous wood, found when the irrigation channel was being dug at Tirumangalum, was presented to the Geological Survey of India by the late Mr. C. Maitland of the D. P. W.

The plant shales in this section yielded a good number of specimens, in fair preservation, of *Palæozamia*, (of two or three species).

The shale is compact, very pure, and of white color, resting on the gritty sandstones No. 5. Near the southern end of the section were some boulders of a very similar grit containing numerous marine shells fossil. These, as already stated (page 61), belong more probably to the cretaceous era, and have, therefore, been described in Chapter VII. These boulders were at first thought to belong to the underlying grits, on the ground of their strong lithological resemblance, but the examination of the fossils showed their non-Rajmahal character, and excavations clearly proved the boulders to have no connection with the grit bed No. 5, which is completely unfossiliferous. Both grits are made up of débris of granitic rocks.

The grit beds are again seen in the off-flow channel below the south kalingula of the Sripermatoor tank, but the shales have been denuded away from them just there.

Sections in and at north end of Sripermatoor tank.

The shales are seen in the bed of the great tank when dry, and again at the northern end, where they rest upon a bed of white grit. The shales are much disturbed at this place, apparently by some lateral pressure, which has also affected the grit bed beneath. A few yards to the west of the small channel above the Kalingula, a part of the grit bed, about 40 feet long and from 1½ to 2 feet thick, has been pushed up into a vertical position and protrudes above the surface like a small dyke. The general dip of the beds is east-north-east at a low angle.

A little outcrop of the shales occurs in a small new well about 200 yards south-west, whence several fossils were obtained, chiefly *Palæozamiæ* and parts of fronds of a coniferous tree allied to *Taxodites ?*

These shales are more compact than those at Sripermatoor bungalow. They are much cut up by shrinkage joints into oblong or rudely prismatic pieces. Some thin layers of pale-buff color are almost porcellanic in texture, a character met with in several other places to be mentioned further on. The fossils in this porcellanic shale are generally the best preserved, but more difficult to obtain than in the less indurated shales, as there is often a tendency to conchoidal fracture irrespective of the planes of lamination.

A tiny outcrop of shales, the most northerly in the Sripermatoor basin, occurs in a little shallow gully close to Todukadu. The shales are less compact than those at the north kalingula, and, like those in the section west of the bungalow, thin bedded. A small fragment of a *Dictyopteris* frond, beautifully preserved however, and showing the venation very distinctly, was the only fossil found here.

The only other two sections in which the grits underlying the plant shales were observed in contact with the shales occur south of the Sripermatoor sections and between them and the Vellakottei section before described (page 97).

Araneri section.

The first of these two sections occurs at Araneri, three miles south-south-west of the bungalow section, and shows the shales resting on whitish, friable grits which are obscurely bedded. The overlying shales dip 10°—15° south-east by east. No fossils were obtained in these beds.

Vellum section.

The second section showing the shales and grits in contact occurs at the south end of the large tank at Vellum. The grits, which are of white color, are seen in a rain-gully opening into the south end of the tank, and in the dry season in the bed of the latter. Resting on the surface of the grits is a small bed of gritty shales, closely resembling in lithological character bed No. 4 of the Vellakottei section. The plant shales do not show in contact, but occur only a few yards off on the surface, having been scratched up in large quantities during the ploughing of the fields. The intermediate bed No. 3 of the Vellakottei section is not clearly seen in this section. If, as supposed, the small bed of gritty shales above described agrees with No. 4 of the Vellakottei section, the position of the underlying grits is fixed, and agrees with No. 5 at Vellakottei. The grit bed is well exposed at Vellum in the gully just mentioned and in the square tank between it and the village.

Silicified wood.

At the bottom of the north end of the gully, and close to the sandy shale bed, lies imbedded part of a silicified tree, about a yard long and 10 inches to 1 foot in diameter. This fossil wood, which is firmly imbedded in the grit, is beautifully silicified, every pore of the close-grained woody structure having been perfectly preserved, and the exogenous character being extremely distinct.

Tirumungalum section.

A gritty sandstone of identical appearance and white color has been cut through, and exposed to the depth of 2 to 3 feet in the new irrigation canal at Tirumungalum on the Arcot road and not quite two miles west-north-west of the Araneri section. The Tirumungalum grit, if belonging to the Sripermatoor group, which it most likely does, has had the overlying shales denuded away from off it, for it is capped by lateritic conglomerate. This grit is probably continuous over the whole area of high ground between Tirumungalum, Kiranullur, Kándoor, and Punnoor, though perfectly covered up by lateritic formations.

The whole of the remaining area of the northern half of the Sripermatoor area appears to be occupied by the plant shales only, for they only are seen in the numerous shallow sections there met with.

The high ground lying east of Araneri and north of Vellum offers the largest area of the Sripermatoor rocks free from a lateritic capping, and affords several good sections of the plant shales, which are not, however, remarkably rich in plant remains.

Vadugal section.

The lower parts of the shale bed exposed in a large bowrie near the centre of the high ground (once the site of a village called Vadugal) are coarser than the usual form of the shales, here and there a little gritty, and a good deal mottled with shades of purple and brown, resulting from iron-stains. These are remarkably unfossiliferous. The higher lying parts of the bed are both purer in composition and color; many layers are almost porcellanic in texture and lustre, and, as at the north end of Sripermatoor tank, of yellowish-buff color inside, and have a lesser tendency to break into thin laminæ. Several fine specimens of *Palæozamia* were found here.

'Porcellanic' shales.

The shales occurring in the lower grounds are a continuation of the beds before described, with the addition, in the northern part of the area, of a bed of much less indurated shale which overlies the lower shales. In some parts of the upper bed the shaley structure is almost lost and the shale passes into a crumbly clay. This clay is almost everywhere unfossiliferous, and generally of whitish-grey color, with a good deal of infiltrated kunkur.

'Tesselated' ferruginous concretions.

There is no sharp line of distinction between the two formations, the shales, as a rule, becoming less compact upward. At the base of the clayey bed, however, is frequently a band of large ferruginous concretions, many of them 2 to 3 feet long and 1 to 2 feet thick and of rudely lenticular form. They generally consist of a reddish-brown sandy-clay ironstone, stained black or purple in parts and often showing a singular tesselated structure.

Fossils in ferruginous concretions.

No recognizable fossils were found in the clayey shales anywhere, but several of the concretions occurring in the section in the feeder of the Chumbrumbaucum tank about half a mile east of Amerumbode, where they are best seen, yielded vegetable remains in the shape of fragmentary portions of *Stangerites.*

A well preserved impression of a small *Ammonite* was also picked up there. The impression is in a piece of clayey ironstone undistinguishable from the more ferruginous parts of some of the concretions.

Fragments of fossil wood were also found in the upper shales in the Amerumbode* section, and it seems not unlikely that this clayey shale bed is the source whence were derived fragments of silicified exogenous wood found scattered on the surface in various places, *e. g.*, at Valerre to the west, and on the high ground between Irunkatti Kotta and Vollaveram to the north.

The upper part of the lower shales exposed in the large nullah at Amerumbode and all along its banks at intervals, from close to Sripermatoor on the west to half a mile from the south end of Sembarrampakkam† tank on the east, are more earthy and less compact than those in the localities already described, and also than those in the remaining parts of the area.

Porcellanic shales near Vellarei.

Porcellanic shales like those found north of Vellum appear in the bottom of the tank at Vellarei (three and a half miles south-west by south of Amerumbode), and in the tank bottom at Nallur ($1\frac{1}{4}$ miles east-south-east of Amerumbode), and again at the extreme north-east end of the Sripermatoor area near Puduperu. In these places, as to the north of Vellum, the porcellanic character is accompanied by a peculiar system of jointing, forming wedge-shaped, triangular, or oblong figures. The color also is generally a pale-buff, or brownish-yellow; and fossils are here very much more abundant than further west.

Distribution of organic remains.

The organic remains in the shales are very unequally distributed, those occurring at the south and north ends of the Sripermatoor tank containing hardly any animal remains, but fragments of plants in fair quantity (see pages 122-124).

* Amanumbaid of sheet 78.

† Chumbrumbaucum of map.

The same predominance of vegetable remains was observed in the shales at the south end of the Vellum tank. Vellakottei section yielded only a few fragmentary remains of *Dictyopteris* and *Palæozamia.* In Vellarei and Nallur tanks and the Amerumbode channel section, the remains of marine shells are nearly or quite as numerous as those of plants.

A remarkable feature in the mode of occurrence of many of the fossils was noted, namely, that the organic impression or cast was generally covered with a thin film of red color contrasting strikingly with the pale-grey, white or pale, buff of the matrix. Occasionally the color spreads beyond the organism on to the surface of the shale, but, as a rule, it is strictly confined to the enclosed body, and appears to occupy part of the space once filled by the organic matter.

The vegetable remains are chiefly fragments of branches and fronds drifted out to sea, but they are well preserved, and among the shells many (the majority, I think,) show both valves.

The following list was drawn up in the field and can only be considered as an approximately correct one :—

Plants.	Animals.
Palæozamia Cutchensis ?.	Fish scales.
,, *acutifolia ?.*	*Ammonites,* 2 or 3 spec.
,, *Bengalensis ?.*	*Belemnites ?* (a long phragmocone ?)
,, *n. spec. ? ?*	*Patella ?*
Pterophyllum.	*Rhynchonella ? ?*
Tæniopteris.	*Cytherea ?*
Stangerites.	*Cypricardia.*
Sphenopteris.	*Tellina ?*
Pecopteris.	*Anatina* (Thracia) ?
Dictyopteris.	*Leda,* 2 or 3 spec. or varieties.
Lycopodium.	*Lucina ?*
Equisetites.	*Cultellus ?*
Poacites.	*Ostrea.*
Scales or bracts.	*Inoceramus.*
Seed vessels.	*Lima.*
Taxodites spec. ?	*Pecten.*

None of the fossils in the above list give any decided evidence as to the exact age of these formations.

THE SOUTHERN PART OF THE SRIPERMATOOR AREA.—As already mentioned, there is a great change in the mineral character of the formation occurring in this part of the Sripermatoor area from that of the beds described above. Topographically also the southern half of the area should be treated distinctly as it is separated from the basin-like valleys to the north, by a ridge of rather high ground running across, and forming the water-shed about half a mile north of the old and now abandoned road from Madras to Wallajabad.

The area thus separated from the Sripermatoor basin is itself divisible into two parts, as a line of water-shed runs across it in a north, west by north to south-east by south direction immediately west of the village of Omeallicherry.

Want of sections.

The south part of this area is greatly obscured by a thick covering of reddish sandy soil apparently washed down from the higher-lying gneiss region to the east, and the laterite plateau of Oragidam (Woodagurm of map) to the north.

It is only north of a line drawn from Vellikaram to Wadakupat (Warracapett of map), where the ground rises, that the surface soil begins to be derived from the underlying white and greyish shaley clays. No good sections are to be found here, and the clays are only seen in the material turned out of tank bottoms and wells.

Vellikaranei section.

The soil is white and sandy and scattered very thinly with patches of large and small quartzite pebbles. Fine dark-grey sandy clay occurs underlying the white soil at Vellikaranei. It is exposed only in a small well, and to a cursory examination proved unfossiliferous.

North-east of Vellikaranei the surface of the Rajmahal beds is much hidden by reddish soils, and nearer the gneiss boundary by scrubby jungle.

East of Omeallicherry the high ground consists of white soil derived from the white shaley clays before alluded to; where the ground begins to fall to the north-east, the soil is more mixed with lateritic gravel and reddish sand.

Much of the country was at the time of my visit entirely hidden by paddy cultivation, while the unusual fulness of the tanks probably obscured many good sections. Only one really good one was met with lying about a mile north-west of Omeallicherry and close to the village of Vautumbaucum.

Vautumbaucum section.

The section is exposed at the north side and point of the southernmost promontory jutting out from below the Oragidam laterite plateau. The headland rises about 30 feet above the level of the village of Vautumbaucum, and in that space a very considerable variety of beds occur, as will be seen by the following list, in which they are arranged in descending order:—

Fig. 12.—Section at Vautumbaucum.

		Ft.	In.		Ft.	In.
1.	Laterite gravel with quartzite pebbles	2	0	to	4	0
2.	White sandy clay with concretionary lateritic ironstone ...	2	0	to	3	0
3.	Coarse, brown, buff and whitish friable grit with shale and sandstone partings passing downward into	3	0	to	4	0
4.	Sandstone, brown and reddish-brown, compact, lateritoid and schistose...	8	0	to	12	0
5.	Sandstone, buff, very fissile and shaley	2	0	to	2	4

		Ft.	In.		Ft.	In.
6.	Sandy clay, white and pale-buff in color, with plant remains, rather friable	2	0	to	2	4
7.	Purple and buff shaley sandstones, with clayey partings ...	2	0	to	4	0
8.	Sandy shale (local)	0	0	to	3	0
9.	White clay	1	0	to	1	2
10.	Shaley sandstone, purple at the top, buff below	2	0	to	3	0
11.	White clay	1	2	to	1	4
12.	Thin-bedded buff sandstones, more gritty and purple at top ...	1	3	to	1	6
13.	Friable whitish sandy shale base	2	0	to	3	0

The general dip of these beds varies within the exposed area from about 5° east to 7° east-south-east, with occasional small rolls to the north and south, which take away from the clearness of the section. The sandy-white and pale-buff clay bed (No. 6) contains numerous vegetable impressions, well preserved, but easily effaced owing to the very friable nature of the matrix. Specimens of two (and probably more) varieties of *Palæozamia* and of *Stangerites* show the true Rajmahal character of this series.

To the north these beds are no doubt continuously developed as far as the steep slope northward of the laterite plateau running westward from Vippoor to Mettapaluyam (Motopullum of map), and here they appear to have been cut off by denudation.

Vippur section.

Where the old Wallajabad-Madras road crosses the bund of the tank south of Vippur, a bed of brownish-yellow shaley clay crops out through the laterite gravel talus, but is exposed only for a few yards along a tank. This yellow clay yielded, amongst other not very characteristic vegetable remains, part of a frond of a small species of *Pterophyllum*, in very good preservation, and strikingly like some of the typical Rajmahal specimens.

The absence of a good section anywhere along the line of water-shed north of the old high road renders it impossible to correlate exactly the Vautumbaucum series of sandstones and clays with the Vellakottei and Sripermatoor series, but the strong probability is, that they (the Vautumbaucum beds) are younger than the typical Sripermatoor shales occurring at Vellaur, Eraur, Alagur, and Vellarei.

The beds forming the Vautumbaucum series appear to be underlaid by blackish grey clays of which great part of the Vautumbaucum tank-bund is made. The bund is built of clay taken from the surface of the fields below it, which are situated at a considerably lower level than the base of the section on the headland.

Similar clays occur in the bottom of the Naralur tank which is situated on very low ground.

The idea of the infra-position of the blackish clays is strengthened by the fact, that where the ground begins to rise again at the north end of the tank, yellowish sandy clays and clayey sands immediately appear, and occupy the water-shed to the north-west and east of the village of Vanjeri.

Orattur Nullah Section.

About 2 miles to the south-east of the latter place, a small extent of pale brick red sandstones is exposed in the bed of the nullah formed by the junction of the muddagoo* of the Orattur tank with the surplus waters of the Naralur and other tanks.

Boulder-bed.

Under these sandstones, which have a westerly dip, is a bed of drab colored sandy clays and clayey sandstones containing scattered boulders of gneiss—some large enough to weigh 2 or 3 cwt. There can be little or no doubt that these beds are an outcrop of some part of the Vautumbaucum series, although no fossils of any description were found here.

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* Muddagoo is the native name for the course of the stream flowing from the Kalingula or waste weir of a tank—which, as a rule, flows from a point near one or other end of the bund, and very rarely coincides with the original stream. Some large tanks have more than one muddagoo.

The clays exhibit a slight tendency to the cone-in-cone structure noticed as occurring at Atrampakkam.

Returning north-westward to Serupanjeri, the surface of the rocks, where exposed in the road, shows yellowish friable sandstone, and tesselated iron-stone concretions. True laterite and lateritic gravel is sparingly scattered over the country, and not unfrequently rounded pieces of the tesselated iron-stone occur washed up with it.

Vanjeri conglomerate.

A few score yards south-east of Vanjeri, a small elliptical space of ground, about an acre in extent, is occupied by large, angular, weathered blocks of a very coarse, hard conglomerate of quartzite pebbles, imbedded in a calcareo-silicious cement of pale grey color. This conglomerate stands on the yellowish sandy clays before described as occupying the water-shed running north of the old road. The blocks which had not been quarried for building stones present every appearance of being part of a true stratum, the separation into loose blocks being only an effect of weathering. A stalactitic incrustation was observed on a few blocks, having at first sight considerable similarity to the exterior rugose surface of cup corals, but when fractured no cellular structure of any kind was traceable. This conglomerate is so strikingly different from any other formation in the Sripermatoor basin that I am acquainted with, and is, so far as I know, so entirely limited to this small spot, that it becomes very difficult to decide to what series of formations to assign it, and whether to consider it as a member of the Rajmahal series, or to regard it as a solitary and fragmentary remnant of some younger system of formations. In the absence of fossils it is hard to decide. The mineral character most resembles the Sattavedu conglomerate as seen immediately west of Sirgulpilly, and it would be rash to separate this Vanjeri conglomerate from the Rajmahal series, no non-conformity having been proved to exist between it and the underlying clays.

OUTLIERS OF THE SRIPERMATOOR AREA.—Four principal outliers connected with this area have been alluded to before, and have now to be described. They are respectively—

Sections at Settorei.

1*stly.*—An important out-crop of unquestionably Rajmahal beds, situated on the eastern edge of the Corteliar alluvium, and about 10 or 11 miles north-west of Sripermatoor. The most important section occurs near the village of Settorei, and exhibits a series of beds closely allied in lithological character to the typical Sripermatoor beds.

Panjur.

2*ndly.*—An extensive series of sandstones and shaley beds, probably belonging to the Rajmahal age, exhibited in an artificially made section, by which the waters of the Cúúm river are led into the great Sembarampakkam tank (near Poonamallee), at Panjur, 9 miles north-east of Sripermatoor.

Coopoor.

3*rdly.*—A very similar series of sandstones and shales, apparently belonging to the Rajmahal age, occurring at Coopoor, about 10 miles north-north-east of Sripermatoor.

Perumalpett.

4*thly.*—A series of similar shales occurring at Perumalpett (Permaulnaigput of sheet 78), and also referable to the Rajmahal series.

Besides these, there are 2 other trifling outliers of Rajmahal rocks, the one an out-crop of gritty sands 3½ miles north-east by north of the Settorei section; and the other an out-crop of clayey shales in the bottom of a bowrie at Puttam, 7 miles north-west of Sripermatoor.

The first of these four sections must certainly be considered as a link between the Sripermatoor area and the underlying beds of the Pyanoor area.

Settorei section.

About 12 miles north-west of Sripermatoor, fossiliferous shales occur below the lateritic gravel south of the Sattorei (Suttry of map) tank, in the sides of a low headland, or series of headlands, rising out of the alluvium of the Old Palar valley. Close to the south end of the tank the shales are grey in color mottled with ferruginous stains, and are divided into several beds by two or three thin beds of slightly ferruginous concretionary sandy shales with more highly ferruginous sandy nodules. The vegetable remains found by me in the shales were rude stalk-like impressions, but in the more gritty parts of some of the enclosed nodules, several fair specimens of unquestionably Rajmahal plants were discovered, *e. g.*, *Stangerites*, &c. The section is anything but clear owing to the talus of lateritic gravel, and the friable nature of the underlying rocks themselves; but in one very small rain gully where the surface of the section was less obscured, the beds appeared to dip 4° to 5° towards a point between north-east by east and east-north-east. The top of the headlands is formed by a bed of lateritic gravel with pebbles and fragments of quartzite; this bed is about 3 feet thick. Half a mile to the south of this headland at a spot where the talus did not obscure the base of the slope, the lowest bed in the section was seen to consist of whitish shaley clay, which also shows in the sides of the irrigation channel running into the Settorei tank; this clay is overlaid by friable buff sandstone and local patches of tesselated ironstone concretions. A few yards to the south of this a fair section occurs at the north end of the Keesary (Reesary of map) tank, which shows a very slight anticlinal roll in the several beds exposed. The general dip of the beds is easterly, at an angle of 8° or 9°, but at the west end of the section, the two lowest beds, the clays and friable sandstones just referred to, dip 1½° to 2° west. The beds are then cut off by the slope of the ground, so it cannot be seen whether there is a real

Plant remains.

Keesary section.

anticlinal axis or a mere local undulation. The annexed drawing (Fig. 13) is a diagram of the section, which shows the following beds:—

Fig. 13.—Section at Keesary.

Several small and barren valleys run into the higher ground in an easterly and south-easterly direction, but their sides and bottoms are too smooth and too much obscured with lateritic gravel débris to afford instructive sections. About a mile south of the Roman Catholic Church at Keesary, these beds, upon which the village stands, are covered up by quartzite gravels and disappear. The beds occurring at the second and third outlying sections (*i. e.*, those at Panjur and Coopoor), though but little like those at the northern road of the Sripermatoor area, have a very considerable resemblance to those seen in the Vautumbaucum section in the south Sripermatoor area, and, like the latter, apparently overlie the plant shales.

Panjur sections.

The strata met with at Panjur* have been cut across the bedding at right angles to the prevailing dip, which is easterly, at an angle of from 5° to 7°. Extensive pluvial erosion has helped very greatly to improve the section since its first being cut. One of the largest rain gullies of those on the east

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* The village of Panjur, not marked on the map, lies on the north side of the great Chumbrumbaucum tank just west of the large feeding channel which brings down the water of the Cúúm river. The section was formed by the cutting through a ridge of high ground capped with laterite. The cutting extends from the bridge, by which the Madras-Arcot road crosses the channel, down to the village.

bank of the Channel shows the following complete series of formations in their true stratigraphical arrangement:—

1. Laterite gravel.
2. Mottled grits obscurely bedded.
3. Drab, friable sandstones.
4. Sandy shale.
5. Light-brown friable sandstones.
6. Sandy shale.
7. Drab sandstones, with ferruginous sandstone nodules, obscurely bedded in some parts.
8. Ferruginous grits.
9. Sandy shales.
10. Ferruginous grits.
11. Thin sandy shales.
12. Ferruginous grits.
13. Grey micaceous sandstones.
14. Ferruginous grits.
15. Fine white micaceous sandstone.
16. Light-brown sandstone.
17. Ferruginous crust (hard) of grit.
18. Sandy shales.
19. Grey sandstone, gritty.

Towards the base of No. 7, the sandstones become increasingly ferruginous, and are much false bedded on a small scale.

On the west side of the channel other greyish-white, gritty sandstones appear underlying the above, and in a ferruginous parting between two of these, shown in the gully next the Madras-Arcot road, a few *Estheria*-like forms and the crushed cast of a bivalve shell were found.

The beds east of the channel proved altogether unfossiliferous, except a few unrecognizable vegetable fragments occurring a little northward of the section gully at the level of No. 17, in hard, purplish, thin laminated sandstone.

The thickness of the whole series of beds here cannot be estimated as less than from 100 to 150 feet.

Strikingly like the above section is that occurring in the banks and bed of the large nullah north of Coopoor, six miles to the north-west of the Panjur section. In the small gully on the south side of the nullah, about three-quarters of a mile north-east of Coopoor, the following succession of beds occurs:—

Coopoor section.

1. Soil.
2. Laterite gravel.
3. Kunkurry sandy loam.
4. Micaceous friable sandstone finely laminated.
5. Buffy-brown gritty sandstone.
6. Micaceous sandy shale, fine grained and finely laminated.
7. Brown, gritty, friable sandstone.

The dip of these beds is between 3° and 5° north. Corresponding beds a few hundred yards to the east show a dip of about 3° north-north-east. No fossils but a few small stalk-like fragments of plants in bad preservation were found by me, though the beds were very carefully searched, but Dr. Hunter and Major Applegath, of the Madras Staff Corps, both state that they have found plant remains in the shaley beds north of the nullah and overlying the beds of the above section. These shaley beds are much obscured by the lateritic gravel in situ and as débris.

In a lump of shaley grey clay said to have been found here, Dr. Hunter showed me the impression of a fossil bivalve shell, which, if my memory be true, is identical with the *Cypricardia* found in the plant shales at Amerumbode. Dr. Hunter also showed me a drawing of a plant found in the same place, and strongly resembling in its outline and shape a pointed *Palæozamia* frond, but the venation was different, and probably incorrectly represented as concentric to the external edges of the leaflets.

These beds unquestionably extend below the narrow alluvial valley of the Cúúm river, and re-appear at the village of Perumalpett (Permalnaigpett of map), about three miles west-south-west of the railway station at Tinanoor. The

Perumalpett section.

section is of very trifling importance except as a proof of the presence of the Rajmahal beds below the lateritic gravels on this spot. The section is exposed in a small rain gully falling from the south into the small oblong tank east of the village. White shales are exposed to a depth of about 2½ feet for a distance of three or four yards below a thin capping of lateritic gravel. No traces even of fossils were discovered after careful search in these Perumalpett shales, but in their mineral character they are extremely like the Sripermatoor shales.

Adigatur section.

The small outlier of gritty sandstones south of Adigatur, three and a half miles north-north-east of Settorei section, is so completely isolated from the other outliers both at Settorei and Coopoor, that it is not easy to know to which series to assign it. This coarse gritty sandstone, which is apparently unfossiliferous, shows locally much false bedding, and in one or two places a largely concretionary structure. Small portions also are somewhat calciferous. No other formations are here seen but this coarse, friable grit, which is only exposed on the north side of a low bluff rising over the alluvium of the 'Old Palar' valley. The high ground south of the bluff is covered with lateritic gravel.

Boulders at Aryapaucum.

South of Settorei outlier, are some traces of a boulder-bed like those in the Pyanoor area, which may be regarded as a connecting link between the Sripermatoor area and the outliers in the neighbourhood of Conjeveram. On the high ground between Aryapaucum and Kanontangul, numerous well-rounded blocks of granite and gneiss occur scattered over the surface of the quartzite shingle. This quartzite shingle is of questionable age, and belongs to the gravels I have named the Conjeveram gravels, which were most likely formed of the materials of destroyed conglomerate beds of the Rajmahal series. The mineral character of the boulders strongly resembles the boulders cropping up through the lateritic shingle at Catramatoor and Moshoor, suggesting the possibility of their being remains of a southward extension of the boulder-beds of the Pyanoor area west of the Corteliar. The origin of these boulders is not made clearer by the fact that some of them have been used to form the Kurumbar rings on the high ground adjacent, still, as most of the Kurumbar rings and kistvæns in this immediate neighbourhood, *e. g.*, at Palnalur and Kunduperrum, have been formed of massive laterite, it seems unlikely that the old Kurumbars should have gone six or eight miles for granite boulders on the high ground of Tukkolum, when an abundant supply of the finest laterite occurs only a mile to the east of Arryapaucum.

Outlying sections west of the Sripermatoor area.

Cotrumbaucum section.

The first outlier of beds, probably belonging to the Rajmahal series, was met with at Cotrumbaucum one and half mile north-north-west of the Rajah's Choultry on the Madras-Arcot road. Very friable, highly micaceous brown sandstone is here exposed in the sides of the new square tank south of the village, which stands on high ground. Obscure vegetable markings occur sometimes in the sandstone, but are of too rude a character to be recognized. The tank was too full of water to see anything more than the very top of the bed.

Rajah's Choultry section.

The second of these out-crops was met with about a mile south-west of the Rajah's Choultry on the Madras-Arcot road, and a couple of hundred yards south of where the road to Little Conjeveram crosses the principal feeder of the great Tennary tank. The section is seen in a large shallow rain gully running down into the feeding channel, and is nowhere more than 2½ or 3½ feet in depth. Very friable sandstones and brownish buff-colored grits resting on fine sandy clay, with an apparent general dip of 3° to 5° north, crop out in the sides and bed of the gully. The beds roll a good deal, and no measurable dip was seen. In one of the lateral gullies, a flat oval mass of rather gritty sandstone about 4 feet long and 3½ feet wide, of grey color, is exposed by denudation, but is probably still in situ. This compact sandstone has been weathered on the surface in such a manner as to simulate a gigantic fungoid coral. The surface shows all round distinct radiating prominences, with slight fossæ between, but no organic structure whatever could be discerned in the mass, nor any mineral peculiarity to account for this somewhat remarkable appearance. The sandy and gritty beds yielded nothing but impressions of fragmentary and ill-preserved plant-stalks. In one spot, however, on the east side of the main gully a large lenticular concretionary (but not concentrically aggregated) mass of ferruginous sandstone of dark-brown color and very fine texture yielded a great number of vegetable impressions; indeed the freshly broken surfaces between the central laminæ especially were altogether covered with impressions of leaves, &c. These impressions, many of which were very well preserved, represent a considerable number of typical Rajmahal plants, as *Palæozamia*, *Sphenopteris?* In the underlying clayey stratum, only a few inches of which was exposed, a few fossils were also found, namely, part of a frond of a *Palæozamia*, part of a coniferous leaf, a leaf of doubtful character, numerous impressions of stalks of no special character, and, lastly, the cast of one valve of a conchiferous mollusc.

The lateritic gravel which forms a small, but well marked scarp immediately north of Little Conjeveram, contains much washed-up material derived from the Rajmahal beds. Rounded fragments of the tesselated ironstone concretions, which occasionally contain characteristic vegetable remains, are by no means uncommon among the lateritic gravel.

Vizier section.

West-south-west of Great Conjeveram at a spot about ¾ of a mile east of the village of Vizier, buff, friable, shaley sandstones are exposed in the sides of a well under a gritty bed of the Conjeveram gravels 8 or 10 feet thick. This well was unfortunately inaccessible, the usual flight of steps being absent, the appearance of the sandstones is, however, so characteristic that it is impossible to doubt that they belong to the Rajmahal series and form the most westerly out-crop of it, known to the north of the Palar river. In this case, as in that of the Cotrumbaucum section described at page 119, there was no appearance of the Rajmahal rocks at the surface; they are, therefore, not shown on the map.

It is not possible to arrive at any conclusion about the relations of these southern Rajmahal rocks to those occurring in Behar and Cutch, till the comparison of the fossil floras and faunas of the several regions shall have been completed and published.

The nature of the rocks in the Trichinopoly region in a lithological point of view accords very clearly, especially in the nature of the boulder-beds and the generally arenaceous character of the micaceous shales. The differences are only what might have been expected from the differences of the gneiss rocks in the two districts. In the Madras and North Arcot districts the quantity and purity of the clay beds is, on the whole, very remarkable, but is the natural result of the degradation of the very coarse granitoid gneiss which occurs so largely in the country north and west of the Palar and Poiney rivers, both in the low country and forming the eastern edge of the Palamanér table land and the mountain spurs descending from it. This coarse granitoid gneiss contains, as a rule, a very large proportion of felspar of more than one variety, which by decomposition would yield infinitely greater supplies of pure argillaceous matter than would the far more highly silicious and hornblendic gneiss of the Trichinopoly and Salem mountain regions.

There is a very marked resemblance between the Rajmahal beds occurring in the Nellore district to the west of Ramiapatnam and those described as occurring in the southern part of the Alicoor area and in the Pyanoor area. Micaceous sandstone and shales with a few beds of gritty sandstone predominate in both quarters, and are remarkably alike both in color and texture. They agree also in containing very few organic remains beyond small chips of wood and tattered unrecognizable fragments of leaves. The circumstances under which they were deposited were evidently very similar.

The study of the Rajmahal beds in the Madras district shows in general a gradual progression in the coarseness of the component parts of the several strata; the finest and most homogeneous shales occur at the most distant point from the sources whence the constituents were derived; the coarsest conglomerates and boulder-beds occur nearest to the rocks which yielded the masses of gneiss and quartzite they inclose.

It is impossible to stand on the Alicoor hills and look northward towards the Ramagherry, and not imagine that the broad valley running north-north-east from Nagloperam was once occupied by great beds of conglomerate and sandstones, which joined the present Sattavedu hills with the slopes of the Ramagherry and Cumbaucum Droog ridge; and that the enormously coarse conglomerates of the Sattavedu hills were formed of masses rounded by the action of a tremendous surf battering against the base of the great line of cliffs now forming the grand and most conspicuous precipices along the sides of that fine mountain ridge. The same conclusion forces itself upon the mind on gazing in a north-westerly direction at the enormous scarps of quartzite which cap the Naggery Nose, the Narnaveram peak, and the Suddashemullay. The great boulder-like masses of quartzite which alone occur on the east parts of the Alicoor hill, (the granitic and gneissic boulders having only been observed on the western and southern sides of the hills and at comparatively low levels), must have been washed into the sea down the inclined plane which abutted on the base of those huge lines of ancient sea cliffs. The violence of the currents requisite to move such weighty masses is further indicated by the extreme disorder in which the materials of most of the conglomerate and of all the boulder-beds are seen to occur. The very fine grained compact shales of the Sripermatoor basin, and also those occurring in the valley of the Kullar and Atrampakkam nullahs, indicate a very different state of things to have existed during parts of the Rajmahal period. These shales show every evidence of having been deposited in perfectly tranquil water at sufficient depths probably to be beyond the agitation of the waves. The fragmentary nature of the fronds and leaves appear to indicate that they were drifted out to sea, while the good state of preservation they are in proves they must have been torn and fragmentary when first imbedded.

In conclusion, it may be well to point out some points in respect to which there is a small contrast between the Rajmahal beds of the Madras area and other parts of the Peninsula of India and those of Bengal and Cutch.

The Madras Rajmahal beds contain little or no carbonaceous matter,* while in other beds of equivalent age in Bengal and Cutch it occurs so largely as to form true seams of coal. All the fossil plant remains found in the Madras beds occur either as mere impressions without any remainder of organic matter, or, as in the case of trees and larger branches, they have been silicified, not carbonized.

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* Dr. Hunter, whose borings in search of coal in the neighbourhood of Sripermatoor have been before adverted to (page 11), claims in a letter published in the *Madras Mail* (early in 1871) to have found three or four thin bands (each only a few inches thick) of carbonaceous shale associated with the plant-shale series at various depths. Not the faintest trace of carbonaceous matter was seen by me in any of the rocks occurring in the sections—I examined most carefully for such traces. Nor can I find the slightest reference to a discovery of bituminous shale near Rajah's Choultry by Dr. Benza in his paper on the geology of Madras in the Madras Literary Society's Journal (see page 6), alluded to by Dr. Hunter in the letter above referred to. Unfortunately I was unaware of Dr. Hunter's borings till long after completing the survey of the Madras area, so could not make any special enquiries into his results, a detailed account of which I have moreover been unable to obtain from him.

Though perfectly assured of the *bonâ fides* of Dr. Hunter's statements, I cannot but be extremely sceptical of the correctness of his determination of the true nature of anything but the very commonest rocks.

Unlike the Rajmahal beds in Bengal which have great flows of trap intercalated or intruded between the sedimentary rocks, and the Cutch beds which are overlaid by trap flows of (?) tertiary age, the Madras series is nowhere penetrated, or overlaid, by igneous rocks of any kind, nor in the least degree metamorphosed.

Of less importance is the contrast in color of the component rocks; the Madras beds, unlike those of Cutch, which are often of very gay and bright colors, are with very few exceptions of dull and sober colour, a remark which applies also to their representatives in the Trichinopoly and Nellore districts.

CHAPTER IX.

SUB-METAMORPHIC ROCKS.

If the extraordinary masses of quartzite conglomerate described as occurring at the base of the Rajmahal series on the south-west slopes of the Naikenpolliam ridge (see pages 67-71) be considered as the ruins *in situ* of a once existing bed and not as carried blocks, the sub-metamorphic rocks are represented in the area treated of in this report, and the quartzite conglomerate in question may be regarded as the basement of the older of the two series into which the sub-metamorphic rocks of Southern India have been divided.

Of these two series, called, respectively, the Kaddapá and Karnúl series, the first, which is the older, consists chiefly of alternating beds of quartzite and slate of great thickness, together with some limestones.

In the region adjoining the Madras area, the lower part cf the Kaddapá series consists of very thick beds of quartzite and quartzite conglomerate, which constitute the main mass of the Naggery mountains,* and are so finely exposed in the huge scarps formed on the flanks of these mountains. It is not difficult to conceive that these great beds once extended much further south and covered the gneiss which now forms the base of the Naikempolliam hills, and that subsequent erosive action failed to remove them entirely.

The members of the younger or Karnúl series do not appear ever to have extended so far south as the Madras area.

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* A group of four isolated mountain masses lying between the Naggery and Soornamooky rivers. They consist of the Naggery Nose, the Narnaveram peak, the Sathoosconda (or Saddashamallei) and the Ramagherry ridge, with their spurs and a few small outliers.

CHAPTER X.

Metamorphic rocks.

The metamorphic rocks lying within the area dealt with in this report all belong to one great series, the gneiss series, the oldest known formation in India. Although they occupy a considerable area, they offer but little of interest and importance, differing in this respect considerably from other gneissic areas to the west and south.

The survey of the gneiss area between Madras and the Palar river shows that the various beds constitute a series of great foldings similar to those worked out in the Salem, Trichinopoly, North Arcot and South Arcot Districts,* while the examination of the country south of the Palar by the late Mr. Charles Æ. Oldham clearly proves that character to be continuous across the space intervening between the country included within sheet 79, and the gneissic area north of the Palar.

These foldings have their axes generally running north-north-east to south-south-west, and are, on the whole, very regular, but owing to the intervention between the various ridges of hills, of very flat valleys thickly covered with soil, and, in many cases, with thick scrub jungle in addition, the perfect sequence of the foldings cannot be followed out.

The rocks predominant in the series occurring south-west of Madras are the hornblendic varieties of gneiss, and next to them the quartzose varieties, but very felspathic rocks are of great rarity, and, except in one instance, of small local extent. Micaceous gneiss is also of rare occurrence.

The foldings are most perfectly seen along the rocky hill ridges extending from Tirukarikunum nearly up to Vengambaucum. They are also well developed in the Chingleput hills and in the group of rocky

* See Memoirs, Geological Survey of India, Vol. IV, part 2, *passim*.

hills at Cuddapary Choultry south-west of Palaveram. The beds forming these two groups seem to be connected by the beds appearing in the Nundiveram and Vendalour hills. In some few places the dips disagree in direction with the theoretical extensions of continuous foldings, but that disagreement, it is not unlikely, may be due to faults, or else to slight local reversing of the strata. Such is probably the case with the hornblendic and quartzose beds at Ottivakkam (Ottawaucum of map) which dip to the west, while the corresponding beds further south and north have an undoubted easterly dip.

Hornblendic gneiss of very compact character is well developed on St. Thomas' Mount and the Palaveram hills, and the quartzose felspathic rocks show at the south end of the Marmalong bridge and to the south of Paliacuramy.

Of the quartzo-felspathic gneiss the only remarkable development is that occurring at the Seven Pagodas. At that place called Mahavalipuram or Mahamalaipuram by the Hindus (the Mahavalipoor of Southey's "Curse of Kehama") is a ridge of the quartzo-felspathic rock about half a mile in length, running nearly parallel with the beach, and rising about 80 feet above the general level of the island. This ridge has been elaborately sculptured in many places. Several temples of considerable beauty have been cut into the solid rock, and several detached masses of rock at the southern end of the ridge have been carved into handsome monolith pagodas. An extension of the same quartzo-felspathic bed occurs nearly three miles to the north, close to the fishing village of Padari. Here also are several very interesting temples cut into the rock. The rock, which is easily quarried, shows its bedded structure very rarely; and has hence often been considered a granite.*

Rock temples at Seven Pagodas.

The strike of the grain of the rock which coincides generally with the direction of the ridges is north-5°-east to south-5°-west. When

* The rock at Mahavalipuram is now being largely quarried for pillars and slabs.

exposed to the spray of the sea, this rock assumes a dark-black color, but where beyond the reach of the spray, it weathers to a dark or pale dirty pink.

The black color may be well seen in the pagoda at the water's edge.

The erosive action of the salt water may be well studied in this ruin, in which parts of the walls have been excavated and pierced by it, and must speedily crumble to the ground.

A few yards east of the pagoda lies a low reef of gneiss rocks which breaks the action of the surf, and but for which this ancient temple would probably long since have fallen a prey to the encroaching action of the sea.

A noteworthy feature connected with these gneissic rocks is the parallelism subsisting between the general strike of the beds and the present coast line. This probably depends in some measure, if not entirely, on the existence of ridges of corresponding strike at a small depth below the bed of the sea, by which the destruction of the uncompacted alluvial formations is prevented. Two such ridges exist opposite to the black Pagoda at Mahavalipuram (Seven Pagodas), the one close in to shore on which the surf breaks and to the presence of which the preservation of the pagoda is due. The second ridge lies about a mile out at sea, and may be seen occasionally between the rollers which are always breaking over it.

Another example of a ridge close to the shore occurs at Covelong. A similar parallelism, but in a less perfect degree, obtains south of the Palar nearly as far as Pondicherry.

Apoor hills.

The only formation of any special geological interest occurs on the crest of the Apoor hill about eight miles north of Chingleput. It consists of bluish-white quartz, perfectly stratified, the lamination of which agrees thoroughly with the bedding. The difficulty which arises in this case is to decide whether it is a highly metamorphosed bed of pure quartzite or a vein of laminated vein quartz, for the bedding seems to coincide in every way with the under and overlying beds of hornblendic gneiss, but on the summit of the hill it presents an appearance which might be the result of sudden thinning out, but might also be considered as proof of injection along the strike of the hornblendic beds which dip 75° to 80° east by south.

Quartz rock.

The outlying patches of gneiss which crop out through the sedimentary formations west of the Chingleput gneiss area have all a more or less north-north-east strike, and evidently form parts of the same or another great series of foldings.

The gneissic rocks lying west of the old Palar alluvial valley are almost everywhere very granitoid in character; the strike of the beds, which is generally more southerly than between Madras and Chingleput, very frequently most obscure and not seldom quite undeterminable. Like the granitoid gneiss of South Arcot, which it frequently resembles in every respect, there is a great tendency to weather into tors and piles of great loose blocks.

Granitoid gneiss.

The rocks are generally very coarse-grained and chiefly quartzo-felspathic, and contain but a small proportion of hornblende or more rarely of mica. They are more largely felspathic than the non-granitoid gneiss.

The granitoid gneiss, like the more typical gneissic beds to the east, evidently forms great foldings, but they are less perfect, and, from the greater change the rocks have undergone, far more difficult to recognize.

It is from the decay of similar highly felspathic coarse granitoid gneiss rocks, which occur very extensively on the east side of the

Palamanair plateau and in its off-shoots, that the great quantities of clay occurring among the Rajmahal formations of the Madras district appear to have been derived.

Granitic rocks.

Of these very few examples were met with, none of any importance or magnitude, unless the doubtful quartzose ridge of the Apoor hill before mentioned be regarded as a vein rock and not as a highly altered bed of quartzite.

The only large vein of unquestionable granite was observed at Turroor, about eight miles east of the Covrepauk tank, where it forms a bare and generally smooth ridge, a mile and quarter long and about 40 feet in height at the highest point. It consists of quartzo-felspathic granite, and is apparently a binary rock, for no traces of mica or hornblende could be detected. The rock is coarse in grain and full of minute cracks and of no value as a building stone.

Whether the handsome red and green syenite rocks occurring in the lower parts of the Naggery Nose mountain occur as veins, or are only highly altered portions of the gneissic series, is a point that has yet to be decided, but they are undoubtedly one source whence came the numerous red and green syenite boulders occurring in the boulder beds of the Rajmahal system in the Alicoor hills and elsewhere.

Trappean rocks.

These, though not of rare occurrence within the metamorphic region described in this report, are of no great importance, nor of any special interest. They belong chiefly to one system, and run generally from west by south to east by north, varying a few points north and south, in some cases, and occasionally changing the direction of their course.

All the dykes observed within the Chingleput gneiss area consist of black hornblendic trap, generally rather coarse in grain, but very compact and tough.

The dykes* traversing the granitoid rocks west of the Corteliar and Alicoor hills are more frequently of very dark-greenish grey color, almost black sometimes, but with the felspathic crystals recognizable from the hornblendic matrix.

The series of large dykes south of Naggery and also those lying between Nellatoor and the Alicoor hills have a truly porphyritic structure. Some of these are of large size and continue westward of the Madras area for many miles.

Economic geology.

The mineral resources of the country under review are not great, but neither are they contemptible. The metamorphic rocks offer inexhaustible supplies of useful and ornamental building stones of various kinds.

The beds of very hornblendic gneiss occurring at Palaveram, Cuddapary Choultry, and Puttandalum (Bootandalum of map) are largely quarried for the manufacture of articles of domestic use, as well as for building purposes. The articles made consist of curry stones and rollers, and mortars for pounding paddy and other grains and chunam. Small troughs, doorsteps, and small flagstones for flooring are also prepared there.

The quarries of Seven Pagodas and of Tirukarikunum have also supplied large quantities of fine building stone.

The granitoid quartzo-felspathic rocks occurring a mile south-west of Nundiveram Bungalow offer a very handsome and durable pale yellowish or pinkish white stone which can be well quarried; both very large and medium sized blocks are obtainable, owing to the favorable position of the lines of jointing.

* The trap dykes near Poody Railway Station show the porphyritic character in perfection, though by no means of a very coarse grain.

Very fine and large blocks of hornblendic gneiss 14 to 16 feet long, are procurable in the quarries about two and a half miles east-north-east of Wallajabad, while the compact sandstones of the Rajmahal beds near Conjeveram, and further north between Sirgulpilly and Nagloperam, and also close to Sattavedu offer a very easily dressed and moderately durable building stone.

Laterite for building and road-making purposes is largely quarried at the Red Hills, Palaveram, and the Trivellore Railway Station, besides other places, but many more localities where it abounds are quite untouched.

Avadi and Tinanoor Railway Stations, Panjur, and Tremunglum and Candoor, Sripermatoor, and Cunam on the new Wallajabad-Trivellore road, also have laterite pits and quarries. The Nellore road north of the Narnaveram river is supplied with laterite from the high ground near Ingawarpolliam laterite plateau.

For ceramic purposes, the clay and shale beds of the Rajmahal series offer an inexhaustible supply of very fine material, more especially the purer beds near Sripermatoor and in the Attrampakkam nullah valley. A small quantity is, or was till lately, obtained by the Madras School of Arts from the beds exposed in the section at Coopum, near Perumalput.

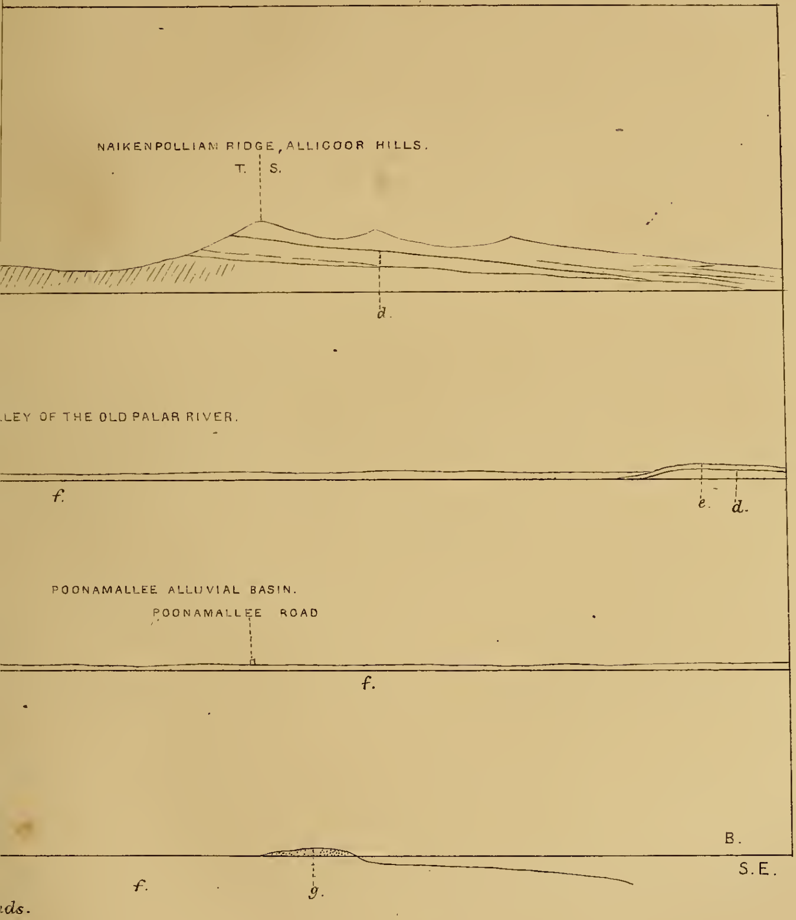
The natives appear entirely to ignore these fine clays, for they are too good to be of use for the common red-ware of which the chatties and cooking pots of the common people consist.

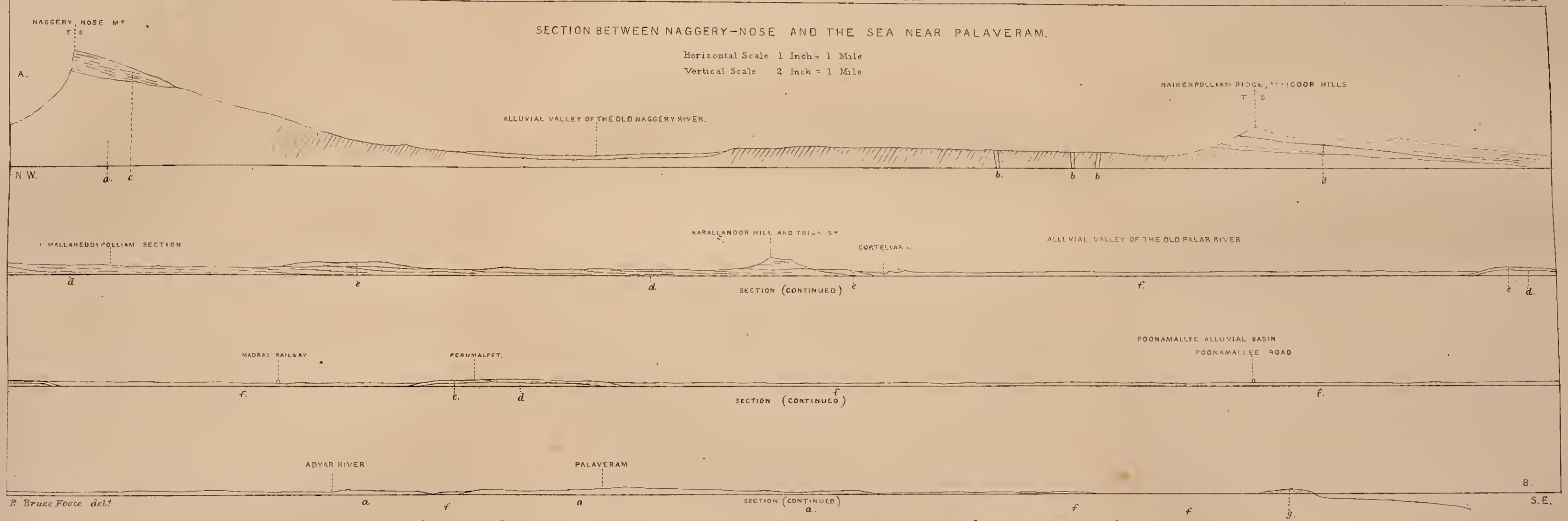
Small quantities of gypsum in the form of selenite in crystals has also been at times obtained for the use of the School of Arts in Madras. It is found in some of the clayey estuarine beds north of Madras.

R. BRUCE FOOTE, F.G.S.,
Geological Survey of India.

October 1871.

Plate. A.


NAIKENPOLLIAM RIDGE, ALLICOOR HILLS.
T.
S.
d.
LEY OF THE OLD PALAR RIVER.
f.
e.
d.
POONAMALLEE ALLUVIAL BASIN.
POONAMALLEE ROAD
f.
B.
S.E.
f.
g.
ds.



a. Gneissic rocks · b Greenstone dykes c. Quartzites of Kadapah system: d. Sripermatur series · e. Lateritic formations f Alluvium: g. Blown sands.

MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Notes on the Sátpúrá Coal-basin, *by* H. B. Medlicott, m. a., f. g. s., *Deputy Superintendent, Geological Survey of India.*

Section I.—Preliminary Notice.

The commencement of the detailed Geological survey of the Narbadá, or Sátpúrá, coal-basin, in connection with which it has been necessary to examine some principal sections of the whole area, has suggested some views upon the general structure of the rocks, the discussion of which is an essential preliminary to the prosecution of the work. Since the publication of the sketch-map of this ground, fourteen years ago, the wide experience gained in the uninterrupted examination in other parts of India of the great rock-series to which the coal-measures belong has, of course, largely contributed to a better understanding of the rocks here. Even when the former work was done subdivisions were known to exist, and were mentioned in the report, but which it was not possible to separate upon the very imperfect map then available; and since then, new groups have been described in other fields, the equivalents of which may be looked for here. The enlargement of the series in the Sátpúrá region is even greater than was expected: it seems probable that we have here a more complete representation of the great 'plant-bearing' rock-series of India than in any other part of the peninsula. It is at least certain, that above the Talchír and the Barákar groups, there are deposits having features of resemblance to the upper groups of the Damúda and of the Godáveri fields, and of thickness equal to, or greater than, that of those strata; while ranging continuously above those again, we find in the Sátpúrás many hundred feet of younger deposits now unrepresented, or but very poorly so, in those other regions, and hitherto casually noticed as the Máhádévás and Jabalpúrs. This general fact I hope to make clear; but the full discrimination and designation of the groups, at least of those beneath the Pachmari sandstone, must await the completion of the detailed work. The present notice will be purely stratigraphical; if this determination of the physical relations be sound, any fossils that may occur must of course accept the 'situation.'

Comparative fulness of the rock-series in the Sátpúrá basin.

There is a question of general structure regarding which it is important to have some information before undertaking the detailed mapping and description of any geological field. On looking at the published sections of many European coal-basins, it is at once apparent that they are, or at least that the view given implies them to be, portions of a formation once spread continuously far beyond the limits of their present area; the actual features and limits being primarily due to great crust-movements, whether of flexure, or of faulting, or of both. Where such is the case, the several subordinate groups of strata in the basin would be expected to maintain some approximate uniformity of thickness and of character; and the changes they exhibited might show little or no connection with the present induced boundaries of the field. The comparative

Two meanings of the word *basin*.

internal regularity existing in a basin of this description, gives, of course, a strong presumption when counting upon the permanence of any particular bed, such as a coal-seam, and makes it possible to estimate with some accuracy its position at any part of the basin. The general geological knowledge of a formation should, on the other hand, be proportionate to the preservation and completeness in which its original basin of deposition is found. The fact I would express for practical men, in connection with Indian coal-fields, is, that a portion of a once very extensive formation now isolated in a basin of flexure, as is the case with many coal-fields, might exhibit a regularity that could not prevail in any considerable basin of deposition as a whole, in which the effects of all the local influences must be exhibited, as is usual in Indian coal-basins. There are thus two kinds of evidence from which to infer to what extent any particular field is a basin of deposition or a basin formed by subsequent crust-movements, *viz.*, (*a*) the distribution of the groups severally and collectively within the field, and (*b*) the features of the boundary.

The Sátpúrá basin is one of deposition.

From both these points of view, it would appear that the Sátpúrá coal-basin is a true basin of deposition; the present boundaries representing, for the strata in contact there, the original limits of the deposits. There must, no doubt, have been an overlapping extension of the upper groups beyond the present low-cut outcrop of the junction; but the actual plane of junction is not either a fault, or a floor of deposition, but an edge of deposition. The general straightness of the northern boundary might suggest a fault; but in detail its outline is often sharply curved and serrated. At scores of places, as at Jabalpúr, the strata are seen stretching at the same horizon into little bays and over barriers of the boundary rocks. There are also some local sections of the contact, as notably in the Shér and the Táwá, where the features might suggest faulting; and there may have been some local slipping along such steep surfaces of contact; but in all these cases beds of the same horizon as those at the supposed fault are found close by, resting upon the older rocks. Further particulars upon this feature will be found in a later section. The same conclusion is broadly suggested by the distribution of the strata within the basin. The many distinguishable bands of strata seen in the central section of the basin, and amounting to a great thickness, are found to thin out, or to die out, both in the strike and the dip. This fact also will be exhibited in the following pages.

The basin is entirely within the Sátpúrá hill-mass.

The so-called Narbadá coal-basin does not even appear in the actual valley of this river, as is approximately the case with many of the fields on the Damúda and the Godáveri. The river only touches these formations at one spot, where it leaves its deep trench through the trap of the Mandlá plateau, to enter upon the broad alluvial area which is generally understood as the Narbadá valley. At that point it crosses obliquely, for about five miles, over the outcrop of a narrow band of sandstones occurring almost continuously along the fringe of the trappean area, and which thus forms a most useful link between the Sátpúrá coal-basin and the much larger expanse of the same rocks in South Riwa. The alluvial deposits of the Narbadá plains seem to be, for the most part, underlaid by metamorphic rocks, with which the sandstone series is in contact along the south margin of the valley. At many points the older rock forms a narrow fringing ridge, sometimes reaching to the full height of the scarp of sandstone, thus more clearly separating the basin of sedimentary rocks from the actual valley of the river. A very large portion of the field is drained into the Narbadá by the Táwá and its tributary the Dénwá; the Moran, the Dudhi, and the Sítárívá being the only other streams of importance belonging to the same river-basin. In the south-east of the area the Kánhán and the Pénch are distantly tributaries of the Godáveri. Thus a main water-shed of the peninsula passes obliquely across this corner of the field; the Motúr ridge, made up of sandstone capped by trap, here forming the crest of the Sátpúrá range. On account of its entire inclusion in the hill-area, this field has been more appropriately designated the Sátpúrá coal-basin by Dr. Oldham.

Limits of the basin.

The field is about thirty to forty miles wide from north to south. The southern boundary is roughly parallel to the northern; and here also metamorphic rocks are almost continuously exposed at the contact. Along the upper course of the Táwá the younger rocks have been deeply denuded, exposing a scarp formed of the crystalline rocks; but on the side of the Kánhán and of the Pénch the surface of the younger rocks, south of the Motúr ridge, is on the general level of the Sátpúrá plateau. To the west the field becomes narrowed: at first by the gradual encroachment of the metamorphics from the south, and then by the overlapping of the trappean formation. On the east there is no apparent contraction of the basin, as defined by the underlying rocks; the visible limitation of the field in this direction being entirely produced by the overspreading trap. Some observations will, however, be noticed seeming to suggest that the basin proper does stop out at no great distance in that direction. The length of the area from west to east is about eighty to ninety miles.

The Moran and Sítárívá terminal areas.

The form of the ground is peculiar; and, dependant as it is upon the local rock-structure, it will be best described in connection with a general sketch of the several formations and their distribution. Such a general view may with advantage be based upon a north and south section through the centre of the field. Along the northern face, towards the Narbadá valley, the hills present two distinct aspects: at each end of the basin, for some fifteen to twenty miles, there is a regular scarp, 800 to 1,000 feet high, the edge of plateaus composed principally of massive sandstones. It will be convenient to have names for these two terminal areas, as they present both physical and geological peculiarities. On the side facing the basin, each plateau is. cut off from the great central range of the Pachmari hills. That on the west presents a steep scarp to the broad undulating plain of the Táwá valley. The strata in this scarp have a westerly dip; and it forms a watershed, the hills behind it being drained by the deep tortuous gorge of the Moran river, by which name also the area may appropriately be designated. The hills at the east end of the basin are similarly, but less completely, separated from the Pachmaris by the valley of the Dudhi, to which they present a broken scarp and watershed, with an easterly slope of the strata. This area may be named after the Sítárívá, by which it is traversed in a deep gorge, having its source in the Motúr range, where this range becomes confluent with these eastern hills. Both the Moran and Sítárívá hills, as also the Motúr range, are for the most part capped by trap.

The Pachmari range.

Between the two terminal scarps, along the Narbadá valley, the outer range of hills is very irregular in outline and of small elevation, leaving a clear view of the Pachmari range to the south. This Pachmari range forms the most striking physical feature of the whole region. It occupies a nearly central position in the basin, its summits ranging up to 4,380 feet. On the south it is defined by sheer cliffs of great height; but on the north the slope is gentle, the outline indicating the steady northern dip of the massive sandstone composing the range. On the west it is cut back towards the dip, and dies out into the valley of the Táwá, across the northern edge of which a low outcrop of distinctive Pachmari rock can be traced up to the scarp of the Moran hills. On the east there is a low flat range connecting the Pachmari with the Sítárívá and Motúr hills, and over which a cart-track passes from Delakári towards the plains of the Narbadá.

The Sonbudra hills.

From the open valley of the Táwá on the west to that of the upper Dénwá on the east, between the Pachmari and Motúr scarps on the north and south, there is a broad stretch of low ridges, preserving a general parallelism to the scarps and to the general strike of the formations. This area is drained principally by the Sonbudra, a tributary of the Dénwá, having its principal sources on the Motúr ridge, which has here been separated from the crystalline plateau, by the denudation of the upper Táwá, into a short independent range, terminating in Kilendéo and Asírgarh hills.

The Motúr ridge.

It thus appears that, although the Pachmari peaks are higher by several hundred feet than the summits of the Motúr, the latter is the main axis of the drainage, probably corresponding to an original axis of greatest elevation; which axis is altogether within the basin of the sedimentary rocks, at a distance of from eight to twelve miles from the southern boundary. It seems to correspond with a broad anticlinal flexure. Both the Dénwá and the Sonbudra, having their most distant sources on the Motúr ridge, pass by deep, narrow, cliffed gorges through the massive sandstones of the Pachmari range. These gorges must have been deeply graven in the rocks before the ground attained anything like its present configuration.

The general cross-section of the basin.

The figured section (fig. 1) very nearly represents the exact features on a cross-section through the centre of the basin, passing south-south-east through the plateau of Pachmari. To make it more typical, some characters at either end are taken from a short distance to one side, where the general features happen to be better exposed than on that precise line. The exceptional features of the northern boundary will be separately illustrated. The several rock-groups are only tentatively designated by letters, pending the complete examination of the field, and because the limits of the groups are locally very ill-defined, owing to the conformable and transitional character of the formations. The section presents a descending series from north to south; a flat synclinal is a very general feature within three miles of the north boundary, but to the south of this the rocks have an almost constant northerly dip.

Groups above the Pachmari sandstone.

There are three groups distinguishable above the Pachmari sandstone. Where the hills along the north fringe of the basin attain much height they are capped by a massive sandstone (*a*) of the section. It is underlaid by a very mixed set of beds, 600 to 800 feet thick; sandstone, clay, and limestone, occurring most capriciously, without any constant order, mixed with each other in any proportions, and often highly conglomeritic. This sub-division (*b*) is the most frequent at the boundary. Under it there occur (*c*) some 1,200 feet of pale bright brownish yellow and bright mottled red clays, with subordinate bands of white sandstone. The longitudinal valley of the lower Dénwá is excavated in these beds. There are many good sections, none better than in the Dénwá at Moár, showing the massive Pachmari sandstone (*d*) passing with a dip of 10° beneath the base of these clays, and passing steadily up into the slope of the ridge, the surface of which slightly undercuts the strata. The thickness of the Pachmari sandstones is very great; on the line of section it can hardly be under 8,000 feet.*

Pachmari sandstone.

The Pachmaris form longitudinally a very marked physical and geological division of the central portion of the field, between the Moran and Sítárívá terminal areas. The detail-work of the present survey has as yet been confined to the northern portion; and a fuller description of the groups already mentioned will be given further on. The southern region presents greater natural difficulties, but some indication of the rock-structure here also can now be given with confidence, based upon several careful traverses of the ground.

Region south of the Pachmari range.

The Motúr range has not the aspect so common in these hills: there is no persistent scarp. Cliffs occur locally at different heights, corresponding to the outcrops

* These thicknesses, of course, represent time-thickness, *i. e.*, accumulated successive thickness of gradually overlapping strata; such as would have to be taken account of in applying any rate of deposition to ascertain the time represented by the formation.

of various strong beds of sandstone; but, as a whole, the surface is shelving and irregular, indicating alternations of soft discontinuous strata. Earthy sandstones predominate; but there are frequent thick courses of gray, brown, and dull or bright red clays up to the top of the range. The dip is northerly, often as high as 15°, and all the rocks are identifiable with those occurring in the low ground along the base of the range. Carbonaceous beds are found in both positions. With such a steady dip all the rocks of the ridge are soon accounted for in the low ground; and still the northerly dip continues, bringing in higher strata, up to the base of the Pachmari scarp. There is a flat roll of the strata north of Bichberi; but making full allowance for this, there remain some 3,000 to 4,000 feet of rocks between the Motúr beds and the Pachmari sandstone. There is a general resemblance between these and the series on Motúr; but I believe the two to be distinct. In the upper horizon strong sandstones, partially of Pachmari type, are predominant; red clays are rarer, and carbonaceous ones more common than in the Motúrs. It was on this horizon, in ripple-marked sandstones alternating with thick carbonaceous shale, at Bijori, that the *Archegosaurus* was found. This horizon, or tentative group, is marked as (*e*) on the section, and the beds of Motúr as (*f*). South of the range, the Motúr sandstone and red clay, again with a northerly dip, continue to within two or three miles of the boundary. The Barákar group was not detected on this line of section, close to the watershed between the Táwá and the Kánhán; it may be overlapped. Its position is indicated at (*g*). In the Pénch, some twelve miles to the east of the section, the coal measures are brought up by a faulted anticlinal flexure. The Talchírs (*h*) are well exposed near to and at the contact with the gneiss, very much crushed. Regarding these southern groups also further remarks will be made. It will be convenient, and, perhaps, permanently desirable, to continue to speak of the three groups, *b*, *c*, and *d*, as the Máhádévá series; and of the lower ones, *e*, *f*, *g*, as the Damúda series.

SECTION 2.—(*a*). THE JABALPÚR GROUP.

Connects the Sátpúrá and South Riwa basins.

The division (*a*) represented as capping the northern range of hills, and as the uppermost band of strata in the whole section, is but a remnant of a group that attains a considerable thickness and extension to the east; and has there been latterly called the Jabalpúr group. The eastern limit of the Sátpúrá coal-basin must be somewhat arbitrary. If unbroken continuity of rocks belonging to these formations were to be the rule applied, the area would extend up to the Sunér, the eastern boundary of the Narsingpúr district, fifty miles beyond the Sítárívá. Still further eastwards there is sufficient evidence, in repeated small outcrops along the edge of the trap, that there is real continuity of these rocks up to Jabalpúr, and similarly beyond it into the South Riwa coal-basin. At Jabalpúr the group consists of massive softish sandstone with subordinate white and pale-tinted clays irregularly associated. They lap up over a flatly denuded surface of crystalline metamorphics, the boundary being very tortuous; and at places they pass under the alluvium of the valley, between hills of granitic rock, so that their true limit in this direction is obscure. In a well in the old jail compound coal was found at a depth of 70 feet, probably at, or close to, the very base of the formation. In the small section exposed in the Narbadá river the coal is seen to rest upon the steep edge of the metamorphics. Near the boundary the sandstone is locally conglomeritic.

The group at Jabalpúr.

In the Umar valley.

In the basin of the Umar (Oomur), the first considerable stream in the Narsingpúr district, there is a larger exposure of the Jabalpúr group than any occurring between this and the Máhánadi in South Riwa; and from the Umar westwards there are increasingly large areas exposed in the successive stream-valleys. The rocks in the Umar area are in every way like those at Jabalpúr: they lie flatly; and the encircling hills being low, there is only a small thickness, under 200 feet, of sandstone seen beneath the covering trap. Along the north-west edge of the area the strata lie against a broad low belt of metamorphics. South and south-west of Srinagar there are some good instances of outliers and projections resting on the schist, the bottom bed being of a character that is very general whenever it is found so placed. It is a compact pseudo-quartzite, coarse, sometimes conglomeritic, and with an excess of white earthy matrix in a porcellanic condition. This rock is found at many places through the station of Jabalpúr. Very rarely it is calcareous, quite a limestone, as in the stream north-west of Rátomati, one mile east of Srinagar.

Limestone in the Jabalpúr group.

In this neighbourhood there are also the most frequent cases known of a limestone, not a bottom rock, within the Jabalpúr group. There is an outcrop of it on the spur south-south-west of Nagwára, and several in the low ground south of Tendukhéra. It is important to draw attention to this rock, as there is great risk in the field of confounding it with the similar limestone of the Laméta, or infratrappean, group. Although there is the most complete unconformable separation between the two, they are sometimes found in parallel horizontal juxtaposition, when it is by no means easy to distinguish them. There is, too, the awkward coincidence that the most westerly outliers of the Lamétas, at Gúrtala and Magni, two miles north-east of Srinagar, occur in the same region as these rare limestones of the Jabalpúrs, calling for very clear evidence that the latter do truly belong to the older formation. There is a slight difference between the two limestones, the chert in the Jabalpúr rock being of a more chalcedonic type; but the only sure criterion is in the associated beds. With the limestone at Magni there is found, round the base of Lutgáon trap-hill, the friable mottled pale green and purple sand characteristic of the Laméta group. The best crucial section of the limestone in the Jabalpúrs is north-east of the village of Dún (Doon): there is a small hill capped by it; and on following the bed to the east-south-east it is seen to pass under a little cliff of typical Jabalpúr sandstone.

In the Shér and Machiríva area.

In the valley of the Shér, or rather of the Machiríva, an affluent of the Shér close to the main rock-boundary, there is a large area irregularly weathered out, partly as inliers, from beneath the trap, and entirely formed of the Jabalpúr group. The junction in the Shér presents one of the best instances of supposed faulting at the main boundary, the evidence being that the surface of junction of the gneiss, about 20 feet in height, is vertical or even overhanging. The strata in contact are at their normal level, and are, moreover, distinctly boundary-deposits, containing several conglomeritic layers with angular blocks of quartz from the contiguous rocks; and at two miles to the west, where the boundary emerges from beneath the alluvium, there is an overlapping contact. At about 150 yards from the boundary in the Shér, the earthy and conglomeritic bottom beds (which may possibly be Talchír) are overlaid, with a southerly dip, by a strong bed of sandstone of the usual Jabalpúr type; upon which rest shaly carbonaceous beds containing some strings of jet-coal. This band is separated from a similar carbonaceous and coaly band by several thick beds of sandstone. The low southerly dip continuing, this upper band passes under a very thick mass of sandstone, which lasts for some two miles up the Shér, to Karheia, at the trap boundary. A few score yards above where the sandstone ends, there is a small outcrop of Laméta beds, weathered out from beneath the trap, at Karheia.

On the Machiríva.

The massive sandstone of the Shér extends for a quarter of a mile up the Machiríva, being there cut off by a broad protrusion of trap. At and above the village of Marpiperia this trap is seen in the banks to pass conformably under sandstones and shales with carbonaceous and coaly layers. After about 300 yards, it passes out of sight beneath these beds, which continue well exposed in the river, the strings of jet-coal appearing at several places. The straia form a flat synclinal, and in about half a mile the trap rises to the south, being again seen for several hundred yards in the bank overlaid by unbroken sandstone; and from here it is certainly traceable into connection with the overlying flows. This is one of the many instances that occur, especially in this region, of sheets of trap intruded horizontally for great distances (considering the strange nature of the feature) between layers of the sedimentary rock. In other directions the same trap is traced into strong vertical dykes. For some nine miles more along the tortuous course of the Machiríva, the trap and the Jabalpúr beds alternate repeatedly, with various modes of contact—transverse and parallel intrusion, and overflow. Where the Jabalpúrs are finally covered by the trap, at a direct distance of five miles from the boundary, the black shales with coaly matter are still at the level of the river; while on the adjoining ridges white shales are freely intercalated with the sandstones. The thickness is about five to six hundred feet. The topmost beds are locally conglomeritic. West of the Shér the pretrappean denudation of the Jabalpúrs was much less than in the country to the east, if one may judge by the greater thickness and elevation of the sandstone.

The boundary at Bachái.

About Bachái, five miles west of the Shér, the Jabalpúrs are found for the first time in force at the main boundary. They here form a cliff some 400 feet high, resting upon metamorphic limestone. The bottom beds are coarse earthy conglomerates, the principal débris being of earthy schists. In the middle portion there are pale red and white shales: and again at top there is a thick mass of earthy sandstone-conglomerate. For some five miles to the west the edge of the hills is again low and shelving, and the bottom beds are but sparingly conglomeritic. Then the high scarped form comes in, which lasts up to the valley of the Dudhi. At first, for a length of some fourteen miles, the scarp is supported upon a high undercliff of the metamorphics; at one point these reach to the full height of the range, the sandstone being weathered back as a low second scarp.

In the Sakar and Hard area.

In the gorge of the Sakar and Hard, the basin of which adjoins that of the Shér and Machiríva within the hills, there is a section exhibiting the conditions in this portion of the boundary. At the mouth of the gorge the schists reach to nearly half the height of the hill; and upon them rest some 500 feet of, at base, coarse earthy conglomerates, both sandy and calcareous, passing into massive conglomeritic sandstone at top. The plane of junction gradually slopes to the south, and cuts the river at about two miles from the mouth of the gorge. At this point the bottom-rock is still the pinkish earthy calcareous conglomerate, at first coarse and massive, but soon becoming finer and flaggy, altogether about 50 feet thick. The low southerly dip then brings in overlying flaggy sandstone and coaly shales, associated with some strong false-bedded sandstone; massive beds of the latter rock separate these shales from the upper band of shales with their jet-coal seen in the Hard at its confluence with the Sakar. This second band is covered by the strong sandstones of the same type forming the surrounding hills. For some three miles the course of the Hard is first from the north-west with the fall of the strata, then from the south-west, all through the upper massive sandstones; and above these reaches, its course is a tortuous one from the south. Along this part of its bed and up the Pitnái, for seven miles in a direct line, the carbonaceous band, but with little or no coaly matter, is frequently exposed, most intricately associated throughout with intrusive trap, either in parallel sheets or in transverse protrusions. This section in the Sakar and the Hard corresponds very closely with that on the Shér and the Machiríva; but in the Sakar it is clearly seen how the massive, high-level conglomerates at the edge of the basin are only the fringing deposits of the Jabalpúr group. The carbonaceous bands here as elsewhere occur at the lowest level, and apparently at or near the base of the group.

Change to west of the Hard: introduction of lower groups.

The sandstone of the Sakar and Hard is not separated by any continuous overlapping of trap from that of the Sítárívá. It forms the north-east portion of the triangular area of sedimentary rocks bounded on the west by the Dudhi valley, on the north by the Narbadá valley, and on the south-east by the irregular line of trap gradually encroaching from the south. Still on the Hard the section is, as on the Machiríva, composed entirely of the Jabalpúr group; the only noticeable difference being, that the upper portion of the Hard section is at a higher level than that on the Machiríva. To the west of the Hard this gradual elevation of the Jabalpúr beds continues, with the concomitant effect of introducing underlying groups not represented in the sections to the east—the beginning of the features noticed in the main section of the Sátpúrá basin. This rise of the rocks to the west is not solely due to a general elevation: within the hills there is a very decided easterly dip in the sandstones to the west of the Hard. Along the boundary this slope is not observable; but instead of it we find a great increase of thickness of the conglomeritic deposits. Here, too, other changes take place, having, no doubt, some relation to those in the newer sedimentary rocks: within three miles to the west of Hatnapúr and of the Sakar gorge, the fringing metamorphic rocks disappear for a length of sixteen miles; and the massive conglomerates occur down to the level of the plains, resting at first upon a small patch of Talchírs at Nibhora. It seems likely that this gap in the fringing rocks was due, through denudation, to a local change in the composition of the metamorphic series: east of the Sakar the limestone and its associated hornstone, so often found crushed into a breccia, occur abundantly, associated with the gneissose schists; but from the Sakar to Nibhora soft earthy schists are the only rocks seen.

In the Sítárívá area.

With these changes commence the difficulties of classification that were indicated in the general sketch of the main cross-section. Taken on certain sections the natural divisions are plain enough; but owing to the transitional character of the several groups one with another, it would be impossible, in the absence of fossils, without perfect maps, and an immense expenditure of time and labour, to lay down accurate lines of demarcation. On the summit of the ridges at the mouth of the Sítárívá gorge the Jabalpúr group, as already described, is well represented. There are 500 to 600 feet of sandstone, with pale shales containing strings of the characteristic jet-coal in its lower-middle portion. These are best seen in the cliffs on the south face of Nimugarh hill. The lower mass of the hill, some 600 feet, is formed of coarse massive conglomerates in rusty clays and earthy sandstone, with some courses of dolomitic limestone. Along the outer face of the range the two groups are distinctly defined, the one forming the cliff, the other the under-cliff. Within the hills the division is still well maintained, as in the Mari cliffs, five miles up the gorge of the river, where the second band of shale with coal is seen at the base of the lower sandstone cliff; the underlying rusty clays and sandstone being still in force, but only sparingly conglomeritic.

Western outliers of the group.

There is thus exhibited a marked contrast between the sections on the Sakar and the Sítárívá. The strong conglomerates at the edge of the basin are somewhat similar in both; the preponderance of a red earthy matrix to the west being the chief difference. But the stratigraphical relation is very different. On the Sakar the whole may be taken as belonging to the Jabalpúr horizon, only about 50 feet of the conglomerate passing under the bottom shales at a mile from the boundary; whereas on the Sítárívá there is no sign of horizontal transition, both groups maintaining their distinctness for a considerable distance. The Jabalpúr group proper, (*a*) of the general section, is the dominant rock in the Sítárívá hills, at least in the northern portion; the southern has not yet been examined. To the west of the Dudhi it is only represented by cappings on some of the eastern summits of the northern hill-range. The jet-coal has not been found west of Nimugarh. In following the group (*b*) along the northern range, notice will be taken of these outliers of the Jabalpúrs.

In all the outcrops of the characteristic jet-coal of the Jabalpúr formation examined since the latest published remarks upon it, the features already described in it have been found to remain constant. In the higher levels reached by it in the Sítárívá hills, the strings of coal in the clays are even less abundant than on the Shér, or the Narbadá.

Section 3.—(*b*). The Bágrá group.

Extension of the group.

Enough has been said at the end of last section to explain the separation of the beds (*b*) from the Jabalpúr group, whether as a sub-division of that group, or as a local group in the series of the Sátpúrá basin. The latter would seem preferable, as these two upper groups are not co-extensive even in this field; and in the South Riwa field, where the Jabalpúrs are well developed, the deposits of (*b*) are not specifically represented. In the Narbadá region, the longitudinal extension of the lower group is great; forming, in whole or in part, the northern hills from Nibhora to Lokartalái. If a name were needed for it, Bágrá would suit, from an old fort built upon these beds at the mouth of the Táwá gorge. The transverse extension of the group is small in comparison with its length. In the Sítárívá hills it disappears, as the river-beds rise into the Jabalpúr horizon; there is no sign of it south of the Dénwá for the greater part of its course; but in the Moran hills it seems to be the predominant group.

Its very variable composition: east of the Sítárívá.

The composition of this group is remarkably variable, and can only be described by brief successive notices of the localities. From Nibhora to the Sítárívá the rocks are undisturbed. The exposed sections along the foot of the hills present very thick banks of coarse conglomerate in a deep red earthy sandy matrix. At higher levels, beds of rusty sandy clay and earthy sandstone are intercalated. It is here that the difficulty of separating the Jabalpúrs from the lower group is most felt; the conglomeritic sandstone of Cháorigarh, certainly of the Jabalpúr group, seeming to form a natural sequence with the beds below it. Two streams issue from these hills, at Chengáon and Dongarko; and in them there is the same obscurity. There is, however, certainly a great thickness of conglomerate below the first appearance of the Jabalpúr shales in the Dongarko stream, about a mile above Ránidha, where there is a good section showing about 80 feet of alternating coaly shales and sandstone with a dip of 20° to north-north-west.

On and west of the Sítárívá.

At, and west of, the Sítárívá there is a region of special disturbance The whole rock-series is broken up by a sharp anticlinal flexure; in consequence of which the scarp is weathered back along the southern dip to about a mile south of the normal run of the boundary. In the Sítárívá there is a remnant seen of the beds on the north limb of the anticlinal, including, at top, some 150 feet of the coarse conglomerates and red clays, quite vertical. At the very base of the hills here, there are some local courses of dolomitic limestone in the clay.

Local difficulties of separation.

Owing to the prevalence of the earthy element in the lower group on the Sítárívá, the separation is easily made at many places for several miles up the gorge of the river. Elsewhere, as along the western scarp of the Sítárívá hills, facing the Dudhi valley, it is often difficult to separate the Bágrá group, owing to the prevalence of sandstone in it. This is most marked at the north-west angle of these hills, where the group is certainly in force, and close to which, in an outlying hill east of the Dudhi at Kámpti (not the Kámpti of Nágpúr), there is a fine section of characteristic rusty red and pale brown clays, pink and dun limestone, with subordinate sandstones, all locally conglomeritic.

In the Chátar-Doria hills.

In the Chátar-Doria hills, between the Dudhi and the Anjan, the Bágrá group is typically displayed. Here again the hard silicious limestone and hornstone of the metamorphics form a fringing ridge, against which, on the south, coarse red conglomerates, just like those east of the Sítárívá, are packed in massive banks. At the base of these some strong courses of limestone are seen quite close to the boundary, in the Dorli stream. Away from the main boundary the conglomerate gradually decreases, passing into clays, limestones, and sandstones; and on the south side the limestone is the prevailing rock. The crest of the ridge is formed of Jabalpúr sandstone.

From the Anjan to Sáli.

West of the Anjan to the Táwá and on to Sáli there is no conspicuous hill on the northern range. The rocks present everywhere the same irregularity of composition—sandstones, clays, and limestones, without any assignable order, horizontal or vertical, only that the conglomerates are always in greatest force near to the main boundary. At Sáli there is another instance of local peculiarity: next the main boundary there is massive earthy and calcareous sandstone-conglomerate; while in the Silpiti hills, a mile to the south on the same horizon, the section is entirely made up of strong lumpy limestone and red sandy clays.

In the Moran hills.

The northern range, of which the Silpiti hills are the western termination, is on the line of the northern edge of the Moran plateau. They are only separated by the narrow gorge of the Sáli. The rocks have the same strikes and are in part continuous; but there is a very rapid horizontal change from the earthy and calcareous beds of Silpiti into sandstone on the west. From Sáli to Lokartalái there is a well-defined scarped edge of conglomerates and sandstone, which spread southwards in irregular ridges for the whole width of the basin, up to the boundary of the traps. There can be no doubt that the northern portion of the plateau, for an unknown width, belongs to the Bágrá group.

Section 4.—(*c*). The Dénwá group.

Nothing was said in the last section about the lower boundary of the Bágrá group, with the Dénwá group. As with the upper boundary, it is only locally well defined.

Its extension.

There is a very marked contrast in the *facies* of the two groups, but, owing to the variable nature of the deposits of the upper one, somewhat similar beds sometimes occur at the junction. Nothing like unconformity, unless as overlap, can be made out. Throughout the greater part of the longitudinal course of the Dénwá, where it runs westward along the north base of the Pachmari range, the valley is excavated in thick beds of pale greenish yellow and bright red mottled clays, with discontinuous and subordinate bands of white sandstone, and very rare courses of limestone. This valley is continuous eastward with the wide transverse valley of the Dudhi, the whole of the low ground being occupied by the same clays. In the longitudinal valley the width of the outcrop is from two to four miles; but on the Dudhi it ranges from the boundary of the metamorphics at Dorli, to where the river cuts the prolongation of the Pachmari sandstone south of Bamni, a distance of fourteen miles. From Karpapúr on the Dénwá these beds extend to the western scarp of the Sítárívá hills, forty-five miles; or perhaps the red mottled clay and limestone in the bottom of the Sítárívá valley at Bíchla should be taken as the most easterly appearance of the group.

As a rule, the Dénwá beds are overlapped along the boundary of the basin; but there are at least two places where they are seen at or close to it. This is the case in the Dudhi; and again twenty-five miles to westward, near Anhoni, where a bay has been weathered back into the Bágrá beds, the red clays and white sandstones are typically exposed in the low ground, in contact with the Talchírs. This occasional appearance of the lowest group of the whole series, in this position, is a source of much difficulty; the fine yellow clays of the Dénwá and the Talchír groups being scarcely distinguishable.

Its northern outcrops.

An instance of this difficulty occurs at the obscure outcrops at the edge of the plains in the troubled ground to the west of the Sítárívá coal-field; in the stream above Pawaria there are some small crops of clay and limestone traversed by several trap-dykes, and provisionally mapped as Dénwá beds; and so also are the flaggy ripple-marked sandstones quarried near Kaklaur.

Boundary sections in the Dudhi and Dénwá valleys.

On the south the boundary of the group is for the most part well defined, where the clays lap up upon the unbroken sandstone of the Pachmaris, as at Moár on the Dénwá, a mile to east of Singanáma. But some obscurity on this score also will be noticed in connection with the older group. There are many good sections of the junction with the Bágrá group: in the under-cliff of the western scarp of the Sítárívá hills, north-east of Budi, a massive bed of conglomeritic sandstone rests upon some 80 feet thick of fine pale yellow clay; again at the south-east base of the Kámpti hill; at Nagarpúra on the Dudhi; north of Tikapár, two miles from the Dénwá. Locally the bands of sandstone intercalated with the clays are of considerable thickness, and sometimes conglomeritic, as along the north bank of the Dénwá, west of Matkúli; and generally at the base of the group, near the Pachmari sandstone, as north of Singanáma.

Western limit unsettled.

The Dénwá group has not been clearly made out to the west of Karpapúr, where the river cuts its gorge through a depressed area of the Bágrá beds. The region is one of special disturbance, as will be presently noticed, involving a confusion of similar deposits. But it is certain that the group does not extend much farther; it probably in part thins out, and partly becomes assimilated to the base of the Bágrá group. In the Sáli section no division can be made in the clays and limestones resting on the Pachmari sandstone and those forming the Silpiti hills to the north of it.

Section 5.—(*d*). Pachmari group.

Its extension.

This group is for the most part the simplest and best defined of the whole series. Consisting entirely of massive banks of sandstone with overlapping superposition among themselves, it is generally in sharp contact with clay deposits on the north, and with shaly carbonaceous beds at its base on the south. There is, however, sufficient evidence of its close relationship to the beds above and below it; that it is but a sub-division of a continuous series of deposits. It measures twelve miles across where widest, in about the exact centre of the basin. For the greater part of this distance, on the north side, there is a steady dip of 10°, flattening somewhat on the rise. This gives a thickness of at least 8,000 feet. As the southern cliffs become worn back to east and west of the central line, the dip produces a decreasing elevation of the range, and also of the lower boundary of the group. At Rorighát and Almód, in the central position, the underlying shales, of (*e*), crop out at a height of about 2,500 feet, and some 700 feet over the gorges of the Dénwá and Sonbudra. At twelve miles to east-north-east, where the Dénwá begins to cut through the range, the base of the sandstone is at the level of the river. The group is here reduced to seven miles in width, and throughout the gorge there is a steady northerly dip of at least 10° in unbroken sandstone, giving a thickness of 6,000 feet. Similarly at fourteen miles to the west, the Sonbudra cuts a gorge four miles long, giving a thickness of 3,500 feet; and fifteen miles further west, the Táwá cuts a straight gorge of two miles through the same inclined sandstones, giving a thickness of 1,700 feet.

Its prolongation in depth.

The interesting stratigraphical question suggests itself, what may be the prolongation to the deep of this great band of hard rock? It is a point of critical importance, as bearing upon the possibility of working the coal which may be presumed to occur beneath all these formations near the bottom of the basin. A leading fact in this discussion has already been given, when it was shown that the northern boundary of the basin is not a fault, but an edge of deposition more or less steeply shelving: along that edge there is no outcrop of the Pachmari group; it has been throughout overlapped by the younger deposits. The massive banked structure of the Pachmari sandstone lends itself readily to this supposition of a rapid dying out to the deep. There is, however, some direct confirmation of these inferences. At some three miles to the east of the Táwá there is a broad area of special disturbance, where the steady scarped ridge of the Pachmari sandstone is quite broken up. Local wedge-like ridges of rock occur irregularly in the position of the ridge, trap being profusely protruded between them; but at many places, on all sides of these remnants of the sandstone, one finds thick beds of pale, greenish, yellow and bright red clays, exactly like those of the Dénwá group. The relation of these to the sandstone is better seen a little to the east, where the disturbance is not so great, in the deeply cut valleys on the north of the range, west of the Sonbudra. In the bottom of the longitudinal valleys one finds the clays in force; and in the cliffed end of the valley these bands are seen dying out on the rise, the sandstone that overlies them below passing up into an unbroken transverse ridge of the Pachmari rock. Thus it would seem that at no great depth from the actual northern base of the range, the layers of the sandstone-band die out between clay beds, being there transitionally blended with the base of the Dénwá group. It is thus possible that some of the beds of red and pale greenish brown clays mentioned as appearing at the main boundary west of Anhoni, may be on the Pachmari horizon; but it is far more likely that they are upper beds belonging to the Dénwá group.

Its extinction westwards.

The longitudinal extension of the group is also a question of stratigraphical interest; and the case is pretty clear for the west end of the field. A few miles west of the Táwá, where the Hosungabad and Bétul road enters upon the Táwá valley, there is much crushing, denudation, and concealment of the rocks. But beyond this again the Pachmari sandstone is typically developed, although greatly reduced in thickness, in a short longitudinal range abutting against the transverse scarp of the Moran hills. This scarp is much higher than that range, and it has already been described (in Section 3) as composed of a southern extension of the Bágrá beds. There is a narrow gorge, formed by a tributary of the Sáli stream, separating the small longitudinal range from the transverse scarp. Some strong trap dykes along this gorge effectually conceal the exact mode of junction of the two sandstones, at the same time indicating the line of fracture or of flexure connected with the abrupt change of feature. But to the south of the longitudinal range, along the base of the Moran scarp, a little flanking ridge of distinctive Pachmari sandstone occurs for about a mile. The rock has a westerly dip of 20°, the same as that in the scarp. The whole band gradually dies out to the south, the beds that underlie it northwards passing beyond it southwards into contact with the sandstones of the Moran scarp. It is a clear case of transverse overlap within the general basin of deposition; and it seems most likely that within a very short distance, the Pachmari group tails out to nothing beneath the Moran hills.

Its eastern extension.

The eastern continuation of the Pachmari group is less definite than the western; and it has not yet been followed out into the very broken ground of the upper Dudhi. Very shortly to east of the Dénwá, it altogether loses its scarped features. Two easy tracks (one of them fit for carts) cross it to north-by-west and north-north-east from Delakári. On both of these, and more frequently on the eastern one, red clays occur in the valleys between the flat ridges of sandstone. It would even seem that the upper portion of the group thus passes along the strike into the lower beds of the Dénwá group in the upper part of the Dudhi section, about Kosmi. Along the base of the group, on the south, there is here a marked easterly and east-by-south bend in the strike; and thus a recognisable band of Pachmari sandstone sweeps across the upper Dénwá valley towards the Motúr range. To the east of the Dosawáni ghât, there are cliffed buttresses and spurs of massive sandstone projecting beyond the normal run of the range to westwards, and quite altering its aspect. They would seem to be outliers and, more to the east, a continuous extension of the Pachmari rock, resting against the Motúr beds, and thus overlapping the intermediate beds (*e*) of the Sonbudra region.

Section 6.—(*e*). The Bijori horizon (Damúda).

Conjectural indications of sub-divisions.

It has been already stated that only a very cursory notice can now be given of the infra-Pachmari groups. It is not unlikely that several sub-divisions may be made in those rocks; I will here only indicate in a general way the Motúr beds, and a considerable thickness of strata occurring between them and the Pachmari sandstone on the central section. A short way to the south-west of Pachmari, about the high-level villages of Rorighát and Almód, there are some beds of sandy micaceous shale, locally carbonaceous and with faint plant-impressions, immediately underlying the cliffs of massive sandstone. In the deep gorge to the west of Rorighát, there is a thick band of highly carbonaceous shale; and again to the east of Almód, in the low ground near Bijori, there is a similar band, possibly the same, both being several hundred feet below the Almód beds.

The *Archegosaurus* band at Bijori.

It was in this lower band, at the crossing of a stream on the bullock-road to Almód, about a mile to south-west of Bijori, that the *Archegosaurus* was found; in honor of which I will speak of this as the Bijori horizon. Associated with all these carbonaceous beds there are massive sandstones, very similar to the Pachmari rock; the northerly dip being maintained throughout. Beds of the same description occupy the ground to the south as far as the Bichberi valley.

Its extinction to east and west.

The longitudinal extension of these beds seems very limited. In a complete cross-section on their strike, in the Delakári stream and the Dénwá, only seven miles to the east of Bijori, there is no specific representative of the carbonaceous band; only a succession of thick soft sandstones with a few subordinate layers of brown and red clay, with occasional faint carbonaceous markings. One of these immediately and conformably underlies the cliff of typical Pachmari sandstone at the entrance to the gorge of the Dénwá.

north-north-easterly dip is constant on this section. To the west a similar interchange takes place. In the Málni stream, close to its junction with the Táwá, and exactly in the position of the Bijori carbonaceous band, there is a run of earthy beds, bright red, dull purplish, greenish brown, and dark gray micaceous, with plant marks. Still further west, the bright red mottled clay is the only earthy rock subordinate to the sandstone, at Saikót, Kesla, and Khoda; the north-north-westerly dip being steady everywhere. The bright red clay with cherty limestone found in the under-cliff of the Moran hills, as about Chikwáni, may belong to this horizon.

Thus it would seem that the carbonaceous element is almost confined to the central region of this horizon, where red clays are rare. But I nowhere found any coaly matter. The thickness of these deposits diminishes greatly on either side of the central region.

Section 7.—(*f*). The Motúr horizon.

Its character in central region.

In the descending section on the central line, highly coloured clays become frequent in the Motúr horizon. There is a thick band of red mottled clay in the river near Bichberi. Again, in the deep valley in the Motúr ridge, under Gorah village, there is a 15-feet bed of red and greenish brown clay, dip 10° to north. Higher up, on left bank of stream, a 2-feet bed of carbonaceous shale with obscure fossils, rests upon a thick mass of greenish brown clay, all dipping at 15° to north. The reverse dip of the Motúr anticlinal occurs a little to the south of Gorah, and lasts to near Kánglá, the northerly dip being again steady from Kánglá to near the boundary; red clays appearing frequently between the bands of sandstone.

Red clays predominate to eastwards.

To east of the main section, in the Pénch valley, these red clays are in great force immediately overlying the coal-measures (*h*); both groups passing, along the strike, under the trap. On the central section the coal-measures seem to be overlapped; at least, they were not observed. The Talchírs, however, are well exposed, much crushed near the boundary, but soon steadying to the northerly dip.

Obscure characters to westwards.

The western extension of the Motúr rocks presents the same difficulties as that of the Bijori set. In the flat ground of the upper Táwá valley the coal-measures are overlaid by an immense thickness of sandstone, with very rare earthy partings; still the northerly dip is steady, on the strike of the Motúr band, and it is presumable that the petrological differences are only local variations of cotemporaneous deposits.

Section 8.—(*g*). The Barákar group (coal-measures).

There is nothing at present to be added to our information of this most important group. The detailed work has been as yet confined to the northern region; and it is so far settled that (as shown in the first report on this district) the Sítárívá coal-field near Mopáni (upon which there are reports recently published), is the only outcrop of the measures on the north side of the basin; and also that the only other outcrops of this group are along the south edge of the basin, on the upper Táwá and its tributaries, and in the Kánhán and Pénch valleys. The group seems to be not more than 400 to 500 feet thick. The appearance of the measures on both sides of the basin gives direct presumption of its continuation beneath; and this is supported by the analogy of other basins. The important point as to what depth it may be found at will be noticed in a subsequent section.

Section 9.—(*h*). The Talchír group.

This group also is too familiar to require much notice. Its greenish and pinkish earthy sandstones and fine silt-beds, with its characteristic glacial boulders, are alike everywhere. They occur continuously along the southern boundary; but on the north they are only found at isolated spots. Omitting the doubtful occurrence at Sehora, on the Shér, the most easterly of these outcrops is Nibhora; some green silt with boulders is obscurely seen where the run of schists ends, and is rapidly overlapped by the Bágrá red clays and conglomerates. On the Sítárívá the Talchírs are well exposed in the centre of the denuded anticlinal flexure, passing up conformably on both sides into the Barákar beds. In the gorge of the Anjan, a mile and a half above Fatehpúr, there is a small inlier of Talchírs; here, too, they are connected with a flexure. A mile further down stream there is a ridge of schists protruding through the conglomerates without any intervening Talchírs. Three miles further west, about Bargóndi and in the Amádi stream, there is a large irregular patch of Talchírs; on the north-north-west the beds are crushed against the steep base of the ridge of metamorphics, and elsewhere are flatly overlaid by the Bágrá beds. This area is only separated by about a mile of overlapping conglomerate from a much larger spread of Talchírs in the neighbourhood of Anhóni. On the east it wraps round the broad irregular base of the metamorphic ridge; along the northern side it is open to the plains, the rock in contact being trap. In this area, especially near the ridge of schists, the prevailing color of the Talchír clay is a dull purple.

Section 10.—Boundaries.

The north boundary: its general features.

In describing the Jabalpúr and Bágrá groups as they appear along the north edge of the basin, the general characters of the boundary have been noticed: how, at many places and for considerable lengths, conglomeritic sedimentary rocks are steeply banked against narrow fringing ridges, or rest upon the edges of low reefs, of metamorphics; both, it is perfectly plain, in their original relative positions. The question thus presents itself—are these metamorphics the remnants of spurs, or headlands, of a once continuous and elevated area of these rocks in the position of the present Narbadá valley? or are they only a chain of islands or hills forming, indeed, the original general limit of the actual basin of sedimentary rocks, but through and beyond which these rocks formerly extended indefinitely over the position of the present valley?

Possible extension in the Narbadá valley.

The direct evidence for the discussion of this question is wanting. The only rocks that do show under the old alluvial deposits of the valley are metamorphics; but there is a very large area, and precisely in front of the coal-basin, where the subjacents have not been observed; so that we are left to more indirect argument. There are some presumptive difficulties that cannot be ignored in approaching this question: supposing the present bounding ridges to be remnants of a former main-land of metamorphics, how to account for the removal of such a prominent mass of the fundamental rock—the actual reversal of the orographical features—the conversion of what must then have been an area of water-shed into what is now the main water-way. The analogy of other parts of India adds much to the force of this objection; for it is there very remarkable how generally the main actual drainage-depressions correspond with the basins of the coal-bearing sedimentaries. From this point of view, therefore, it would seem probable, that no mountainous mass of metamorphics occupied the ground to the north of the present boundary at the time of deposition; that the Vindhyan scarp on the north side of the Narbadá valley was then, as now, the water-shed of the basin; that shallow extensions of the deposits existed, and that remnants of them may now exist, within the Narbadá valley proper. Some confirmation of this view may be found in the fact that the arrangement of the groups in the main basin suggests their accumulation from the south; if, as is now generally considered, they are to be looked upon as pluvial, fluviatile, and lacustrine deposits. If, indeed, the action of general faulting is to be taken into account for the disappearance of the supposed main-land, it must, for reasons already given when describing the border groups, be placed beyond the line of any actual junction seen, outside the fringing ridges of metamorphic rocks; and it would, from the point of view now under notice—the actual low ground to the north of the field—require to be a great downthrow on the north, instead of on the south, as was at one time conjectured.

Characters of the boundary east of the Sakar.

There are structural features at the boundary that may be interpreted in support of either of the foregoing suppositions respectively—the former extension or non-extension of the deposits. The overlapping boundary at Jabalpúr is the most distinct case that occurs of the sedimentaries stretching, continuously and undisturbed, between and almost beyond the fringing ridges of the metamorphics, and there becoming lost under the alluvium. From here to the Sakar, to west of which the special features of the Sátpúrá basin are first noticeable, the gaps in the metamorphic rocks are very narrow. The region of the Shér lies between the two large patches of schists of Srinagar and Kishanpúr; and the boundary in the interval projects beyond its position on the south flanks of those rock-masses, apparently corresponding to an original depressed inflection of the edge of the basin. At places, too, as at Bachái, the sedimentaries present a steep edge facing the plains. Still within very short distances there are low outcrops of the schists at the base; and they occur at the lowest points in the main rivers, the Narbadá, the Shér, and the Sakar; so that, if the sedimentaries occur to the north, it must be as outliers. The local disturbances of the deposits in this eastern region are very trifling, and are not specially exhibited near the main boundary. The only fact here to suggest a rapid original stopping out of the sedimentaries near the actual boundary is the occurrence of massive coarse conglomerates in the cliffs over Bachái, at the most advanced point. Such deposits as these are never found unless along the boundary; and independently they would indicate shore-deposits on the supposition of a water-basin, or torrential accumulations if these rocks are of diluvial origin; in either case implying the immediate proximity of an area of denudation.

Blank boundary in the Sítárívá region.

If the last argument is to carry much weight—and it is not easy to see how it can be made light of—there is a strong case for the present boundary being very approximately at the original limits of the deposits. The longest stretch of boundary without any appearance of the metamorphics is for sixteen miles between Nibhora, the west end of the Kishanpúr ridge, and Deori, the east point of the next metamorphic ridge; yet nowhere in the whole field are the conglomerates so coarse and so massive. The Sítárívá flows from the hills in the centre of this blank boundary. To the east of the river the thick banks of conglomerate are undisturbed, presenting sheer cliffs to the plains, on a line with the northern base of the adjoining metamorphic ridges.

Contortion at the boundary on the Sítárívá.

At and west of the Sítárívá, these same beds exhibit the most remarkable instance of intense local disturbance that occurs in the whole field. There is a full section of it in the river-bed. It is a 'normal' anticlinal flexure; the beds on the north of the axis-plane being quite vertical. The feature is attended with considerable elevation, Barákar and Talchír beds being well exposed in the centre of the flexure; to which is owing the outcrop of the Sítárívá coal-field. The last beds seen in the river are massive coarse conglomerates, quite vertical; and this, too, is nearly on a line with the outer fringe of the metamorphics. The anticlinal flattens rapidly to the east, obliquely to the general strike of the rocks: in the most northerly outcrop seen, at Pakuhi, on the run of the outermost beds in the Sítárívá, and only one and a half miles to east, the dip is south-easterly.

What it may signify.

The fact of special disturbance along the boundary conveys as positive an indication, as does the presence of peculiar deposits, that the present limit to the extension of the sedimentaries at this blank boundary is not due merely to denudation—that the deposits were especially affected by other rocks in this position; but it leaves it an open question whether this were due to original conditions or to subsequent faulting. The coincidence of the evidence from the composition of the rocks gives, of course, a presumption in favor of the former supposition; in accordance with which view a figured section was given in my report on this coal-field at page 65, Vol. iii, of the Records, Geological Survey. Whatever the structure may be in the concealed ground to the north of the exposed section, the flexure we see would be fully accounted for by simple compression; and it necessarily implies compression whatever other effects may have been associated with this. Any argument for faulting must, therefore, be purely conjectural, there being no direct evidence whatever. If, however, the feature is to any dominant extent due to faulting, and if the flexure seen continues up to the fault, this form of contortion would suggest a downthrow to the north, the edges of the broken beds on the south being turned down along the direction of relative motion. But a downthrow to the north, unless succeeded by an upthrow of greater amount, would, unless the fault had occurred along a bank of deposition, imply the present existence, to the north of the fault, of a more complete, at least, a less denuded, series of the sedimentaries than to the south; and for or against this, direct evidence is wanting. If then a fault does exist, it must be beyond the limits of any observable junction; and the introduction of it there would be rather gratuitous, a complication rather than a simplification of the observed facts, whether the downthrow be assumed to occur on the north or on the south.

Change of features to east of the Sítárívá.

The very marked contrast of the structural features to the west and to the east of the Sítárívá, along the same reach of blank boundary, seems puzzling; but there are facts to suggest an explanation of this. At about a mile to the south of the undisturbed portion of the boundary, there is, south of Ránidhá, a region of local disturbance to which there is nothing to correspond in the same position on the Sítárívá. It is thus apparent that the compression, which on the west took effect close to the boundary, operated on the east at some distance from the boundary; suggesting simply variations in depth of the sedimentary basin—that the consolidated base-rocks lie at no great depth beneath the undisturbed conglomerates to the east of the Sítárívá, thus throwing the contortion further into the basin, while on the west there must have been (as the upfold of the bottom groups declares) a considerable depth of sedimentaries close to the boundary.

Outcrop at Jhiria, north of the ridge of metamorphics.

There is, however, one observation to show that the little ridges of metamorphics were to a great extent detached from any main upland of these rocks that may have existed as a general limit to the main sedimentary basin. The ridge of limestone and hornstone west of Deori attains a considerable elevation. At its middle and highest point, the Dudhi passes directly across it through a precipitous gorge. It is one of those tell-tale features of river-formation, pointing to a state of the surface very different from the actual one. To west of the Dudhi, on the south, the conglomerates lap up against the ridge, forming a scarp on the north front. But close to the north base of the ridge, in the stream beds both on the east and west of the village of Jhiria, there are small but unmistakeable outcrops of the bright red mottled clay, either of the Bágrá or the Dénwá group, confusedly associated with trap. If this occurrence were to be much insisted on, as possibly an indication of a former extensive deposit of the same kind, it would negative the supposition of an elevated mass of metamorphics in immediate connection with the existing ridges. If, on the other hand, this supposition be adopted, the clays at Jhiria would have to be regarded as originally local deposits in a sheltered valley.

Section on the Anjan.

In the Anjan at Fatehpúr there is a very important section of the boundary (see fig. 2), ten miles to west of the outcrops at Jhiria. About a mile above the town a nose of metamorphics projects into the river on the right bank. It is the termination of the Bagráj and Deori ridge. The Bágrá conglomerates have a quâquâversal dip from it. The north-north-westerly dip, down stream from the ridge, is reversed, forming a flat symmetrical synclinal; and then, just below the town, there is a sharp normal anticlinal, the dip rapidly rising to an angle of 70°, to north-30°-west, where the section ends; bedded trap rocks appearing a few yards lower down. Corresponding sections are seen along the boundary in the small streams to east and west of the Anjan. Structurally, this normal anticlinal with its axis-plane dipping southwards is a repetition of the Sítárívá section; and it may be taken as a type of the northern boundary of the Sátpúrá basin, when these stratified rocks come clearly to the front.

What it may signify.

The question again arises, what does this structure indicate, and what rocks may we infer from it to exist in the concealed ground to the north, beneath the trap and the alluvium? In discussing the Sítárívá section it was said that the flexure, as such, only implied compression; but it may well be objected, that a constant form of flexure implies some special determining cause besides the presence of a steep face of hard rock bounding a deep accumulation of newer deposits. This objection may be fortified by the remark, that along the inner face of the existing ridges of metamorphics, from which the general compression was communicated to the contiguous deposits, this structure does not obtain, as has already been exhibited in several sections, and as will be further illustrated. The *primâ facie* explanation would certainly be a fault with a down-throw on the north. But in a possibly analogous case in another geological field,* it was found, that such a structure had to be accounted for by the tilting tendency accompanying the action of compression, and specialized along the line of junction; in this case having a set to depression on the north of the boundary, and thus determining an anticlinal bend in the yielding rocks near the boundary. If the analogy here suggested were rigidly applied, this 'set' would imply the sinking of an elevated mass on the north of the boundary; but this is not a necessary condition.

Relation to the ridges of metamorphics.

This section on the Anjan differs from that in the Sítárívá, in that it shows what takes place outside (to the north of) the fringing ridges of metamorphics. The trend of these rocks does not run strictly parallel to the general boundary of the basin; it is more oblique to the line of latitude. The point above Fatehpúr is the termination of the Bagráj and Deori ridge. At three miles to the west of the Anjan, on the strike of the boundary, another ridge commences at Pindrai; disappearing in its turn to the west-south-west, near Anhóni. To the north of the metamorphic ridge in the Anjan, the strata are less conglomeritic than those to the south, the uppermost beds at the boundary being earthy sandstone and clays. As already suggested in the case of the clays at Jhiria, this may be accounted for by deposition in a more sheltered position; but it equally suggests the indefinite spread of the deposits northwards, beyond the present

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* See Mem. Geol. Sur., India, Vol. III, Part 2, page 110.

blank boundary. The section of the Anjan is also interesting for the appearance of the Talchírs so far within the boundary, about one mile from the point of the metamorphic ridge. At first sight, there would seem to be an extremely unconformable junction of strong conglomerates upon crushed Talchír boulder-clay; but in the Pátpáni branch of the river there is a section showing, on the south of the inlier, some thinner earthy beds of the Bágrá group; and these fully partake in the local contortion. It is a good instance of the very deceptive appearance produced by disturbance upon contiguous conformable strata of very different resisting power. There is nothing to suggest that there is much elevation connected with the appearance of the Talchírs at this local anticlinal. The absence of the Barákars over them rather suggests that there was here an originally elevated extension of the bottom group.

Section in the Amádi stream.

Three miles to the west of the Anjan, the Dévi ridge of metamorphics forms the boundary for six miles, running west-35°-south, somewhat oblique to the general strike. Along the inner (south-east) base the Talchírs are largely exposed; and in the Amádi stream there is an excellent section, showing on the south a slightly disturbed junction with the Bágrá beds, and, close by, the effects of concentrated compression near the boundary (see fig. 3). The first contact is about 600 yards from the ridge; bright mottled coarse conglomeritic sandstones rest upon a slightly denuded edge of Talchír boulder-clay, the dip in both rocks being about 15° to the south. At fifty yards down stream a strong dyke or thick sheet of trap rises at a very low angle from the south, scarcely tilting the Talchír beds at the contact. The outcrop of the trap is about twenty yards wide, the northern edge seeming to rise steeply; and at a few feet from it, sandstone conglomerates have a dip of 65° towards the trap. There are only about 60 feet of the sandstone, the same beds apparently as at the upper junction; and they are here again underlaid by parallel beds of the Talchír clays, the boulder bed amongst them.

These become greatly crushed near the base of the ridge, and are there cut by a thin dyke, the end of a very strong dyke to eastward. Here again we have an instance of excessive local contortion in thinner and softer beds underlying very massive strata of the same series: at half a mile to the west of this section, the upper coarser conglomerates lap over against the ridge; and in them the main trap of the section seems to die out or to be very thin, coming in again in force in the Talchírs of the valley to west. The section in the figure involves the supposition of a local fault at the north edge of the main dyke.

The Anhóni region.

No rock of the sedimentary series is exposed along the north base of the Dévi ridge, the western end of which expands into an irregular mass nearly two miles wide. Talchír clays are well exposed at the southern and eastern base of this hill. In the former position they are intensely crushed, as always in such positions, at right angles to the general strike. In the broad spread of the same beds to the west, on the run of the ridge, the strata are flatly undulating; having near the ridge a low westerly dip from it. Anhóni is in the centre of this area. It would seem that here the rocks were protected from compression by the proximity of the hard supporting rock; the contortion being concentrated at the two boundaries of the Talchír outcrop, one on the north, which is the main boundary of the basin, and one on the south with the Máhádévá rocks (see fig. 4). Both these junctions deserve separate notice.

Inner (southern) boundary of the Talchírs in the Anhóni region.

All along the junction of the Bágrá group with the Talchírs here, for at least eight miles, there is much disturbance, with profuse intrusion of trap. The eruptive rock seems to have come up along the northern limb of a broken synclinal, appearing under and between highly tilted beds of the strong conglomeritic sandstone; the Talchírs on the north being greatly crushed. At a bend in the Ghogra, south of Dévi hill, there is a fault well seen at this boundary; the Talchírs being nearly vertical, with the Bágrá beds sloping from them at a low undulating dip, a thin dyke locally occupying the fault. It is at the edge of one of the branches of the complex dyke along this boundary that the hot springs occur south of Anhóni (Unhonee). The feature, on the whole, suggests a rapid southernly thickening and settlement of the deposits close to the edge of the basin. North of this boundary, the Talchírs quickly assume a low dip and are even horizontal for some length. At a mile down the Kúkúrkhodi stream, to west of it at a bend, the clays rest against a small low inlier of metamorphics, within half a mile of the main boundary.

Main boundary in the Anhóni region.

The main boundary here, in the bay of Anhóni, the Talchírs being the group at the contact, presents two features that have been already noticed in this position; namely, special disturbance, and the occurrence of trap in force as the contact-rock; and both are difficult of interpretation. In the soft Talchír strata the feature of disturbance does not present the constant form of a steep normal anticlinal, as seen in the harder rocks of the upper groups. Here the high underlie is sometimes from, sometimes towards, the boundary. The suppositions suggested in explanation of this special disturbance were—the original presence of a mass of metamorphic rocks, subsequently removed by denudation, or, a general fault throwing down the rocks, whatever they were, on the north. A leading difficulty in both cases is, how all subsequent denudation should have just worked up to this ancient line of disturbance, leaving it intact at so many points. In the section described in the Anjan the mode of contact of the trap is not seen. In the Sítárívá, trap does not appear outside the boundary, being probably only covered by the superficial deposits. There was the further reason for ignoring the trap in the discussion of the boundary to the east, in the fact (to be shown presently) that its eruption was of later date than the main disturbance, and the main denudation, of the sedimentary rocks. But in the Anhóni region it seems impossible to separate a connection of the trap with a disturbance of the rock in contact. In several streams here the contact is pretty well seen: the plane of junction is always steep, sometimes even overhanging; and the trap in contact being massive and dense, the feature has the appearance of a strong dyke along the boundary. But this may be deceptive; it may only be an accumulation of hard trap against a steep edge of the clays. At all events, this massive rock is continuous down stream with well-bedded volcanic rocks of various textures, compact, vesicular and earthy, all having a very gentle northerly slope, and capped by a bed of rock-laterite at Ghúgri, two miles from the boundary. This section is itself sufficient proof of the fact just stated—that the trap is subsequent to the denudation of the coal-series, when even the Narbadá valley was lower than it is now; but the question before us is, the relation of the actual boundary to an original limit of deposition or to one induced by general faulting. Whatever may be the case elsewhere, it would seem that the boundary here was determined by pre-trappean denudation; and that the crushing along it was induced by the trap either at the time of its eruption, or, as is more likely, by some subsequent compression, when this whole country was overlaid by many hundred feet of the eruptive rock. To attribute the present crushing in the Talchír clays along this line to action at a former primitive boundary with metamorphics would be very far-fetched and untenable; and equally so, and for the same reason, to connect it with a pre-trappean faulting. Against this latter supposition there is the additional objection of abrupt irregularity of direction—the contact in the next stream, a short distance to east of the Kúkúrkhodi, is a mile more to the north; and the northern promontory of Dévi hill is again considerably in advance of this.

West of Anhóni, to Sáli.

To the west of the Anhóni bay, the metamorphics are again in force. From south of Sohágpúr to Lokartalái the outer base of the hills is very regular, the crystalline rocks appearing at intervals for the whole way; at first forming low hills against and upon which, on the south, the Bágrá beds rest along an irregular line; but from Sáli to Lokartalái the sandstone series forms the scarp, the crystallines being only obscurely seen at the very base. None of this western portion has yet been worked in detail; but at the few points examined there is again found the structure that has been so repeatedly noticed at the boundary. In the Sáli glen, the strata for some distance from the boundary have a low dip towards it, increasing to 20° near it, terminating in a steep face, not a dip, of 70°, very like a fault-surface. Close in front of this, ribs of metamorphic limestone and hornstone weather out through trap. Whether the trap occurs as dykes or as overflow was not determined.

North base of Moran hills.

Five miles to the west of Sáli, along the base of the scarp of the Moran hills, east and south of Jondal, the sandstone and clay conglomerates have a moderate dip to southwards; but immediately at the boundary they have a crushed dip of 70° to northwards; and here, too, one finds local outcrops of gneiss where the trap has been removed, close to the base of the scarp. Again, near Dopalwára, the fine sandstones extensively quarried at the base of the scarp have a moderate northerly dip towards the trap in the lower ground.

Indications from the boundary in the western region.

It would simplify matters very much to attribute the special crushing along this boundary of the Moran hills to post-trappean disturbance—at a steep contact of trap with a denuded edge of the sedimentaries, as in the case of the Anhóni area. This would, of course, leave the question of the original extension of the sedimentaries quite untouched; giving rather a presumption in favor of their spread over the area of the present Narbadá valley. Or, if we attribute the present features of the boundary to pre-trappean faulting along this line, and take the form of the contortion as indicating a downthrow on the north, we might also infer the former indefinite extension of the deposits and their present existence beneath the valley. The remaining supposition—of an original upland of metamorphic rocks at which the deposits stopped, and against which they were crushed at the time of the main disturbance, the said rocks being subsequently removed by denudation, or let down by a fault—would exclude the consideration of northern outliers of the coal-rocks. The special lithological evidence in support of this latter position, as noticed in the blank section of the Sítárívá region, is found also in the Moran hills—coarse conglomerates are frequent in the scarp: and this fact is too weighty to be altogether set aside. There are great difficulties in the way of the supposition that the whole area of the Narbadá valley was occupied by a continuous upland of metamorphics; but it is almost necessary to suppose that there were extensive patches of these rocks, between which the coal-series would of course have extended; and the remnants of such prolongations may still be looked for under the alluvium of the valley.

No decided inference can be drawn upon the nature of the northern boundary.

Under the uncertainty to what extent the disturbance of compression along the boundary may have been post-trappean (for it may have had little or no effect upon the trap itself) one cannot lay much stress upon that feature in arguing upon the relation of the actual to the original boundary, or to a supposed fault, and so draw any decided preference in favor of any one of the suppositions here discussed. They all, however, seem much more likely than the only remaining supposition, that of a fault with an upthrow on the north. Whatever positive evidence exists is adverse to this view; and it would immensely increase the difficulty of accounting for the actual configuration of the ground—the presence of the Narbadá valley in what would thus be an area of upheaval.

South boundary of the Sátpúrá basin.

There is little to be said at present upon the southern boundary of the Sátpúrá basin. As seen in the deeply denuded area of the upper Táwá valley, the very tortuous outline of the boundary manifestly suggests an original line of deposition.

The position of the boundary here lies more to the south than the run of the boundary on the upland, in the region of the Kánhán and the Pénch; so that any great fault there would strike into the basin to the west. The junction on the upland is much concealed by trap; but when seen, as on the Kánhán south of Nandóra, the Talchírs are in force along it. Both here and in the Táwá valley there is often much crushing at the boundary; and within the basin, near and within some miles of the boundary, and parallel to it, there are many small and large ribs of pseudomorphic vein-quartz. This is identical with the rock so often assumed as 'fault-rock'; but it is remarkable here that this rock is not found at the contact, even where most steep; nor is there any sign of it in the well-exposed fault throwing up the coal in the Pénch river near Chenda. And at these ribs themselves there is no sign of special contortion or shifting, although the contiguous rock is often splintered and ramified with quartz.

The whole structure of the rock-basin suggests that there was a general rise of the ground to the south, probably at the time of the general disturbance of the strata; but there is as yet no sufficient evidence that this was attended by general faulting at the boundary.

SECTION 11.—DECCAN TRAP.

Use of the word *trap*.

With the most profound respect for the labors of those who are endeavouring to establish some order in the nomenclature of eruptive rocks, and to ascertain what geological significance may attach to their leading types, it seems necessary to enter a protest against their too sweeping condemnation of a term in familiar use. Whatever success may ultimately reward such researches, it is pretty certain we can never dispense with so convenient a term as *trap*, in the sense at present attached to it. However convinced we may be *á priori* that eruptive rocks in their composition and texture do bear the stamp of the conditions to which they owe their origin, we must not be too hasty to adopt the systems elaborated from the very imperfect information we possess upon this most obscure subject. Geologists will ever object to the introduction of distinct names for identical rocks differing only in the age of their eruption, as has been proposed by some distinguished vulcanists. The word 'trap' has been objected to by too exclusive classifiers as unscientific, because clubbing together rocks of very different aspect, age, and mode of occurrence. It is with full knowledge and due appreciation of all these important distinctions that geologists adhere to the general term 'trap' to denote all lava-oid rocks, whether intrusive or overflowing—those rocks which from their complete analogy with the ejections of actual volcanoes we know certainly to be of igneous origin. It would be as reasonable to object to the use of the word sandstone; nay more so, for the several types of sandstone do convey definite information regarding the nature of the conditions of deposition, whereas we are very far from having like certain information regarding the products of eruption. Yet there is no ambiguity in the use of the word sandstone. It would rather be convenient if we had a short term to stand for *sedimentary rock*, as *trap* does for the products of bygone eruptive action. The object of this paper being purely stratigraphical, it is sufficient to notice that the trap here is of the basaltic family.

It was at one time thought that there were two or more periods of trappean intrusion in the sedimentary series of the Sátpúrá basin. The re-distribution of the several groups goes far to invalidate the evidence upon which that conjecture rested, as one finds dykes nowhere so abundant as in the Jabalpúr and Upper Máhádévá groups. There are, no doubt, cases of dykes in a lower group that cannot be traced in the overlying beds close by; such is the third dyke in the Sítárívá section, which is strong and apparently steady in the Talchírs, but no sign of which is traceable in the coal-mines at a quarter of a mile to eastward and directly on the run of the dyke. In every such case, however, where the dyke can be traced to its termination, it is seen that its disappearance is due to obstruction in the upper rock, and not to denudation during interrupted deposition. There is a very pretty section of this kind in the Ránidhá stream just above the village of Dongarkho; a dyke twenty yards wide at the base of the section is entirely stopped out in a number of wedge-like tongues, within a height of 15 feet, by a massive bank of conglomerate; the rock under the conglomerate is not exposed.

All the trap of one period.

That all the intrusive trap belongs to the period of the Deccan outspread would also seem evident. In many places the dykes are confluent with great overlying masses, becoming lost in them; and sheets of trap intrusive between the sedimentary strata are continuous with the main superficial flows.

Belongs to the Deccan trap.

It is also demonstrable that the sedimentary series had undergone the main disturbance by which it has been affected, and very extensive denudation (probably subsequent to the contortion), before the advent of the igneous rock. The latter fact is apparent everywhere: in the upland valley of Delakári, between the Pachmari and Motúr scarps, there are ranges of low hills formed entirely of overlying trap; again, in the lower valley of the Dudhi there are immense

Later than the main disturbances and denudation of the sedimentaries.

accumulations of trap lying against the scarp of the Sítárívá hills, and in places connected with the rock capping the hills. The fact of great disturbance prior to the trappean period is, of course, not so conspicuously seen, owing to the very partial nature of the disturbance; but there is at least one section placing it beyond doubt. The steep anticlinal flexure in the Sítárívá section is the most remarkable instance of disturbance in the whole sedimentary basin. Close to Mohpáni at the level of the plains, about a mile west of the river, and exactly on the line of contortion, there is a considerable hill, half a mile in diameter, of superficial trap. Crushed Talchír beds are seen close to its eastern base; carbonaceous Barákars pass under it on the west. The section already described (Fig. 4) in the Anhóni region gives good evidence to the same effect; the undisturbed trap-flow at the level of the plains abutting against the Talchírs, shows at least the pre-trappean denudation of the sedimentary series, and suggests that the chief disturbance of the latter must have been of older date. The frequent occurrence of trap along lines of local disturbance, as along the inner junction on the Anhóni section, and conspicuously in the Sítárívá region, only shows that the eruptive rock availed itself of pre-existing lines of fracture.

Distribution of the trap.

The distribution of the trap in the basin is a point of much interest that cannot be fully discussed till the detailed mapping has been completed; but it is sufficiently apparent already that there is a marked concentration of dykes near the northern boundary. It would seem to be somehow connected with the flat synclinal depression that is so general a feature at a short distance from the boundary. It is this circumstance that brings such a preponderance of trap into the topmost groups. There is a noticeable cessation of trappean intrusion in the sandstone east of the Shér river, and to as far as beyond the Máhánadi in South Riwa. This may possibly be a case of negative evidence, owing to the smallness of the areas exposed; but there is also a comparative absence of disturbance along that same narrow outcrop. I am inclined to take both circumstances as an indication of the shallowness of the deposits in this intermediate ground; and so, by implication, to suggest that general contortion of the strata and a profusion of trap may coincide with positions of greatest depth.

Pseudo-interstratification with the upper group.

The peculiar form of pseudo-interstratification assumed by the trappean intrusions is sometimes puzzling. It seems to affect shaly bands between massively bedded rocks, and is most frequent in the upper groups, especially in the Jabalpúrs. When it occurs in disturbed strata, as in the section in Fig. 4, it is intelligible enough; but it is very frequent between sub-horizontal strata. Some examples occur in the Bágrá beds in the hills immediately south-west of Fatehpúr; in the hill east of the Dudhi at Kámpti; and in the flanks of the Báragáon hills in the gorge of the Sítárívá. The most complete examples occur in the Jabalpúr beds, on the horizon of the coaly shales. For several miles along the bed of the Hard, above and below Monighát, trap weathers out from beneath the sandstone within every few score yards, occasionally protruding into connection with masses covering the flanks of the hills. The best single existence is seen on the Machiríva, above the village of Marpiperia; the coaly band forms a flat synclinal, about three-quarters of a mile wide, and on both sides the trap is seen on the river's bank for several score yards regularly underlying the sandstone. This latter rock is visibly affected at the contact, but not broken or tilted, except very locally when the injected rock breaks through to higher or lower levels. The thickness of the sheet cannot be measured; it is at least 20 feet, and it exhibits parallel variations of texture, which add much to its false appearance of cotemporaneous interstratification. This trap is continuous on both sides with a large spread of superficial outflow, and is only separated by a narrow strip of denudation from the main trappean area to the south. The sections do not admit of determining to what part of the trappean period these sheets belong; probably to the close of the eruptive action, when a great mass of tough rock had accumulated on the surface, so as to obstruct the free outflow of later eruptions. But the rock of these intrusions is the same rough dolerite that prevails in the flows on the surface.

The relations I have exhibited between the trap and the sedimentaries imply, according to all usual modes of interpretation, a great lapse of time between the Jabalpúr beds and the advent of the Deccan trap.

Section 12.—Practical and General Conclusions.

Boundaries partially original.

The details given in the foregoing sections seem to warrant the following conclusions upon the stratigraphical features of the Sátpúrá coal-basin. The present outline may be taken to represent approximately the original area of deposition. Along both the north and the south boundaries, natural (unfaulted) contact is the rule at the exposed sections. This does not preclude former overlapping extension of one or more of the groups, possibly connecting this field with others of the same series, over an irregular intervening surface of metamorphic rocks. In the transverse (north-south) direction limitation is also proved by the arrangement of the groups within the basin. East of Delakári, the Pachmari sandstone laps up on the flanks of the Motúr range, overlapping all the beds of the Bijori horizon. The Pachmari sandstone is in its turn altogether overlapped in the Moran hills by the Bágrá beds, the same overlap including the Dénwá group and, to an unknown extent, the Bijori beds, all having thinned out to the west. In the Sítárívá hills, the Bágrá and Dénwá groups, and probably the Pachmaris, are overlapped to the south by the Jabalpúr group.

Several groups limited to the actual area.

Regarding the longitudinal (east and west) limits of the field beneath the trap, we have only the evidence of the lie of the groups within the field; but this points unequivocally to an approach of limiting conditions, or at least to a great contraction and diminished thickness of the deposits. All the middle groups of the series—the beds of the Lower Máhádévá and Upper Damúda horizons—either die out, or are greatly reduced in thickness before reaching the Moran hills; and there dip westward under the Bágrá beds, as they do northward along the northern boundary. At the most westerly appearance of the sedimentaries, near Lokartalái, sandstones, apparently of the Bágrá horizon, pass steadily with a westerly dip, or rather a flat sloping anticlinal, under the trap. Similar indications occur to the east; there is a very marked change in strike of the Pachmari sandstone as it approaches the Sítárívá hills; the dip becomes easterly, and there is a considerable intercalation of clay beds.

Possible outliers, with coal, in the Narbadá valley.

The most pressing question regarding the former, and possibly actual, extension of these deposits refers to the northern boundary. At many places, the whole series is unquestionably stopped out against ridges of metamorphics; but elsewhere, for considerable lengths, the deposits present steep faces to the plains, no rocks being seen in front of them under the alluvium, or over a very large area of the Narbadá valley. At least in one case there is an outlying outcrop of the sedimentaries at the north base of the ridges of metamorphics. The *primá facie* conclusion certainly is, that at one time the strata extended indefinitely over the area of the plains. The facts opposed to this view are, the littoral or torrential character of the deposits even at these blank boundaries; and, the special features of disturbance in this position, suggesting either faulting, or the former presence of obstructing masses of hard rocks. The details of this question were fully discussed in a former section (§ 10), but no decided conclusion could be drawn. The possibility of the Barákar group, with its coal, occurring in any such extension would make the matter of sufficient importance to recommend some experimental boring. It would probably be very soon ascertained whether it were worth while to continue the work to any depth. For such a trial, Gádarwára and Bankéri would be good positions.

Probable greater development of the coal-measures within the basin.

There is a more important practical question connected with the distribution of the groups within the basin, as to whether the Barákar coal-measures occur extensively throughout the field, and at what depth they may be expected to lie. The prospect is based upon the fact of the appearance of the two lowest groups at the northern boundary—the Barákars at the Sítárívá only, and the Talchírs at many places—the same groups being almost continuously exposed along the southern boundary. This undoubtedly gives a strong presumption in favor of the more or less continuous extension, and even the greater development, of the coal-measures within the basin. From the same evidence one might infer—from the position of the Sítárívá field far to the north-east, and from the much greater development of the coal at the east end of the southern outcrops, in the Pench than in the Táwá—that the eastern side of the basin may be more productive than the western. It was upon such considerations that the exploration of the ground on the south of the Sítárívá mines has always been urged.

Difficulty as to depth.

Supposing the coal to be there, the question of depth is of great importance and of equal difficulty. A glance at the figured section (Fig. 1) will show that if there were any approach to continuity in depth of the several groups successively overlying the Barákars of the southern outcrop, the coal would be hopelessly out of reach over the greater part of the area. It has been shown with some probability, in the case of several of these groups, that their continuity in depth is very small, the beds of the Motúr horizon being those regarding which least information exists at present. But for these, as for the Bijori, the Pachmari, and the Dénwá beds, there is the fact, of the complete overlap (extinction) at the Barákar outcrop on the Sítárívá.

Partial denudation of the lower groups.

This feature of extensive overlap with obscure unconformity has been a puzzle in many of our Indian coal-fields, and it is nowhere so pronounced as here. All over India, the Talchír and Barákar groups are found to have the widest extension and the most constant characters, and to be overlaid in different fields and in different parts of the same field by groups of local character. Partly, perhaps, owing to original difference of deposition, but largely also to protection from denudation by a greater covering of the Deccan trap-formation, there is a fuller series of these groups in the

Sátpúrá basin than elsewhere. From an inspection of the general cross-section of this area, seeing the great difference in age that must be introduced between the beds resting upon the Barákar and Talchír groups on the south and those overlying them on the north, any geologist would expect to find very marked unconformity in the latter position. It is, indeed, easily shown (see preceding sections) that the youngest groups of the series have fully participated in the disturbance that has affected the oldest; but independently of this it would be asked,—how, if the Barákars on the north and the south were strictly contemporaneous, can the beds in the former position have been sheltered from deep and irregular denudation during the great time it must have taken to accumulate the younger groups, before the topmost of these could have been laid down on the north side of the basin? One can only very partially fill the gap by supposing the coal-formation to have commenced later and to have been more protracted on the north. All this is the more surprising, since most of these rocks are of shallow-water, if not in great part of sub-aërial origin. Overlap such as that of the Bágrá on the Dénwá beds implies only nominal unconformity, but where one finds the Bágrá group resting broadly with parallel stratification on the Barákars and Talchírs, with nothing to represent the intervening Dénwá, Pachmari, Bijori, and Motúr deposits, great unconformity must be implied. This position is so strong that one must, in spite of such evidence as we possess, suppose the existence of strongly contrasting stratification in unexposed contact-sections. There is the more room for this conjecture here, in that at nearly all the contacts seen the rocks are greatly disturbed. In the only instance where this is not the case, in the Amádi river section (Fig. 3), the Talchírs do show a slightly denuded edge of junction with the Bágrá beds. This conclusion would, of course, render the search for coal along the northern margin of the field more precarious; involving, as it would, the consideration of removal by an ancient denudation, of which no forecast would be possible.

Position for trial borings.

Although it would be quite impossible in the face of such uncertainties, and without any local precedent to guide one, to attempt any definite estimate of the depth at which coal might be struck at any point within the field at a distance from the actual outcrops, I am strongly of opinion that the experiment should be thoroughly tried. I would recommend Budi in the Dudhi valley as a suitable position. It is sufficiently far (eight miles) from the boundary to be clear of the unfavorable original and induced conditions affecting the rocks there—the coarse conglomerate, which is the most troublesome of all rocks to bore through (as has been so unfortunately proved near the coal mines on the Sítárívá), and the troubled stratification with trappean intrusion prevailing in that position. It is, on the other hand, sufficiently far north of the run of the Pachmari sandstone to give this group room for extinction. An analogous and almost equally favorable position may be selected about Bichla in the gorge of the Sítárívá. Should coal be found, the open area of the Dudhi would afford a good field for the extension of mining enterprise, and there would be no great difficulty in establishing communication with the railway. It is at least as accessible as the Táwá valley. In this latter region, according to the small evidence already indicated, there does not seem to be as good a prospect of the coal being in force; but there is here the apparent advantage of being clear to the south of the Pachmari rock. For a trial in the Táwá area, I would select a spot well to the south of Kesla, somewhere about the Suktáwá. There is so little upon which to base an exact opinion, that the precise selection of the site may be made with reference to convenience of the surface conditions, of course giving a wide berth to trap-dykes.

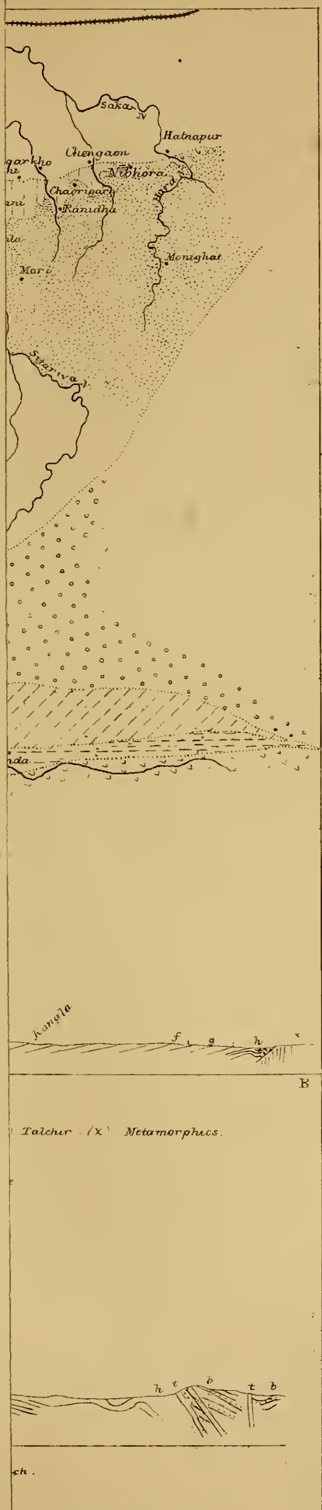
Local character of the groups.

From what has been already said, it is apparent that several of the sub-groups, as indicated in the sedimentary series here, were largely determined by local conditions; that there is no reason to suppose that in a corresponding series in any other basin there would be any specific agreement in the composition, number, order of sequence, or duration in time, of the several respective sub-divisions. Such, too, has been proved by experience. From the great steadiness of petrological aspect and wide distribution of the two bottom groups of the series—the Talchírs and the Barákars—it was thought that analogous similarity might obtain in the succeeding groups. It was thus at first believed that the sandstones and ferruginous clays overlying the Barákars in the Wardá field represented the similar deposits of the Panchet group in the Rániganj field; but the fossil evidence showed that their affinity is with the Damúda series, of which the Barákar is the bottom group. About the same time a similar conjecture was made as to the Panchet affinities of the red-clays overlying the Barákars in the Pench valley; but it is sufficiently evident from the section of the Sátpúrá basin that the beds belong to a much lower horizon than the Panchet. It is, indeed, very apparent from this western basin alone that the lithological criterion can be but of small assistance; it would be impossible to distinguish the clays and limestones on the Pench from those on the Dénwá, their position in the series being widely different. The sandstones of the Jabalpúr and the Pachmari groups are also exceedingly like each other.

It would be difficult, one might say unnatural, to form any scale of groups applicable to this sedimentary series in the different basins. One must for the present be content with the independent arrangement of the groups in the several basins, (as here suggested for the Sátpúrá basin,) postponing the final correlation of their local divisions till all the scattered basins of the deposits, and such fossils as they may yield, have been worked out.

August 1872. H. B. MEDLICOTT.

Plate I.


Sakar N
Hatnapur
Chengaon
Nibhora
Chairigarh
Ranidha
Monghat
Mari
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Talchir (X) Metamorphics
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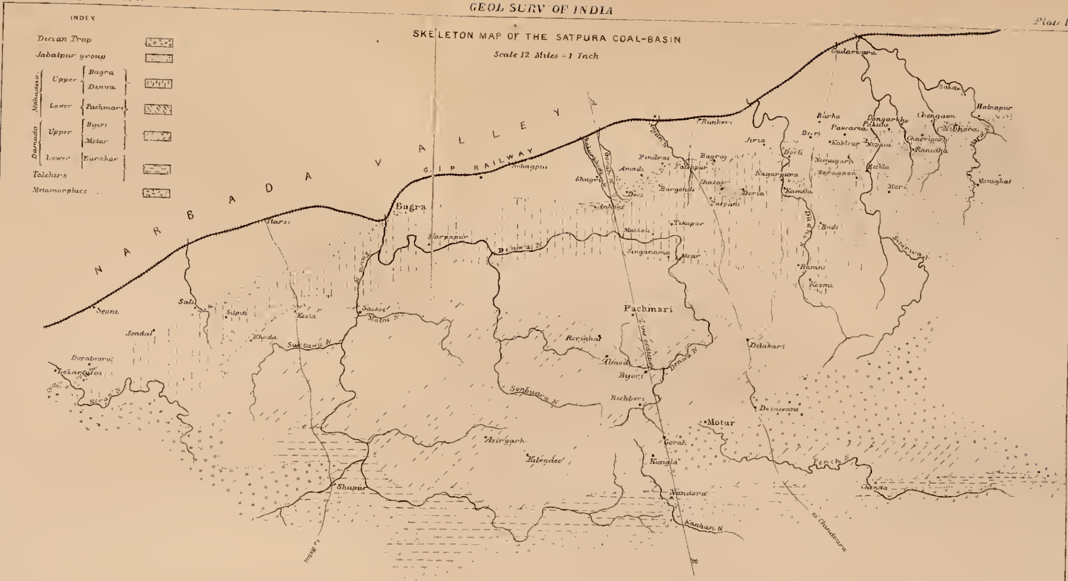

Fig 1 General section NNW SSE through Pachmari Scale 4 Miles = 1 Inch

t Deccan Trap (a) Jabalpur group (b) Bagra (c) Denwa Upper – (d) Pachmari Lower – Mahadeva (e) Byori (f) Motur Upper (g) Barakar Lower – Damuda (h) Talchir (x) Metamorphics

N B The Talchirs and Barakar are shown separately in the sections, but are united on the map, owing to the smallness of scale

Fig 2 Section in the Angan Scale 1 Mile = 2 Inches

Fig 3 Section in Amadi stream Scale 1 Mile 6 Inches

Fig 4 Section in the Kukurkhodi Scale 1 Mile = 1 Inch

MEMOIRS

OF THE

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INDIA.

VOL. X, Pt. 2.

PUBLISHED BY ORDER OF HIS EXCELLENCY THE GOVERNOR GENERAL OF INDIA
IN COUNCIL,

UNDER THE DIRECTION OF

THOMAS OLDHAM, LL.D.,

Fellow of the Royal and Geological Societies of London; Member of the Royal Irish Academy; Hon. Mem. of the Leop-Carol. Academy of Natural Sciences; of the Isis, Dresden; of the Roy. Geol. Soc. of Cornwall; Corr. Mem. of Zool. Soc., Lond., &c., &c.

SUPERINTENDENT OF THE GEOLOGICAL SURVEY OF INDIA.

CALCUTTA:

PRINTED FOR THE GOVERNMENT OF INDIA.

SOLD AT THE

GEOLOGICAL SURVEY OFFICE,
OFFICE OF SUPERINTENDENT OF GOVERNMENT PRINTING,
AND BY ALL BOOKSELLERS;
LONDON: TRÜBNER & CO.

MDCCCLXXIII.

CALCUTTA:
OFFICE OF SUPERINTENDENT OF GOVERNMENT PRINTING.
1873.

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ERRATA.

Page 17, line 22, *omit* "and population."

Page 17, line 30, *for* 2,483,861 *read* 550,266.

Page 17, line 30, *for* 4,340,806 *read* 2,407,211.

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I.—PRELIMINARY REMARKS.

Prior to the occupation of Pegu by the British forces, and its annexation to the dominions of Her Britannic Majesty, very little was known regarding the geological constitution of the province; and great expectations were entertained of the mineral wealth which it was supposed awaited merely the advent of skill and capital, to requite munificently the early pioneer in this direction, and give an additional instance of the difference between Eastern apathy and Eastern misrule, and the felicitous results of Western energy and Western good government. The old adage, however, of *omne ignotum pro magnifico* was never more strikingly illustrated than in the case of Burmah, in contrasting the material poverty and political weakness of the kingdom of the haughty

Lord of the white elephant, with the ideas current regarding them for the last few centuries, when the wealth of the kingdom of Ava, was as proverbial, as that of the still classic names of Golkonda or Samarkand.

The mental process of course is easily understood, by which the erroneous idea becomes developed, that that land must be wealthy, and its inhabitants prosperous also, where gems are dug out of the earth, worth a kingdom's ransom; yet experience, no less than sound political knowledge, teaches us that the humblest minister to the manifold wants of a civilized community, is better off materially, than the slave (actually or essentially) who spends his days in pursuit of those gems and pearls and yellow ore, whose very names throw such a halo of splendour, unreality, and fiction over the land of their production, the 'gorgeous East.'

There is another idea too, which though not often put into shape, yet lies at the bottom of much of the groundless belief touching the mineral resources of unknown lands, and that is, that the existence of coal and iron, meaning cheap coal and iron, is so necessary to the spread of Western civilization, that to doubt, or rather not to entertain full faith in their existence in all lands, sufficiently inviting to tempt the Saxon, would seem like arraigning Providence for not so providing for the necessities of that favored race. Without coal and iron the hardy Saxon pines like a gudgeon in a punchbowl, and hence his instinctive unwillingness to conceive of countries otherwise eligible and tempting, but deficient in these two elementary essentials for his well-being.

As regards Pegu proper, there is very little indeed to quote from earlier writers, and I need only mention a few papers indirectly connected in a geographical sense with the province, but from which it is not necessary for my purpose to make many extracts.

In the Gleanings of Science, Vol. III, page 59, James Prinsep gives an analysis of a very interesting alloy of platinum, received in the form of a 'button' from Bhamo; and although platinum, or its alloy, would seem to be known to the Burmese by the name of shwe-bew or white gold, yet I am not aware of there being any specimen of the Burmese metal here in Calcutta, and my endeavours to procure some in Rangoon have hitherto been fruitless. The most curious point connected with this alloy, is the very large amount contained in it of the comparatively scarce metals iridium and osmium; but till other samples of this curious compound are available for examination, there is little use speculating on the cause of the curious proportions of the components of the assay:—

Specific gravity of the alloy		17·2
Platinum	25·0	
Gold	5·0	
Iridium and Osmium	40·0	
Iron	10·0	
Arsenic and Lead	20·0	
		100·0
Rhodium?		
Palladium?		

In the Asiatic Researches, Vol. VI, page 136, Captain Hiram Cox, Resident at "Ranghong" (Rangoon) or Rainanghong, as he also calls it, gives some particulars of the earth-oil wells of Ava; but I will only extract the interesting information of the price at which the oil was then selling, *viz.*, at the wells, at seven annas and seven pies per cwt. avoirdupois, and at the port of Rangoon at three sicca rupees three annas and six pies per cwt., or fourteen rupees seven annas and nine pies per hogshead of fifty-three gallons weighing 504 lbs., or per Bengal Bazaar maund, two rupees five annas eight pies; vegetable-oils at the same time fetching eleven rupees per Bazaar maund.

In the Journal of the Asiatic Society of Bengal, Vol. I, page 14, (1832), James Prinsep gives the following list of minerals from Ava:—

"1. Asbestos.
2. Mica.
3. Crystallized and anhydrous gypsum.
4. Hornblende.
5. Quartzy malachite; 18½ per cent. copper.
6. Black oxide of manganese.
7. Pisiform oxide of iron.

8. Argentiferous galena; ½ per cent. of silver, with slight contamination of copper and zinc.
9. Crystallized oxide of lead or litharge.

Analysis.	Oxide of lead	99·0
	„ iron and copper	1·0
		100·0

10. Platina.

An interesting account is also given in the shape of an abstract of a letter from Major Burney, Resident at the Court of Ava, of the means employed to collect platinum in the streams of Northern Burmah. Major Burney writes:—"A good deal of the platina ore is brought from some mountain torrents or small streams which fall into the Kyendween river from the westward, near a town called *Kannee.*" Kannee is a common Burmese name signifying 'red bank,' and is nearly the equivalent of the Bengal word 'Rangamuttia' applied to a village in the Bhagirathi river, where a bluff of the older alluvium is scarped by the river, and by its contrast of color with the newer alluvium has suggested the name Rangamuttia (colored earth), as similar sites in Burmah, are, for a similar reason, termed '*Kannee.*' The Kannee or Kannee-myo on the Kyendween river is situated 70 miles West-north-west from Amerapura according to Pemberton's map. Describing the mode of collecting the platinum, Major Burney writes—"it is collected in a very curious manner, as Mr. Lane is informed, although he hesitates to believe the fact. The horns of a species of wild cow, in the country called T'sain, perhaps the same as the Nylgao of India, have a velvet coat before the animal reaches the age of two or three years; a number of these horns are taken and fixed in the beds of the small streams, and at the close of the rainy season when the water subsides, a cloth is put down over each horn separately, and the horns and cloth, as well as a portion of the sand around it, are taken up together. The horns appear to collect around them a good deal of gold-dust, which the streams have washed down, and with this dust, grains of platina are found mixed."

I see no reason to doubt the above circumstantial account, although of course the horns possess no occult powers of attraction, but act merely as pieces of stick might, in determining the arrest of heavy particles by the check they give the current. The Nylgao does not occur in Burmah, the T'sain being the Bos Sondaicus. The horns of no sheath-horned ruminant ever present the appearance termed *'velvet'* in the deciduous horned species; but the phrase is accounted for by a subsequent statement, that "deer's horns are sometimes used in place of them," and those in the velvet may possibly be best esteemed for the purpose. It is added that these horns (gold and all of course) sell sometimes for 12 or 13 tickals a piece, equivalent, I presume, to half a tickal of gold at 24 or 26 rupees the tickal, which may be regarded as its ordinary price. Among the minerals, No. 9, Litharge, was subsequently stated to be an artificial product, imported from the Shan States (page 305). The quartzy malachite is also an interesting mineral, but I am unable to obtain access to the Asiatic Society's minerals, which at present are packed up, and am, therefore, unable to offer an opinion as to the identity of this substance with a specimen shown to me as malachite from Bhamo by Colonel Fytche in 1871, I think. The specimen in question I at once said was not malachite, as a knife made no impression on it, and very likely contained no copper; but it is quite possible that it may have been a variety of Prase containing the amount of copper stated by Prinsep, though the combination is an unusual one.

At page 458, Mr. Prinsep gives an analysis of two specimens of fossil bone from Ava, one consisting almost wholly of carbonate of lime with a little coloring matter (iron), the other composed as follows:—

Carbonate of lime	25·0
Phosphate of lime dissolved in nitric acid ...	34·0
Silica and oxide of iron not dissolved	41·0
	100·0

In the sixth volume of the Journal of the Asiatic Society of Bengal for 1837, page 245, is an "Abstract of the Journal of a Route travelled by Captain S. F. Hannay, of the 40th Regiment Native Infantry, from the capital of Ava to the amber mines of the Hukong valley, on the south-east frontier of Assam, by Captain R. Boileau Pemberton, 44th Regiment Native Infantry." Captain Hannay thus describes the situation of the serpentine district (meaning of course jade-stone):—"The Chinese frequently proceed to the mines by water for two days' journey up the *Mogoung* river to a village called *Kammein*, at which place a small stream called *Engdau-kyoung* falls into the *Mogoung* river. From thence a road leads along the *Engdau-kyoung* to a lake several miles in circumference called *Engdau-gyi*, and to the north of this lake eight or ten miles distant are the serpentine mines, the tract of country in which the serpentine is found extending eighteen or twenty miles." In Pemberton's map, the position of the above lake is Lat. 25° 25′, Long. 95° 0′. Captain Hannay remarks—"The Chinese choose pieces which, although showing a rough and dingy colored exterior, have a considerable interior lústre, and very often contain spots and veins of a beautiful bright apple-green." This is the true jade, called by the Burmese *Kyouk-tsein* and by the Chinese *Yueesh;* and the Editor remarks that the stone called by the Chinese *Yu* is a silicious mineral, a species of Prase. Of the amber mines a very brief account is given, those producing the best being situated 30 miles North-east of the serpentine locality. The mines are mere pits, 6 to 15 feet in depth and 3 feet square, the only implements used being a bamboo sharpened at one end and a small wooden shovel. "The soil throughout is a reddish and yellow colored clay; and the earth in those pits which had for some time been exposed to the air, had a smell of coal-tar, whilst in those which had been recently opened the soil had a fine aromatic smell." Elsewhere, however, Captain Hannay remarks that the finest amber of "bright pale-yellow is only got at the depth of 40 feet under ground."

The common amber costs "$2\frac{1}{2}$ tickals a viss, or four rupees for one and a half seer."

As I shall hereafter show, serpentine is pretty common in parts of Pegu, and is doubtless also common within the territories of Ava, but the 'serpentine' of the above extracts is jade (or, in some cases, Prase), which alone is worked by the Chinese for exportation. I am not aware that the serpentine of Burmah, properly so called, is applied to any use whatever.

I need not here quote from any more papers having reference to Burmah, many of which may be referred to in the Journal of the Asiatic Society of Bengal, as they all have reference more to those parts of the Empire with which I am not at present concerned than to Pegu, as, for instance, Arakan, Assam, Moulmein, Tavoy, and Mergui.

I must not, however, pass over without mention two papers in the Transactions of the Geological Society, 2nd Series, Vol. II, by the Reverend William Buckland, D.D., and W. Clift, Esq., giving an account of the geology of the country between Prome and Ava, and describing the fossils brought from that region by J. Crawfurd, Esq., on his return from a mission to the Burmese Court. From the evidence of the shells contained in this collection, Mr. Sowerby was inclined to refer the beds yielding them to the epoch of the London Clay; but though Nummulitic rocks occur at no great distance from the river below Thayet-mio, it is certain that the fossils examined by Sowerby came from beds which more recent examination has shown to belong to the Miocene era. The vertebrate remains in the collection belonged to the following genera: Mastodon (M. latidens, Clift, and M. Elephantoides, Clift); Hippopotamus, Sus, Rhinoceros, Tapir, Ox, Deer, and Antelope. A Trionyx and Emys, among Reptiles; and in addition to Leptorynchus, a species of Crocodilus resembling C. vulgaris (or perhaps I may say C. palustris, the local race at the present day, which at the date of the paper in question was regarded as a variety of the Nilotic C. vulgaris). Dr. Buckland points out the interest of the discovery of these remains; and enters into speculations touching the period of their entombment, which need not here be reproduced. A single sentence will, however, suffice to show the divergence of views then held from those current now: "The evidence before us, then, is such, that I believe no practical geologist will be disposed to assign the origin of the wood or bones under consideration to the comparatively impotent exertions of existing causes," —this, I presume, may be regarded as a confession of faith touching the cataclysmal origin of all diluvial deposits, which was not exploded till a later period, constituting in fact the supposed distinction between diluvium and alluvium.

At page 378, in noticing the fossil-wood, the following passage occurs:—"The larger portion of the fossil-wood is beautifully silicified, and displays most delicately the structure and fibres of the living plants: in other specimens of it, this structure is more obscure, though sufficient to show that the trees in which it exists were dicotyledonous. This obscurity arises from the fact of most of these dicotyledonous plants being impregnated with carbonate of lime, whilst all the monocotyledonous stems are silicified, as are also a few of the dicotyledonous." If I may be allowed to venture an opinion from that portion of the great fossil-wood deposit which stretches down below the frontier into the Prome district, I would suggest that the sentence quoted above conveys a misconception. Certainly, below the frontier, monocotyledonous wood is extremely rare; dicotyledonous, on the other hand, in places very abundant; both being silicified; and no fossil-wood has ever been met with by me from these beds, mineralised by carbonate of lime. One piece of wood impregnated with gypsum exists in the museum of the Geological Survey of India from near Yenan-gyoung, but no calcareous wood whatever; neither can Dr. Oldham, who has traversed the same ground as Crawfurd, recall ever having seen any such. The only explanation that suggests itself to me is, that Dr. Buckland had before him fragments of fossil-wood which were more or less imbued superficially with carbonate of lime during a very recent period. The extent to which this fossil-wood has been silicified varies considerably; and even pieces originally well silicified are often seen converted into a very tender friable mass, by the absorption of atmospheric water, and the conversion of the more or less hyaline silica into the earthy and porous hydrate. In this state, if embedded in a clay containing lime, a considerable infiltration of that mineral might take place, giving rise to a secondary mineralization, which would go far to account for the description by Dr. Buckland, quoted above.

In a postscript to his paper, Dr. Buckland alludes to the current popular belief in the petrifying power of the waters of the Irrawadi, and quotes a passage from Lieutenant Alexander's travels in the Burman Empire (London, 1827), wherein it was stated, that during the late military operations at Prome "the pioneers were ordered to remove a house, and upon endeavoring to cut down the massive teak pillars on which it was raised, they found that the edges of their hatchets were all turned. On examining into the cause of this, they found that the pillars were petrified throughout, though the house had only been built ten years, and the pillars were under water three months of the year during the monsoon." After adducing some arguments to disprove the possibility of any such rapid petrifaction of timber, as here described, having taken place, Dr. Buckland suggests what was doubtless the true explanation of the case, *viz.*, that the pillars were in reality silicified logs of fossil-wood, which even at the present day are frequently seen stuck up as posts round Pagodas and Khyoungs (monasteries), and may, where abundant, have been used to support a building, especially if such were a sacred edifice or Hpungi Khyoung.

Subsequently to the annexation of Pegu, an important contribution towards a precise knowledge of the geology of a portion of the valley of the Irrawadi was made by Dr. T. Oldham, in the appendix to the work of Captain Henry Yule, entitled "A Narrative of the Mission sent by the Governor General of India to the Court of Ava in 1855." Dr. Oldham's notes embrace "the geological features of the banks of the Irrawadi and of the country north of Amerapura," and, besides matters of technical interest, contain some detailed calculations of the yield of the celebrated petroleum wells at Yenan-gyoung. According to one calculation based on native report, the annual yield amounted to ten and a quarter million viss, or by a more reliable calculation of his own, to only four and a half million viss, equivalent to about 1,278,060 gallons. Major Phayre's enquiries (page 22, Op. cit.) gave a higher estimate, equivalent to 2,612,354 gallons. The mean between these, or 1,945,207 gallons, may be provisionally taken as the annual yield of the petroleum wells of Upper Burmah. Among the fossils not previously noted, Dr. Oldham mentions remains of an Elephas and a portion of the skull of an animal nearly allied to Merycopotamus.

The position of the ruby mines was also indicated, though no opportunity was afforded any member of the mission of visiting them. On this point great confusion appears to have prevailed: in Danas' Mineralogy, edition of 1868, the best ruby-sapphires are said to occur "in the Capelan mountains near Syrian, a city of Pegu, and in the kingdom of Ava." This Syrian is evidently Syriam, an important place in Burmese history, a few miles South-east from Rangoon across the Pegu river. The Syriam Pagoda stands on a low ridge of slightly rising ground, which can hardly be dignified by the name of a hill, and beyond a little laterite for building, produces nothing whatever. Syriam lies in Lat. 16°45′ North; whilst from Dr. Oldham we learn that the ruby-mines are situated about 22°55′. In a memorandum by Lieutenant Colonel S. F. Hannay, in Selections from the Records of the Bengal Government, No. XXV, the position of the ruby-mines is laid down "about 25 miles south of the town of Moong-meet, and 60 miles north and east of the Burmese capital," at two "localities called Mogant and Kyat-pen," which last name may perhaps have become converted into the extraordinary "Capelan" mountains of the American mineralogist.

Another interesting paper I may here allude to is an account, by Mr. W. T. Blanford, of the volcanic hill of Puppa in Upper Burmah, contained in the Journal of the Asiatic Society of Bengal, Vol. XXXI, page 215. The interest of the paper as regards the geology of Pegu lies in its clearly establishing the fact of an active volcano having existed in this region during the deposition of the beds containing the silicified wood, no traces of volcanic action having been detected in these beds within the limits of the province; though evidence exists of cotemporary volcanic action in the Prome district in beds somewhat older than those round Puppa.

Among the earlier contributions towards a knowledge of the geology of the province, I should not, perhaps, pass unmentioned two mss. maps (of very different value), one of Tonghu by Mr. O'Riley, when Deputy Commissioner of the district, and the other a "Geological Sketch-map of the eastern portion of Pegu, including Tonghu and a portion of Martaban," by Dr. J. MacClelland, when Conservator of Forests in British Burmah. As regards the map of Mr. O'Riley, it is seen by mere inspection to be the work of an amateur quite unacquainted with the subject, and must be rather regarded as a monument of the many-sided zeal of an energetic and hard-working officer of Government than a contribution in any sense to geology; farther allusion to it, therefore, is unnecessary. The map of Dr. MacClelland is of a different character, though far from free from grave inaccuracies, and disfigured by being laid down on an extremely bad topographical basis.

It represents the entire Eastern, or Pegu, Yomah as consisting of Eocene strata, a determination very possibly based on the mistaken view of Sowerby, as regards the fossils brought by Crawfurd from between Ava and Prome. Scattered over these Tertiary beds numerous patches of "basaltic trap" are shown to occur, a feature which my own examination of the entire country failed to verify; and on this point I would fain say a few words, tending to explain how this curious discrepancy can be accounted for. On referring to Dr. MacClelland's sketch of the geology of the district, it is somewhat remarkable that the term "basaltic trap" *nowhere occurs in it.* In the selections from the Records of the Government of India, No. IX, page 7, Dr. MacClelland thus expresses himself:—"The rocks of which the country is composed are laterite, slate-clay, and bituminous often dark argillaceous sandstone assuming a *basaltic character, with a concentric form of disintegration.*" In a still later Report, dated 27th June 1855, Dr. MacClelland thus epitomises the geological constitution of the Yomah hills: "The Yomah hills, throughout their whole extent, are composed of slate-clay and argillaceous sandstone in alternating beds passing into each other. These rocks are generally soft and friable, affording a fine light grey colored loose and dry soil, in some places hard and stiff, *but the rock is sometimes hard and basaltic,* and where this occurs, it yields a dark brown soil." Now, it is very remarkable that in no part of Dr. MacClelland's description of the ground any allusion to "basaltic trap" occurs, and I cannot but suspect that the "basaltic trap" of the index to the map is a copyist's error or alteration, originating perhaps in the fact that *basaltic sandstone* might easily be converted into *basaltic trap* in a manner I shall try to make clear.

In the selections from the Records of the Government of India, No. XX, page 4, Lieutenant E. C. S. Williams, R. E., in giving a sketch of the physical features of Pegu, quotes Dr. J. MacClelland as regards the geology of the Yomah, using the following words:—"The Yomah range, from the frontier to lat. 17° 15′, is composed of brown or grey slate-eclay with thin layers of bituminous limestone containing fossil testaceous remains frequently alternating with and passing into beds of argillaceous sandstone, generally soft and friable, though indurated in places, especially in the higher ridges, where *it assumes at times a basaltic character.......*". Thus far it would seem as if Lieutenant Williams were following Dr. MacClelland closely, even to copying the unfortunate word "*basaltic,*" as applied to an unaltered sedimentary rock; but he goes on and says, "*so much so,* that towards the north in the Prome district *basaltic trap* frequently occurs in the main ridge." It would thus really seem that the term "*basaltic trap*" is due to the too facile pen of Lieutenant Williams, and that somehow or other the term which nowhere occurs in MacClelland's reports on the geology of the district has become appended to his map. How far Lieutenant Williams may have been acquainted with what may be almost described as a trappean ash bed, which occurs at three spots in the Prome district, and portions of which might possibly be regarded as a "*basaltic trap,*" I am unable to say; but he clearly regards his "basaltic trap" as akin and to some extent synonymous with the very different basaltic sandstone of MacClelland. After arriving at such a conclusion, it would be a very small step to put in freely, representative patches of the said trap here and there throughout the Yomah; and this is all the explanation I can suggest for their appearance on Dr. MacClelland's map in spots where I failed to re-discover them, and for the complete silence which Dr. MacClelland himself maintains regarding them in his written description of the geology of the district.

A broad band of laterite is shown on Dr. MacClelland's map fringing the entire Pegu Yomah, and a similar one skirting the granitic region east of the Sittoung, which convey a very exaggerated idea of the development of laterite in the province. The Poungloung range is shown to be "granitic," and the prevailing error thereby avoided of considering it to be mainly composed of granite or "igneous rocks" as depicted by Mr. O'Riley. It may indeed be doubted if any granite, save in the form of veins, occurs in the Poungloung range, or within the British frontier line; though the schistose rock, of which the Poungloung consists, displays a great tendency to a massive structure lithologically resembling granite, but neither intrusive nor in any way dissociated from the more bedded members of the group. This remark, however, is not intended to apply to the rock a little beyond the frontier, containing the tin-stone wrought in the district, which is probably a veritable granite in every sense of the word. The interesting feature in the map to the geographer and engineer is the connexion shown to exist between the Naweng above Prome and the head of the Myit-ma-kha-choung, known lower down as the Hleing or Rangoon river; but the topographical inaccuracy of the map is too great to allow our placing any reliance on its testimony in a point of such great nicety, and the more so as the channel in question is crossed by a geological color band, which, I presume, is rather intended to represent an ideal watershed between the drainage areas of the two streams, than an actual exposure of rocks, which are nowhere revealed, the whole country hereabouts being a vast alluvial plain.

Other remarks on the geology of Pegu by Lieutenant Williams may be referred to in the Records of the Government of India, No. XX; but they are mainly interesting, as showing how thoroughly erroneous much of the information may be which a zealous officer not well versed in the subject may be betrayed into putting on paper. We are, for instance, informed (loc. cit., page 4) that—"In Henzada district, granite, greenstone and hornblende are met with," seemingly an unacknowledged reference to a report by Lieutenant Trevor, in selections from the Records of the Government of India, No. XV, page 42; and again the following not very intelligible sentence—"Quartz nodules are common, and with clay-slate make up the Grauwacke formation, which with the limestone beds and fossil remains of molluscs and fishes which abound, would denote the Silurian or Transition system."

There is the possibility that Lieutenant Trevor's allusion to granite and greenstone may refer to some of the small developments of serpentine in the Henzada district; but what can have originated the idea of

Silurian rocks in Pegu is difficult to say; the more so as one of the proofs adduced—the abundance of fish-remains—would go far to counterindicate a Silurian age for the beds containing them, that class only making its appearance in the highest strata of the Silurian period; and moreover, the fish-remains in Pegu are mainly squaline teeth, a family which would seem to have culminated in the Tertiary epoch. It may seem to some unnecessary to notice such errors of previous writers who wrote and compiled to the best of their knowledge; but I do so because erroneous statements of the kind I have mentioned above get quoted and re-quoted by successive writers, an instance of which is afforded by the Administration Report of British Burmah, 1868-69, wherein occurs some geological information of a startling character, which never would have been allowed to appear, if that portion of it had been submitted to any qualified person for revision, as where the islands of Arakan are stated to be "all of volcanic formation," a sentence which, I believe, might easily be made to tally with the true state of the case by the simple substitution of the word "*none*" for "*all*."

Finally, a report by Captain G. A. Strover, Political Agent, Mandalay, dated 22nd January 1873, has just been placed in my hands, containing some interesting information to which I would draw attention. Under the head 'gold' occurs the following statement, which, if corroborated by future exploration, is not only of great interest, but of great importance commercially likewise:—"At Thayet-pein-yua, near the Myit-nyay on the road to Pyoungshoo, to the south-east of Mandalay, the gold quartz is found in abundance, the reefs cropping up from the ground, and there is reason to believe, that very valuable gold-mines are in existence, and could be worked and developed with little trouble. A Shan lately procured from here a piece of quartz 3½ ℔s. in weight that produced exactly 2½ tickals of gold." The distance of Pyoungshoo not being given, I can only infer that it is probably the place called in Pemberton's map "Neaungsheway," 80 miles south-east of Mandalay, a distance not too great for the erection of works on a large scale for quartz crushing by the European method, if only the quartz is there to be crushed. But on this point I confess it would have been more satisfactory if Captain Strover had stated that he had himself seen a specimen. A good deal more requires to be known regarding the history of the above Shan, and his nugget of gold quartz, before the existence of auriferous quartz reefs, in so accessible a locality, can be taken as an established fact.

Silver.—Captain Strover gives several localities for argentiferous galena, one of them near *Theebaw*, being probably identical with the "Bo-dwen silver mine" of Pemberton's map, 30 miles north of *Thee-bo.* Captain Strover adds:—"The metal is also found in other towns (townships?) unmixed with lead," but without naming any of the spots.

Copper.—Captain Strover says:—"This metal is found in the Shan States, *but* is not worked. It is also found at Kolen-myo and Sagaing. At Bawgine and Kolen-myo, the malachite appears to be of a rich description." Here again it would have been more satisfactory if Captain Strover had said whether he had himself seen any of this malachite. The lump of stone shown to me as Burmese malachite by Colonel Fytche was nothing of the kind, but a silicious stone of a green color, probably prase, which, without an analysis, I should not like to assert, contained even a trace of this metal, though, as I have before said, it may be the same mineral called "quartzy malachite" by Prinsep. Valuable and interesting, therefore, as Captain Strover's remarks are, they would have been increased tenfold in value if only accompanied by authentic samples of the minerals alluded to therein, with localities attached. I need not make more extracts from this interesting report, which embraces a variety of other mineral productions, beyond alluding to the opinion of a M. Bredamajee, employed at the ruby-mines by the King, who would persuade people that "with careful working, rubies as large as pigeons' eggs could be extracted," an assertion which, I imagine, could only have been hazarded by this astute foreigner from the well grounded conviction of the enormous number of gullible people at large in the world.

The geological survey of Pegu was commenced by Mr. W. T. Blanford in 1860, assisted by Mr. F. Fedden. In two seasons these gentlemen had completed the examination of the districts of Henzada and Bassein, and a portion of the Rangoon district likewise. Mr. Blanford was now transferred to Bombay; and, after a brief interval, Mr. Fedden was deputed in company with Lieutenant Watson to examine the course of the Upper Salwin, and eventually was transferred to Bombay in 1865, after having examined a considerable area in the district of Western Prome under the serious disadvantage of having no adequate map of the country to work with. Since that date the survey has been carried on by myself, interrupted only by a visit to Europe on furlough, during which, all field-work remained in abeyance. It will only be, therefore, incidentally that my colleagues' names will be mentioned, when alluding to such portions of the ground as were examined and reported on by them; it being understood that I am indebted to their manuscript reports and maps for much information respecting the districts examined by them during the earlier years of the survey.

II.—Physical Geography.

Area.—The province of Pegu, though inferior in area and population to Tenasserim, is—from its geographical position as regards the countries situated along the course of the Upper Irrawadi and Western China, of which it constitutes, commercially speaking, the gate—the most important of the three provinces into which British Burmah is divided.

These provinces are Arakan, with an area in square miles of 18,630, population 453,314; Pegu (exclusive of Tonghoo) 28,404, population 1,403,631; and Tenasserim, including Tonghoo, 46,050, population 2,483,861; giving a total of square miles 93,084, population 4,340,806.

The area embraced by the present Report is not, however, strictly bounded by the limits of the province of Pegu, but includes a portion of the adjoining district of Tonghoo (now united to Tenasserim), and the greater portion of the district of Sandoway in Arakan; though the examination of these districts has been from several causes partial and incomplete. Nor can the limits of the province be strictly adhered to when sketching its physical geography, inasmuch as its main features are common to it and the adjoining provinces. Including, therefore, 3,500 square miles in Sandoway, and about 1,500 in Tonghoo, the entire area to which the present Report applies slightly exceeds 40,000 square miles.*

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* The details of area and population given above are extracted from the "Administration Report" of the province for 1868-69; but the chapter in it which treats of the "Physical, Political, and Fiscal Geography" requires careful revision and correction, as the numbers given in it, and those recorded in the statistical tables at the end, do not correspond through some clerical error, the source of which I am unable to detect. For instance, at page 23, Pegu, including Tonghoo, is said to embrace 33,440 square miles, whilst in Statistical Table C, it is said to contain 36,454 square miles. The disagreement in figures may be a clerical error, but such an explanation will scarcely serve to explain the startling discrepancy as regards the boundary of Tonghoo to the eastward which exists between the statement at Page XI of Statistical Table A 2 and the boundary as laid down by Captains FitzRoy and Edgecombe in their official map of the province, dated March 1867, with revision up to February 1868. Under the head Tonghoo we read (*loc cit.*).—"There are three mountain ranges in the district, running parallel to each other and the Sittoung river, the Pegu "Yomah," the "Poungloung," and the "great watershed." The highest of these is the great watershed, which at Nattoung attains an elevation of 8,000 feet above the level of the sea."

Now, in the map of Pegu by Captains FitzRoy and Edgecombe published by Government, the boundary of Tonghoo is distinctly laid down as following the crest of the Poungloung range from the Burmese Frontier, close to 19° 30′, to where the range is crossed by the Thoukyay-gat river, a distance of 41 miles; whilst the crest of the "great watershed," meaning the range separating the drainage areas of the Sittoung and Salwin, is shown by the map to be no less than a fraction under 36 miles east of the Poungloung range in the parallel of 19° 30′, or 36 miles east of the British boundary as laid down by the officers of the Pegu Survey. If, therefore, the passage above quoted from the Administration Report of 1868-69 regarding the *inclusion* of the Poungloung range within the Tonghoo district is a clerical error, it is one which amounts in fact to the annexation of the entire drainage area of the Thouk-yay-gat below the frontier, comprising some 1,000 square miles of hilly country, possessing one of the finest climates in the east, and inhabit-

The province of Pegu embraces the whole of the valley of the Irrawadi below the parallel of 19° 30′, with that portion of the Bassein district also lying between the Arakan Yomah and the sea, and so much likewise of the Rangoon district as edges round to the eastward into the valley of the Sittoung. It is bounded on the east, for the greater portion of its length, by the Eastern or Pegu Yomah,* a small portion only of it lying East of that range; which portion, however, contains the old, though now unimportant, city of Pegu, from which the province derives its name. To the West, it is bounded by the Western or Arakan Yomah, but comprehends the strip of country intervening between the hills and the sea, as far north as Gwa Choung, which separates the Bassein district from Sandoway. To the North it is bounded by the possessions of the King of Ava, the boundary line nearly coinciding with the 19° 30′ parallel of latitude, whilst to the South it is hemmed by the waters of the Gulf of Martaban.

Climate.—Embracing, then, as Pegu does, a littoral tract of country hemmed in between the sea and the Arakan range, a delta wherein debouches through a thousand creeks, a mighty river beneath a tropical sun, and a large spread of country towards the frontier, lying beyond the immediate influence of the sea, Pegu possesses a very considerable range of climate in its different sub-divisions. As rainfall in the East plays a part in geological agencies, second only to the action of frost in northern lands, I shall devote a brief space to its consideration; and this is the more necessary, as a hankering for averages seems to have betrayed the compiler of the Meteorological Table A 3, appended to the Administration Report for 1868-69, into a misplaced attempt to strike a general average for the entire province.

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ed by sparse and disunited Karen tribes. If, on the other hand, it is a statement based on legitimate grounds, the sooner the official map of the district is brought in accord with the views of Government as to the boundaries of the province, the better. At present it would seem as though a British officer claimed jurisdiction beyond the limits assigned to British Territory by the official survey of the Frontier.

* Yomah—backbone or main range.

It requires little reflection to perceive the essentially artificial nature of any such result, when the factors dealt with to obtain it embrace stations having a rainfall of 50 inches a year, and others indicating a rainfall of 220. Any Procrustean attempt to evolve from such data a uniform climatal mean for the entire province must be misleading, and I accordingly append the accompanying table (p. 22.) to enable the reader at a glance to take in the rainfall at the several stations in Burmah where observations are recorded. From the data before us, it is clear that in Pegu there are three main divisions or zones of climate as regards rainfall, *viz.*, a littoral, sub-littoral, and inland zone. The littoral rainfall is afforded by the stations of Mergui, Kyouk-hpiu, and Akyab, all immediately on the sea. These stations exhibit a mean rainfall (neglecting fractions) of 188 inches, and a mean range of excess or variation among them of 31 inches. The sub-littoral rainfall is shown by the station of Shuay-gyin, Moulmein, Sandoway, and Tavoy, all within or close on the tideway of their respective rivers, and reaches to 224 inches with a range of difference between the stations of 40 inches. The inland rainfall is shown by three stations, Thaiet-mio, Prome, and Myanoung, the record of the two first stations ranging over 10 and 6 years respectively. This inland rainfall is only 50 inches, with a range among the stations of 6 inches only.

The above-mentioned stations are those which seem best adapted to represent the three divisions of rainfall and climate, which appear to be met with in Pegu and the adjoining region; but I may add a few words in explanation of the omission of some other stations from the calculation. For instance, Henzada stands at, or a little above, the termination of the tideway, and its rainfall is a little under 90 inches, but from its geographical position it is clearly not a representative station, standing as it does a little out of the inland climatal zone, and at the same time on the extreme edges of estuary conditions. Its rainfall coincides with its position, but it cannot be used in calculating the mean fall of a zone within which it just barely falls.

For like reason I have omitted the stations of Rangoon and Bassein, as though they belong geographically to the estuary stations, yet from some cause or other their rainfall approximates more with the lesser fall of the littoral zone. Perhaps in reality, the littoral rainfall, and that of the sub-littoral, or estuary region, should properly be regarded as one, and the very high rainfall derived from such tidal or *quasi* tidal stations, as Tavoy, Moulmein, Shuaygyin, and Sandoway, be regarded as due, as it no doubt is, to purely local circumstances, causing an increased condensation of aqueous vapour at these points. The fall, however, at those stations, whatever may be the reason of it, exhibits too great and striking a difference from that of the rest of the estuary region, to permit of passing it by, or of confusing all attempts at classifying meteorological phenomena, by making it one of the factors for obtaining a general mean rainfall for the entire Province, as was attempted by the compilers of the Administration Report previously quoted.

Another station presenting an abnormal rainfall is Tonghoo. Its position is clearly that of an inland station, but it has double the rainfall of the inland stations lying in the Irrawadi valley, and it cannot be properly included in an analysis of the climate of Pegu, being also geographically excluded therefrom as well.

Such analysis, however, of the climate of Pegu as I have here attempted must be merely considered as tentative and approximate, from the fact that the observations whereon it is based, are neither spread over a sufficient number of years to give a satisfactory result, nor have they, in the infancy of meteorological science in these provinces, been kept with that accuracy which can alone conduce to satisfactory results. So strongly indeed do I feel the inutility of endeavoring to evolve reliable results from unreliable data, that I have abandoned the attempt to carry the analysis of climate in Pegu further than mere rainfall: so untrustworthy are some of the statistics of temperature, and so little interest do these tables appear to excite, that in the laboriously compiled table of temperature appended to the Administration Report of 1868-69, the mean temperature of one station is shown to be higher than the maximum registered at the same place, and the temperature at night higher than that recorded during the day. No other case was so glaring as this, but some other tables did not appear altogether free from suspicion on inspection, and I have, therefore, refrained from any attempt to correlate temperature and rainfall; with regard to which last, it may be observed, that though a more thorough and correct system of registration in future may modify the actual amounts given here, yet there is no probability that it will invalidate the general conclusion deduced.*

Of the great value of meteorological science as regards public hygiene there can be no question; and in tropical lands it is no less obviously connected with geology—as may be seen by the relation which the interesting beds containing fossil-wood in Prome, bear, as regard their extension southwards, to the increased rain-fall of the district wherein they disappear. It appears to me if not a necessary, at all events a perfectly legitimate conclusion, to refer the preservation of what remains of their upper beds in Prome partly to the diminished rainfall of that district.

Table displaying the mean annual rainfall of ten stations in British Burmah.

		Mean.	
Littoral Zone ...	Mergui ...	155·77	167·00
	Kyouk-hpew ...	154·50	
	Akyab ...	190·89	
Sub-littoral Zone ...	Tavoy ...	220·90	220·00
	Moulmein ...	228·45	
	Shuaygyin ...	201·90	
	Sandoway ...	228·00	
Inland Zone ...	Myanoung ...	52·40	50·00
	Prome ...	49·73	
	Thaietmio ...	46·77	

* I must here express my obligations to Dr. Kelly for the extracts he was good enough to furnish me from his office in Rangoon; and also to Drs. White, Haneks, Pyster, and Marr for extracts furnished by them from the registers of Prome, Thaiet, Sandoway, and Moulmein.

River-system.—As regards the physical conditions of its surface, Pegu displays great variability, more so, indeed, than is often found within an equal area in India. Towards the mouths of the Irrawadi and within its delta, we have a tract of country of no less than 12,000 square miles in extent, which, with the exception of about 1,000 square miles of more or less elevated ground, occurring in patches in different parts, is almost everywhere characterised by its extreme flatness and low level. So low, indeed, is the level of vast tracts in the delta, that I calculate no less than 2,000 square miles, in round numbers, are actually below the level of a spring tide. This delta is bounded on the East by the Myit-ma-kha-choung, which, under the name of the Rangoon river, falls into the sea below that town, and on the West by the Bassein river, which enters the sea near Negrais island. The Myit-ma-kha-choung takes its rise in a swamp behind the town of Prome, and first receives the flood-waters of the Irrawadi, through some channels opposite and below the village of Poukteiu, 45 miles above the origin of the Bassein river at Tham-byadeing. Menghyee, situated between these two points, may be therefore assumed to be the apex of the delta for all purposes of calculation, in which case its Eastern and Western sides, measured from Menghyee to Elephant and Pooriam Points, marking, respectively, the entrances to the Rangoon and Bassein rivers, will be 129 and 176 miles, with a base between these points, measured as the crow flies, of 137 miles.

The Myit-ma-kha requires a passing notice here, as it rises in so unusual a fashion as to give countenance to the belief sometimes expressed, that it is merely a disused channel of the Irrawadi, of which it once constituted an important, if not the main channel. East of Prome a range of low hills having a general South-south-east direction, and stretching some 32 miles, divides the Myit-ma-kha valley from the Irrawadi. Below this point, the flood-waters of the Irrawadi find their way into the Myit-ma-kha, or the Myit-ma-kha's waters into it, according to the height of flood in either river at the time. Six miles East of Prome, on the edge of the sandy tract of country fringing the above line of hills to the eastward, and sloping down to the swampy basin of the Myit-ma-kha, stands the village of Mosa, with a flat champagne country in front of it, partly swamp, partly paddy-field, and diversified only by groves or clumps of Borassus Palm, which thrives wonderfully in this district, and is an important source not only of toddy, but also of the coarse sugar, or jaggery, for which the district is famous. In front of Mosa is a swamp, the waters of which discharge into the Naweng, a large stream in the rains, with a course about South-west-by-west, and falling into the Irrawadi two miles above Prome. Two miles South-east of Mosa is one of the many small feeders of the swamp in which the Myit-ma-kha rises; though this feeder can hardly be said to have any regular bed till it issues into the plain a few miles below the villages of Zyit and Toa-hpangain, situated 11 miles to the Eastward. Looking on the map, or even when standing on this flat ground, it seems that very little is required to deflect the Naweng into the Myit-ma-kha; and one is tempted at least to regard that stream as a sort of escape-channel for the flood-water of the Naweng, when ponded back by an unusual rise in the Irrawadi. From this view it is a very small step to look on the Myit-ma-kha as an old channel of the Irrawadi itself, now cut off by an alluvial bar, or shallow opposite Mosa, but formerly an occasional channel of the larger river. I believe both views to be without foundation, and that, flat plain as it seems, there is a sufficient rise in the general level of the ground to constitute an actual water-shed between the head-waters of the sluggish Myit-ma-kha and the eddying volume of the Naweng in flood, which sweeps past it but a few miles to the North. It is a far more open question, however, if a canal might not be easily cut, so as to deflect some of the water of the Naweng into the Myit-ma-kha, for the purpose of improving this as a navigable channel, as it is the great highway down which all the timber from the forests to the Eastward finds its way to Rangoon; but this is an engineering question easily determinable by a few cross-levels from one stream to the other.

From Menghyee, the assumed head of the delta, to where the Irrawadi crosses the frontier, is 92 miles, and the general course of the river may be taken as coinciding in direction with a line drawn through Prome and Henzada, having a bearing North-west-by-north.

On the East bank of the Irrawadi, only three streams of any importance enter the river, *viz.*, the Kini stream, 6½ miles from the frontier, the Boolay stream, 11½ miles below the Kini, and the Naweng stream, 26½ miles below the Boolay, and 2 miles above Prome. On the West bank, the only important streams are the Mahtoan, 3 miles above Kahmah; the Muday, 31 miles below Kahmah; the Thahn-ni, 6½ miles below Pudoung; the Thalaydar, 4¾ miles above Akouktoung, and the Tsandah, 4 miles above Myanoung. The whole of these streams pour down a large body of water during the rains, but shrink to small streams during the rest of the year.

All these streams, however, from the presence of quicksands at their mouth, present difficulties to the traveller; and in the case of elephants and cattle, a considerable detour is necessary to obtain a firm fording place. The most formidable in this respect are the Naweng and Boolay, though they intersect the so-called military road to the frontier, and yet remain unbridged after 20 years' occupation.*

One remarkable feature which must not be overlooked in any physical description of the Irrawadi valley, is the general narrowness of the actual bed which the river has carved for itself through the plains. In no part of the course of the Irrawadi do we see such a vast breadth

* This is all the more remarkable when the enormous sums of money are considered which are expended on roads and culverts, where no such expenditure is needed to meet actual risk, difficulty, or danger. If the cost, labor, and materials, expended on the numberless little culverts and trumpery bridges which can in no way be regarded as essential to traffic, had only been expended on such dangerous spots as the Naweng and Boolay, these formidable streams might have been bridged ere this three times over. Where is the use of a Railway to Prome, if between Prome and the frontier two such dangerous streams as the Naweng and the Boolay are allowed to remain unbridged? It is a new illustration of the hankering for ruffles before the owner is possessed of a shirt?

of river channel, or ground occupied by river deposits, as we see in the valley of the Ganges, where these cover entire districts, but merely a well marked channel rarely exceeding 3 miles in breadth, and which is barely sufficient to give delivery to ordinary floods, though of this narrow area but a small portion is occupied by the cold-weather channel of the river. At no place does the width of the stream between its permanent banks* carved out of the older alluvium exceed 6 miles; and it only attains this unusual width at Tham-bya-deing, where the Western bank of the river is very low, and has been subjected to very destructive erosion at the point or outlet where the Bassein river is given off. Indeed, considering the low nature of the country, and a fall which, I believe, exists from the Irrawadi at this point to the Bassein river, it seems not improbable that this cutting back, would, if left unchecked by man, prove the first step towards the formation of a great delivery channel of the Irrawadi into the Bassein river, along the course of the small creek before alluded to, which has now been closed by the engineers. At Prome, 48 miles above Menghyee, the assumed head of the delta, the ordinary flood-rise of the Irrawadi according to Colonel Stoddart (*vide* Report in Supplement to *British Burmah Gazette*, September 17th, 1870, and original in Public Works Department Office), is from 33 to 34 feet above the lowest level of the river; but in 1868, the great flood of that year rose to a height of 36·23 feet, or 2 feet higher than any previously recorded flood. The discharge per second during the great flood, was 1,424,000 cubic feet per second, whilst the discharge of an ordinary flood amounts only to 1,312,000 cubic feet,†

* My use of the term 'permanent banks' may be objected to, as high floods establish a spill over them; but as they are carved out of the older alluvium as distinguished from the modern river's deposits, I believe my use of the term is correct.

† I have been given to understand by J. R. Gordon, Engineer at Henzada, that by a series of careful and extended experiments he has found that the calculations of discharge made by Colonel Stoddart are somewhat below the truth, the ordinary flood maximum of 31st August 1872 giving a discharge per second of 1,442,007 cubic feet with a mean velocity of 6·451 feet per second.

with a surface slope of between 3 and $3\frac{1}{2}$ inches per mile, and a mean velocity of 3·90 miles per hour. When the discharge at Prome reaches 1,182,000 cubic feet, the permanent banks of the river opposite Myanoung begin to be capped by the flood, which finds its way across country into the Myit-ma-kha stream, submerging vast tracts at the head of the delta, and in this district, it is not uncommon for horses and cattle to be penned in dwelling houses built on supports, having several feet of water under them, and for two or three months only approachable by boats.

The above description of the Irrawadi may not exactly suit the views of those who would divide all rivers into either *excavating rivers* or *depositing rivers*, but if facts interfere inconveniently with theory, so much the worse for theory. As a matter of fact, the Irrawadi has carved for itself a passage, adequate for its ordinary discharge, but inadequate for an extraordinary one. I presume some such period must have been passed through by all rivers, which have by slow degrees excavated their own channel; and to my mind it seems the most natural thing possible, though it may necessitate our classing the river so situated as an excavating one at one period of the year and a depositing one at another. Indeed so far as the river is itself concerned, and apart from all elevatory movements, a river can only be termed an excavating one (save in the most passive of all passive senses) when it periodically, is a depositing one also, that is, when its channel is insufficient for occasional floods, which create a *spill* over its banks, and deposit silt. Till this ceases to occur, the river is still engaged in enlarging its channel, the ultimate efforts, like that of a balance seeking equilibrium, being necessarily slow; but for my part I see little gain in any hard and dry classification of rivers into these two classes, or attempting to draw a more rigid line than nature does.

The true test of whether a river belongs to the category of excavating or depositing, depends, not on any process of modification in the formation of its proper channel *per se,* but on the larger question of whether it runs through an area undergoing elevation or depression. A river in the former case being an *excavating* one, in the latter a *depositing.*

As I have elsewhere stated and argued, and restricting the assertion to the lower portion or delta of either river, the Irrawadi gives us an example of the former; the Ganges of the latter. The Irrawadi ploughs its way to the sea unhesitatingly and undeviatingly (whence its narrow channel, on which I have so much dwelt) through plains of homogenous alluvium, mainly, as I hold, deposited under estuary conditions, and identical, in every particular, with the deposit now forming in the Gulf of Martaban, of which they are simply the extension, above the limits of the sea; whilst the Ganges hurries to the sea, through a delta, composed of its own proper fluviatile deposits as distinguished from the homogenous or older alluvium of Bengal, whereon they rest with a thickness of 60 to 80 feet at Calcutta, and the very existence of which in one case and non-existence in the other, sufficiently reveal the contrasting conditions of the two areas. But on this I shall enlarge in another place.

Hill-ranges.—The main orographical features of Pegu are extremely simple, the two main ranges of the Eastern and Western Yomah, being two hill systems bounding the valley of the Irrawadi, whose simplicity of structure, viewed as a whole, is the result of the uniformity of the forces to which their elevation is due; and this remark will probably be found to hold good of the ranges running parallel with them to the Eastward, *viz.,* the Poungloung and the Great Salwin watershed, which separates the basins of the Salwin and Sittoung.

The minor orographical features, or subordinate hill systems and surface arrangement, into which the main range is sub-divided and parcelled out, are more varied and complex; since, being mainly due to the abrading powers of rain and rivers, their shape and direction is considerably modified by local circumstances, as the character of the rocks, their hardness, any geological irregularity in dip or strike, and such secondary agencies, as vegetation, rainfall, &c.

Marine denudation, whatever part it may once have played in abrading the land, has left few or no traces of its action (save perhaps along the coast) in Pegu, any traces of it which may have existed, having been effaced by the energetic atmospheric or aerial denudation which, in Pegu perhaps more than in most countries, displays its prodigious power in carving out the land and modifying the surface whereon it works. In tropical countries, where aerial denudation is strongest, the dense growth of forest and underwood greatly interferes with our actually taking in at a *coup d'œil* the progress or results on a large scale of the work; but exceptional causes occasionally allow a more perfect view, and a rich sight it is to the observer so favored. This once fell to my lot in the Arakan hills in about lat. 17° 30′. The hills are here covered for miles with a small species of bamboo (*B. baccifera*), which, according to native report, fruits once in 30 years. After fruiting, the plants die off and are readily consumed by fire, leaving the hill sides as completely bared, as though they were situated above the range of vegetable life. The illusion is heightened and a weird aspect imparted to the landscape by the grayish coating of ashes spread over the whole mountain, relieved only here and there by a charred stump sending up perhaps a thin curl of smoke, or the reddened walls of burnt clay, of a whiteant's nest, projecting above the surface. Viewed under these conditions, the full potency of aerial denudation and the part it has played in carving out the surface features of the Arakan Range, from crest to valley, stands confest, and the impression created is rather that of gazing on some well-executed model or panorama, than on an actual portion of the earth's surface, as it ordinarily exists, divested of its forest garb and temporarily bared to our view.

The Pegu, or Eastern Yomah, stretches uninterruptedly 156 miles from the frontier to a point about 30 miles North of Rangoon, with a general direction North-by-west. From this point, where as a hilly range it may be said to terminate, it is still continued as an elevated ridge of ground, as far down as Rangoon, and past Syriam as far as Kyouktan, where it finally disappears beneath the alluvial plains of the delta, being last seen in some rocks which crop up in midchannel of the Hman-won-choung.

According to Lieutenant Williams (Selections, Records of the Government of India No. XX), the Pegu Yomah attains its maximum elevation of 2,000 feet in lat. 17° 55'. From this to the frontier the height varies from 800 to 1,200 feet, in which respect it differs from the Western Yomah, whose highest portion is near the frontier, which its geological composition may help to explain.

The general character of the hills throughout the Pegu Yomah is everywhere much the same. The hills, though nowhere rising into such imposing masses as may be seen in the Western Yomah, yet, as a rule, are extremely steep, and the valleys sharply excavated. This peculiarity depends partly on the soft character of the shales and earthy sandstones constituting the range, and partly on the heavy rainfall of Pegu; and but for the protective effect of vegetation on the surface, a much more active denudation than at present would take place.

The Arakan, or Western Yomah, which stretches almost uninterruptedly from the frontier to a little South of Cape Negrais, a distance, in a straight line, of 247 miles, observes a rude parallelism with the Eastern Yomah, but is somewhat less regular, forming an irregular curve, with its concavity facing the West or towards the Bay of Bengal. In some places, as West of Bassein, and again further to the South, the range sinks down, and does not probably exceed 200 feet in altitude; but towards the frontier its peaks attain a height of probably double that of the highest part of the Pegu Yomah, and some of them do not, I imagine, fall short of 5,000 feet. In this, the Northern part of the Yomah, the mountain scenery is remarkably fine and picturesque, which, in some measure, arises from the higher peaks being covered with grass, and with but little forest here and there interspersed, which at lower altitudes clothes the whole hillside with one uniform mantle, and masks completely the features and arrangement of the ground. Near the frontier, the Arakan range bifurcates into an Eastern and Western branch, which feature is better displayed in an unpublished frontier survey in the Quartermaster General's Office, than on the published map of the province on a smaller scale. On the Eastern branch of the Arakan range, two peaks stand out prominently, Boamadoung, about 4 miles from the point of bifurcation, and Kidoung, close to the frontier. Between these peaks, the range is deeply cleft, to allow of the passage of the Mahton stream, and nothing can exceed the picturesque beauty of the forest-clad gorge of the Mahton where it crosses the frontier. The Western branch, or main range as it really is, continues on from the point whence the Eastern branch is given off, with apparently an increasing elevation beyond the frontier, where one of its peaks forms the triple boundary between the provinces of Arakan, Pegu, and the dominions of the king of Ava; and at this point, the Eastern and Western branches of the Arakan Yomah are eight and three quarter miles apart. Twenty-six miles from the frontier following the general direction of the range, which thus far is North-west-by-north, stands the remarkable hill of Shuay-doung, or Shuay-loung-gi. This hill, though inferior in height to some peaks nearer the frontier, yet, when viewed from any point in the plains, presents a far more striking appearance than any other hill in the Province. This is partly due to the diminished height of the hills in its immediate vicinity, an effect considerably heightened by the peculiar manner in which Shuay-doung stands forward from the other hills which might compete with it, and partly from the mode in which it has weathered into crags of the sharpest and most precipitous forms, so that the hill stands out in relief against the sky as though chiselled out of a single block of stone.

In the Records of the Geological Survey, No. 2, 1871, page 40, I thus describe the peculiar manner in which the hill stands out from the main line of the range:—"It is situated between the sources of the Hlowah and Paymyouk streams, and marks a remarkable change in the Arakan Range, of which in some respects it is the culminant peak. Instead, however, of the range continuing its course Northward past Shuay-doung, it here takes a sharp sigmoid curve to the Westward before again tending North, giving thereby the appearance to Shuay-doung of standing out from the main range, like a promontory, round which the sources of the Hlowah wind, so that the drainage pertaining to the mountain, received by the Hlowah and Paymyouk streams, represents an arc of no less than 300 degrees at least, with the hill as a centre."

From Shuay-doung as far down as where the Tonghoop road crosses the range, a distance of 38 miles, the range tends South-south-east. South of the Tonghoop road as far as Lat. 17° 30′, a distance of 78 miles, the general direction of the range is South, veering round for the rest of its length as far as Hmandeng or Pagoda Point, a distance of 114 miles, to South-south-west, though its direction is not quite regular over the entire distance. The elevation of the Western Yomah has been approximately determined at a few points South of the frontier. Near the frontier some peaks do not probably fall short of 5,000 feet in height, but South of Shuay-doung a diminution occurs in this respect, and at the Tonghoop road, the highest peak, Shoukben-toung, is only 3,200. Opposite Myanoung, the peak of Sab-ka-pon-toung is 4,003 feet (the highest peak that has been measured), whence the height rapidly diminishes, till in Lat. 17° 30′ the mean height of the peaks would seem to be about 1,400. South of this, the range steadily decreases in height. West of Gna-theing-khyoung it is only 892 feet, and 25 miles further South, on the Baumi Pass, this is reduced to only 270 feet. South of this to Pagoda Point the height ranges between 200 and 400 feet, in some spots probably falling below even 200; the lofty forest vegetation, however, greatly interferes with anything like a general view of the country at such low elevations as these.

III.—General Stratigraphy.

I will now preface my description of the particular groups met with in Pegu, with some remarks on the general geological constitution of the valley of the Irrawadi, more particularly as it has reacted on the physical configuration of the surface. Reference may also be made to previously published notices by myself, in the Records of the Geological Survey of India, Vol. II, page 79; Vol. III, pages 17 and 72; Vol. IV, page 33; Vol. V, pages 79 and 120.

The geological history of Pegu and the country adjoining it (for the two must to some extent be included in any general and comprehensive review of the past), is extremely simple as regards its grander and more cardinal features, a simplicity to some extent indicated and portrayed in the general geographical features of the province as already described; and what is true of the lower portion of the Irrawadi valley will, no doubt, largely apply to the upper portion also, which at present is very little known, save in the immediate vicinity of the river.

In both the Eastern and Western Yomah, we have an instance pure and simple, as far as possible, of the formation of a great mountain chain through the direct operation of lateral pressure; causing a folding and, as a result therefrom, an elevation of the sedimentary beds, along a line or lines of least resistance, which lines, or the principal among them, coincide in direction with the axes of the mountain chains so produced; and we have very generally wanting in the Western or Arakan Yomah, and completely so in the Eastern or Pegu Yomah, any complex system of faulting on a large scale, or intrusion of igneous rocks, whether in a solid or fluid condition, which adds such an element of complexity to the historical record of the genesis of such chains as the Alps.

As a conjoint result, with the production of an anticlinal fold, is the simultaneous production of a synclinal trough; and in this dynamical truism we have the primary means whereby the main physical features of the province have been determined, and on which the minor and ultimate details of surface configuration have been subsequently impressed.

The proofs that such has been the history of the formation of either Yomah are simple enough, and consist in the condition and arrangement of the beds composing the ranges in question. Whether we examine the Eastern or Western Yomah, the same general section and arrangement of beds is displayed in either, the beds being tilted up and folded (the prevailing dips being at right angles to the axis of the range) across the whole breadth of mountainous country, to which I here comprehensively apply the term Yomah, and which embraces a number of parallel ranges of various heights and extent.

It is not my intention to enter into any discussion as to the causes which have produced the lateral pressure in question; sufficient it is that the conditions of the beds demonstrate its existence, and that an adequate and proximate cause, though not the ultimate one, may be supposed in the forcible compression of the unyielding beds at the immediate surface from failure through shrinkage of support below; or, in other words, such mountain chains as those bounding the Irrawadi valley are puckerings of the earth, crust along lines of least resistance produced in the same manner, mechanically speaking, by lateral pressure, as the 'creep' which takes place by degrees in the floor of a deserted coal gallery—making the necessary allowances when comparing great things with small.

It may be asked, what is it that determines the straightness and parallelism of these presumed lines of weakness, granting that such exist. It must be admitted that no such effect is ever produced, as the formation of a great mountain chain, in an accidental manner, or other than through the operation of fixed laws, and the question, therefore, above raised is a pertinent one. In the present instance, however, I shall waive any theoretical discussion which might seem to bear on the question, and endeavor to offer a solution of the phenomenon before us by travelling a little beyond the actual area of Pegu. It must be borne in mind that the Arakan Range is the most Westerly, not of two, but of several parallel ranges, whereof the second is the Pegu, and the third, as we proceed in an Easterly direction, the Poungloung Range, loftier than either, which separates the Sittoung from the Salwin. The Arakan Range, it will be seen (if we except a small portion near the frontier, composed of beds of Triassic age), is wholly composed of beds of early Tertiary age resting, it may be presumed, on Cretaceous beds which rise to the surface in Arakan on the Western side of the range; whilst the Pegu Range is composed, as far as we know, wholly of beds of later Tertiary age; these two ranges together embracing a belt of country having an East and West breadth of nearly 150 miles and almost wholly made of Tertiary deposits.

The third or Poungloung Range holds the same general direction as the others, and although it has not been so completely examined as they have, yet enough is known of its composition to throw considerable light on the relations between it and the others, as it consists of two distinct groups of rocks, an older and metamorphic one, and a younger one of Carboniferous age, to which the picturesque limestone-ranges bordering the Salwin, and the grotesque insular hills of the same rock near Moulmein, belong.

The Poungloung Range in fact forms approximately, a portion of the margin of that vast oceanic basin wherein the Secondary and Tertiary deposits now met with to the West of it were deposited; and we may feel sure that, whatever may have been the determining cause of *its* direction, we see in it a perfectly adequate and potential cause, for the direction and parallelism of the ranges to the east of it, composed of such very much younger groups. Of the comparatively recent origin of both the Arakan and Pegu Yomahs there can be no question. Without placing undue reliance on the presumed but not established age of certain masses of limestone at Gwa and Baumi, it may be safely assumed from the general arrangement of the Nummulitic strata, that at that period the Arakan Range had been hardly more than lined out along the bottom of the Eocene ocean; and if, considering the probably joint origin of these twin ranges, we assign the same age to both, then the age of the Arakan Range must be still younger, since indubitably the Pegu Yomah could hardly have taken shape and form before the later Tertiary period, or have experienced its final elevatory movements before the post-Pliocene period, if indeed it is safe to infer that such have even now ceased, a view I am inclined to question. Indications of elevation during a very recent period are not wanting in Arakan, along the coast, in the shape of raised beaches, in the physical aspect of the country, and even in native tradition; and though we might safely infer a greater amount of elevation along such an axis of elevation as the Arakan Range, the opposite supposition that a rise of the coast was confined to it, and not participated in by the mountains behind it, would be, *primâ facie,* highly untenable and require strong evidence in its support.

Towards the frontier the central mass of the Arakan Range is composed of a well-marked group of beds, to be noticed as Axials. They are of Triassic age, to judge by the sole recognisible fossil they have afforded, the *Halobia Lommeli Wissm,* a species also found in the Triassic rocks of the North-Western Himalaya, the "*Lilang series,*" (*vide* Memoirs, Geological Survey of India, Vol. V, page 50). The relation of these Triassic beds to the younger groups is not so clearly made out as is desirable, and their boundary on the Western or Arakan side of the range is altogether unexplored. On the Western side of the range, it is, however, certain, from a cursory examination along the outer ranges, that a very great thickness of beds of Cretaceous age intervenes between the Axial group and the Eocene Tertiaries, and the probability seems to be, that on this side of the range, the Axial beds form a natural boundary for the newer groups resting on them.

On the Eastern side of the range, however, the case seems very different. The beds along the Axial boundary are tilted up at a high angle, and subjected to great disturbance and pressure; the beds in contact with the Axial group being presumedly Nummulitics. The only supposition, therefore, which seems to accord with the above fact is, that the Axial beds form a narrow wedge possessing a natural boundary on the West, on which side a great thickness of Cretaceous strata is seen to intervene between them and the Eocene rocks; whilst on the East the Axial group is faulted against the Eocene group, to the exclusion thereby of the Cretaceous series. This fault attains its maximum throw (the upthrow is to the West, downthrow to the East) at the frontier, from which it gradually dies out to the South, where by its so doing the Axial beds disappear beneath the newer groups finally in that quarter, and are no more seen.

If this is not the relation of the two groups, and if no fault is interposed between them, then the whole of the beds given as Nummulitic in the Hlowah section must belong to the Cretaceous period, and represent the bottom beds of that group; but I do not think that this is the case, and merely state it as an alternative view, which in total default of fossil evidence throughout the beds in question, it is as well to bear in mind. An argument against it, is moreover in the occurrence not far from the spot of a mass of Nummulitic limestone close to the Axial boundary. Now, if the boundary is not a fault, there must be prodigious unconformity between the Nummulite limestone and the beds whereon it rests; but no such unconformity in the sequence of beds wherein the Nummulite limestone appears as an integral member, is elsewhere suggested by any sections wherein the relation of that rock to the beds around it is seen. In using above the term 'alternative', I of course dismiss the idea that the great thickness of Cretaceous strata seen on the Western side of the range was confined to that side by the limitation of the basin of deposition by the range in question; as such a supposition is opposed to the general physical features and history of the entire area whereof that portion of the range at present in question forms but a very small portion. There is no evidence whatever in favor of the idea (a strong presumption, however, existing against it) that whereas the entire series of deposits from the Eocene upwards accumulated in a broad basin of deposition, not broken up by the formation of any such mountain barrier as the Arakan Range till a subsequent period, yet that any such barrier or surface of deposition as would be requisite to account for the restriction of the Cretaceous group to the limits it now occupies should have existed, without any other trace of its existence save the feature under notice, which seems most naturally accounted for by a master-fault.

I have attempted to represent in a diagrammatic section the view of the general structural features (*See* Pl. I), but it is not in Pegu, that the unravelling of the relations of these groups to each other, can be looked for; nor, from the nature of the country, can much more be expected to the North in Arakan, where, if the rocks are better developed, the nature of the ground is no less opposed to investigation than in Pegu.

It is among these Triassic rocks that the largest development of serpentine occurs; but it is not confined to them, and is met with among beds classed by me as Negrais, possibly indicating an age for these outbreaks not older than the earliest Tertiaries. A reference to the map will, however, best serve to convey an idea of their general disposition in the province.

In the Eastern Yomah, no intrusive rock of any sort occurs, the trappean bed near Zen and elsewhere not falling within that category, though in hand-specimens pieces of that rock might readily be mistaken for an intrusive rock. The remarkable occurrence of an outcrop of trachyte in the Bassein district will be described in another place.

The rocks will be described in the order given in the following tabular statement, in which the word 'group' has to be taken somewhat freely, *e. g.*, the Negrais group is a band of metamorphism rather than a definable stratigraphical division.

I.—NEWER ALLUVIUM	*a.*—Blown sand	RECENT.
	b.—Littoral concrete	
	c.—Mangrove swamp	
	d.—Recent alluvium	
	e.—Regur	
II.—OLDER ALLUVIUM	*a.*—Older alluvium	
	b.—Sands and gravels ...	
	c.—Laterite	
III.—FOSSIL-WOOD GROUP	... ...	POST-PLIOCENE TO PLIOCENE.
IV.—PEGU GROUP	... ...	MIOCENE.
V.—NUMMULITIC GROUP	... ...	EOCENE.
VI.—NEGRAIS ROCKS	... ...	LOWER EOCENE TO CRETACEOUS.
VII.—MAII GROUP	... ...	CRETACEOUS (Cenomanien).
VIII.—AXIAL GROUP	... ...	TRIASSIC (*Lilang series.*)
IX.—MOULMEIN GROUP	... ...	CARBONIFEROUS.
X.—GNEISS OF MARTABAN	... ...	?

TRACHYTE. SERPENTINE. GRANITE. ELVAN-DYKES.

IV.—Newer Alluvium.

Blown sand.—The first of these marine beds, if I may so term it from its intimate relation to the sea-shore, occurs at a few places along the Arakan Coast, though the sand dunes rarely attain any great height. Where there is a considerable spread of these sand dunes, they form a grazing tract for buffaloes, as a small supply of brackish water is usually obtainable from shallow wells sunk along their landward slope. Between Cape Negrais and Pagoda Point a somewhat similar formation attains some importance, but is rather more earthy than sandy, and from its reddish color, viewed from a distance, is termed 'kahn-ni' or '*red bank.*' From this to Kayntuli, these sand dunes occur in spots favorable to their formation, that is to leeward of an extended tract of sandy beach; but North of Kayntuli they are less frequently met with.

Littoral concrete.—All along the Arakan Coast a deposit of somewhat similar origin, only coarser and distinctly accumulated under water, is commonly met with along the course of many of the less-sheltered tidal creeks. This deposit was found at several spots South of Kayntuli by Mr. Fedden, and described by him under the vernacular name of 'Loon Kyouk'; but it is identical in all respects with what has received the comprehensive name of 'littoral concrete' in Bombay by Carter and other writers which precisely describes its nature. It is in fact merely the calcareous sand composed of comminuted shells and corals of living species, consolidated into a more or less compact calcareous sandstone or ragstone, and displaying the same local variations as are seen in the deposits now forming along the Indian shores. It is a deposit of a very porous character, and often yields a supply of very sweet water, being free from organic or other impurities, save perhaps in some places a little salt.

Mangrove swamp.—Where the above littoral concrete does not form the banks of the tidal streams of the Arakan Coast, its place is taken by the fœtid mud, or sand and mud of the mangrove swamps. In low lying spots within the tideway, whether mud or sand predominates, the deposit is equally offensive, the whole area being marked, by a peculiar flora, and by the abundance of the strange crab, *Thalassina scorpionoides.* Geologically considered, however, the deposit is insignificant, being extremely superficial, and rarely covering any great extent of country beyond the immediate vicinity of the tidal creek.

Recent alluvium.—The recent alluvium, that is, the deposit thrown down by the water of the existing Irrawadi, occupies a very small area in Pegu. Its relations have been already pointed out in the Records of the

Geological Survey (No. 1 of 1870), and a mere recapitulation will therefore suffice here. From the frontier to a little above Pantanau, this deposit follows very closely the existing bed of the river, nowhere attaining a greater breadth than 6 miles, or on an average not more than half that. Sixty square miles was what, by a rough calculation, I estimated it to cover in the above distance. At Pantanau, however, occurs a remarkable depression along the channel of the Irrawadi, which I may term the navel of the delta. This patch of newer alluvium, which evidently occupies a silted-up depression in the surface of the older alluvium, covers an area of 140 square miles, making a total of 200 square miles occupied by the newer or Irrawadi alluvium, which I shall discuss at greater length presently, in connection with the older deposit universally spread over the province outside of the limits of the hills.

Regur.—The term 'regur' has been adopted by Indian writers to express one of the many varieties of soil met with in India, characterised by its dark color, and suitability for the cultivation of cotton, whence it is also called the 'cotton soil.' It is a light soil, ranging in color from blackish to gray, *but devoid of any tinge of red*, and frequently contains fragments of agates and other trappean minerals. It is also more or less calcareous, though not so rich in lime as the older, red, or kunker clay, which underlies the whole of the Gangetic valley.

It would be foreign to my purpose to discuss the different theories held by previous writers as to the origin of regur, which may, however, be seen by referring to Carter's "Geological Papers on Western India," Bombay, 1857; but the mode of occurrence of regur in Pegu is too peculiar to be passed without comment, especially as it entirely supports the view of those who hold regur to be derived from decomposed trap, a view always held by myself, from a study on the ground, of the relation of regur to trap areas in the Rajmahal hills and Narbada valley (*vide* Records, Geological Survey, Vol. II, page 298). I have never, of course, entertained the idea of any other connection between regur and trap, than that many trap rocks in India do as a matter of fact decompose into regur, though of course many do not, the result being simply dependent on the composition of the trap in question; and hence, of course, the fact of much trap decomposing into quite a different soil was quite in unison with the admission than any rock, even though non-trappean in character, might give rise to regur if its composition was such as to yield the requisite elements. The fact of the existence of hundreds of square miles of regur where no trap is now known, though not without force, has never appeared to me so conclusive as to some of my colleagues, since the decomposition and removal of the trap is antecedently involved, in the very genesis of regur (from trap); and it is only consequently in the great trap regions, and on their skirts, that the actual derivation can be ordinarily witnessed of one from the other. I cannot here do better than quote from the Gazetteer of the Central Provinces, the views so succinctly expressed on the subject by Dr. Oldham, under the head 'Regur,' page XLVII: "Regur can then be formed wherever a truly argillaceous soil is formed, and its general, but by no means universal absence over the metamorphic and other rocks, is easily accounted for by the fact that these rocks for the most part yield sandy, not clayey soils."

It remains, however, that as a matter of fact, it would seem that the trap rocks of India have more largely and directly contributed to the formation of regur, than any other description of rocks, whence, the too hasty assumption that all regur was derived from trap. Dr. Oldham again remarks (*loc. cit*)—"The color of this soil, often a deep and well marked black, with every variation from this to a brownish black, would appear to be solely due to an admixture of vegetable (organic) matter in a soil originally very clayey." This doubtless is often, perhaps generally the case, but a series of analysis are, I think, required to show that to no other cause than this is the dark color due, since the massive trap rock weathers black on the surface, which must be due not to the presence in the rock of organic matter, but to some superficial condition of the iron or some other components of the rock.

The first intimation I received of the occurrence in Pegu of a soil which I consider myself as justified in terming regur, was from an intelligent native official at Menghi, no less than 80 miles to the South of the spot where it occurred. The Burmese are close observers of natural peculiarities in rocks and stones, and this Burman asked me if I had heard of, or could explain the reason of one hill being covered with black earth, whence it derived the name of Minet-toung (the black hill), by which it was known far and wide. I afterwards discovered there were two 'Minet-toungs', called from the villages nearest each respectively, Zen Minet-toung and Pebingoan Minet-toung, distant from the former 4 miles in a West-south-west direction; the latter I should estimate as barely a quarter of a mile in diameter, the former at perhaps three times that size. The entire country consists of shale and sandstone of Miocene age, forming hills with a somewhat tame outline, though the valleys are rather deeply cut in these soft and unaltered strata.

Viewed from Zen, Minet-toung appears to be one of the highest points in the hills to the South, forming a regular conical eminence above the hills in its neighbourhood. The ascent to Minet-toung from a Chin village near it, lies at first over the ordinary sedimentary beds, to about a little better than a quarter of a mile from the summit, where the road is seen to enter on what has the appearance of grayish decaying trap, which I shall presently show to be a bedded trap, in reality, an integral member of the sedimentary group; and this rock forms the entire summit of the hill. The whole of the surface is much decayed, but in some places the underlying rock has resisted decomposition, and presents the appearance of a trap decomposing into regur. On the slopes of the hill the soil is gray, but at the summit it passes into a perfectly black regur, undistinguishable from a dark colored typical regur of Central India. Precisely the same features of surface are seen on a smaller scale at the Pebingoan Minet-toung. Whilst the mode of occurrence of regur at these two spots gives striking and unequivocal support to the view of the direct derivation of at least some regur from the *in situ* decomposition of a suitable trappean rock, it no less shows the connexion between the darker hue of the soil and certain paludal conditions present; for thus I should explain the greater intensity of hue of the soil at the top of the hill than is seen lower down its slopes, the drainage and removal of surface water being of course much more complete in the latter than in the former position.

At a third spot, nearly equidistant from the two abovementioned, the same bed of trappean character is seen crossing the hills; and a narrow band of regur here also marks its outcrop, as at either of the abovementioned *Minet-toungs*.

It may here be remarked that the formation of regur from the *in situ* decomposition of certain beds of the Deccan and Central India traps is a process coeval with the existence of those rocks; for what is the black jaspideous rock so often seen crammed with Lymnæas, Physa Prinsepii, and other fossils of the Inter-trappean fauna, but an ancient regur, formed, as we now see it to be, by the surface decomposition of trap, accumulated in depressions of the then surface of the country, and finally baked into a jaspideous mass by the outpouring over it of the next flow of trap?

V.—Older Alluvium.

The older alluvium, or emphatically *the* alluvium of the valley of the Irrawadi and of Birmah generally, consists of an homogeneous deposit whose general relations and character I have already sketched in the Records of the Geological Survey of India, No. 1 of 1870. A little recapitulation here is therefore unavoidable. This deposit may be divided into (*a*) an upper and (*b*) a lower portion; the latter (*b*) of irregular development and consisting of coarse gravels transported from a distance with large included masses of silicified wood derived from the neighbourhood, whilst the former (*a*) consists of a very homogeneous clay differing mainly from the older clay of the Gangetic basin, by being less rich in lime, but otherwise resembling it in general appearance and mode of deposition and arrangement.

(*a*). *Older alluvial clay.*—This deposit (with the exception of the trifling patch of newer alluvium below Pantanau previously described) comprises the entire level plains of Pegu, within the valley of the Irrawadi and the alluvial plains of the Sittoung valley also, the two deltas so blending to the South that no distinction can be made between the deposit in either, unless perhaps the alluvium in the Sittoung valley is slightly more sandy than that along the course of the Irrawadi.

This clay is in constitution very homogeneous, somewhat arenaceous, decidedly more so than the older alluvial clay of the Ganges valley, and of a uniform yellowish color, in places assuming a more reddish color than usual, and under certain conditions of exposure and weathering assuming an imperfect lateritic appearance superficially. The last appearance is usually seen in the sides of wells, and is indicated by the peculiar mottled appearance the rock presents from the irregular manner in which the peroxide of iron arranges itself. The whole deposit is very homogeneous, a little more sandy in some spots than in others, and with occasional thin layers of sand irregularly and sparingly dispersed through it; the only recognisible band possessing a distinctive character in it, being a dark layer of a few inches only in thickness, but of wide distribution. Judging from this band the whole deposit would seem to have a gentle slope to the South, at a somewhat greater rate than the present surface of the country; for whilst above Myanoung this dark band is clearly seen high up in the bank and but little below the high flood level of the river, in the tidal parts of the delta it is found at about the level of midwater mark or lower. Whenever conveniently exposed for the purpose, this dark clay is dug in preference to the other for the manufacture of the coarse earthenware of the district.

The concretionary argillaceous limestone, commonly known as 'gooting' or 'kunkur,' is generally absent throughout the older clay in Pegu; and, where present, it occurs in small concretions quite insignificant in amount, and never in the pseudo-stalactitic and tabular masses seen in the alluvium of Northern India. This deficiency of lime, and its slightly more arenaceous character, are what mainly distinguish the Pegu deposit from the corresponding one in India. By 'corresponding' I do not, however, mean a strict correspondence in age; since in all probability the Pegu deposit is far the younger of the two, and, as far as actual age goes, probably corresponds more nearly to the earlier portion of the newer alluvium of Bengal. The correspondence meant by me between the older alluvium of Pegu and the older alluvium of Bengal is one of position rather than age, both being the deposit wherein the existing drainage system of the present rivers has been excavated; but without supposing that the formation of either deposit was more than cotemporaneous in part, as from general considerations of the relative magnitude and importance of them, a far greater age may, I think, be fairly claimed for the Bengal deposit than for that of Pegu.

Not to recapitulate much that I have said in the Records (loc cit), I may merely state that I am not aware of any fossils having been found in the alluvium of Pegu, which, on the supposition that this extended deposit is of fluviatile origin, is not a little remarkable. Putting aside the consideration of the probable occurrence of fluviatile and lacustrine conditions towards the upper portions of the drainage-basin of the Irrawadi, I have always inclined to the view of the estuary origin of the older alluvium, not only of Pegu, but of the Gangetic basin also. Two considerations guide me to this conclusion, *viz.*, 1*stly*—the negative evidence afforded by the entire absence, as far as my knowledge goes, of fluviatile and terrestrial mollusca from the older alluvial clay,—a deposit which seems peculiarly fitted for their perfect preservation; and 2*ndly*—the physical argument which exists in the complete homogeneity of the entire deposit, which seems strongly to militate against the idea of its being the result of river action.

With regard to the 1*st* argument, I am aware of the disfavor with which mere negative evidence is regarded, but it is not therefore to be altogether neglected. In the Narbada valley we find a clay not greatly dissimilar from the older alluvium of Bengal, and usually devoid of organic remains. At some spots, however, it contains land shells and mammalian bones (*vide* Memoirs of the Geological Survey of India, Vol. II, p. 279), and what is more important, two or three species of *Unio* with valves united and in the position they occupied in the clay during life. Now, neither in Bengal nor Pegu have any similar remains of freshwater Pelecypoda been found, though the conditions for their preservation are very similar to those which are present in the Narbada valley; and unless we suppose, which I am not prepared to admit, that a less careful and anxious search for fossils has been made in Bengal and Pegu than was made in the Narbada district, it is not easy to account for this almost total absence of organic remains if the conditions of deposition were identical. The presence of either land or freshwater Gasteropoda would certainly not prove the freshwater character of the deposit, as such are found in undeniably marine beds; but the evidence of any species of *Unio* having occupied the clay in a living state is indisputable; and this simple evidence of the lacustrine nature and origin of the older alluvium is, as far as I am aware, totally wanting.

The second or physical argument against the fluviatile origin of the clay is perhaps stronger than the last. It has been argued that the homogeneity of a deposit like that I am describing may be the result of the extremely small increments of sediment by which it has been built up, whereby no traces of bedding or intercalation of deposits of varying composition ever took place, and the final result was the homogenous one we see. This hypothesis is, of course, a possible one; but is there any river within the tropics where such a mode of deposition can be confidently said to have given rise to such a bed as we are dealing with? The Nile, of course, is cited in point; but one requires a better knowledge of its deposits before the cases can be compared. The inundation of the Nile may be strictly compared with the inundations of the Irrawadi; but the result is practically nil in the case of the latter river. It is open to great doubt if so much is deposited on the surface of the inundated country, save in the immediate vicinity of the river banks, as is removed from it by scour on the falling of the river, and the drainage of the country, which thereon takes place, as I will shortly explain. Anyhow, the superficial crust of fluviatile silt ranging, according to circumstances, from a few inches to a few feet, *is sufficiently distinguishable, as a rule, from the homogenous clay whereon it rests*; and to suppose that the whole of this clay has originated by infinitesimal accretions to a land surface occasionally flooded, seems not to be warranted by our experience of the behaviour of modern rivers, and least of all by such rivers as now occupy the area in question. It is difficult, indeed, to conceive a greater contrast between the composition of a deep bank of the older alluvium and a similar one composed of modern fluviatile deposits; and this contrast may be studied almost anywhere within the Gangetic valley. The ancient alluvium is a homogenous clay. The newer alluvium is compounded of beds ranging from a fine silver sand to a fat unctuous loam, thrown down not in extremely thin beds, but in strong one, 2 or 3 feet beds, which are often composed of thin laminar strata, but each thick bed representing the result of one flood. Thus far this contrast is simple, but the question doubtless remains if the other method supposed in the case of the spill of a river, whose annual inundation gives merely an infinitesimal addition to the surface growth of the country, would not adequately explain the homogeneity of a deposit like the older alluvial clay, without necessitating the supposition of estuary conditions? Stated thus, it can be only answered by a balance of probabilities, for the supposition involves conditions of which we have no certain knowledge to guide us. The condition and mode of arrangement of modern river deposits may be familiar to us, but this does not enable us to solve a purely supposititious case. What evidence there is from analogy with the present Irrawadi, would rather seem to be adverse to the idea of any such gradual increments taking place without leaving some mark or other behind them.

Local causes operate to place the Irrawadi during flood, very much in the position of a river which shall deposit the least possible amount of sediment over the area inundated by it, and this happens from the following reason. The delta of the Irrawadi is not only intersected by the river, whose flood waters spread over the country within the ordinary limits of inundation, but is bounded by hills, which gives rise during the monsoon to a number of streams of considerable magnitude, all discharging into the river. By a well-understood law of all rivers overflowing their banks, the land in the immediate vicinity of the main channels is higher than that more remote; hence it happens that by the time the flood waters of the Irrawadi have overtopped the banks, the land between the banks and the hills skirting the delta has been to some extent submerged, partly, from rain water, and partly from the flooded streams which have been ponded back by the rising of the main river. Most of the coarse sediment brought down by these streams is deposited as a sandy talus along the edge of the hills, whilst the water, depurated of sediment overflows the country, and on the rising of the river to its full height, opposes a perfect barrier to the spread of the river water charged with sediment, over the low-lying part of the country, which would be most benefitted by its deposition. Of course under surface conditions such as I have described, large tracts of country remain in the condition of jheels or swamps for half the year, and their coffee-colored waters, almost devoid of sediment, strongly contrast with the surcharged flood waters of the river, which wind like a ribbon of another color through them. Now, where the amount of deposition under subaerial conditions is thus reduced to a minimum, it seems to me open to serious question if the supposed intimate blending of one year's sedimental mite with the mites of preceding years can possibly take place in such a manner as to form an uniform and homogenous deposit; since, let the inundations subside ever so gradually, a scour must be set up on the subsidence of the waters proportionate in force to the area covered by the inundation; and as we cannot imagine such an effective inundation, effective that is to the extent of inundating the vast area covered by this older clay, without the intervention of a river of the first magnitude, we should hardly fail to find traces in its deposit, of those channels which could not but have existed, in such a drainage system as above imagined. Yet, as a matter of fact, I am unacquainted with any such channels or the trace of any such in the homogenous deposit under consideration.

There is another point which goes far in my mind to contravene the idea of the older clay being deposited from the waters of the Irrawadi when the whole country was at a lower level and the river was engaged in raising the general surface rather than in deepening its channel, and that is that along the Arakan Coast at various spots, remnants of the older alluvium can be detected near the hills, in some places almost buried beneath recent debris swept down by torrents from the adjoining hill sides. Now, these remnants of the older alluvium have clearly no connexion with the deposits in the Irrawadi valley beyond a similarity in. appearance, due probably to the deposits skirting the West base of the Arakan hills being derived from very similar rocks to those which contributed towards its formation on the East; but the arrangement of these remnants, and their proximity to the hills, rather point to their being the relics of a now nearly denuded belt of clays of littoral origin, strictly cotemporary with the deposit in the Irrawadi valley on the opposite side of the Yomah, and like it deposited in the sea when the land stood at a lower level than at present. During the South-west monsoon the whole of the Gulf of Martaban opposite the mouths of the Irrawadi, is a sea of muddy water, from which at the subsidence of the monsoon a considerable, wide-spread, and homogenous deposit must every year be taking place; and the conditions over the whole area are so similar and constant that I see no difficulty in supposing that the clay thrown down over that area should prove identical, if elevated, with the older clay of the Irrawadi valley. All then that my supposition of the marine origin of this older clay requires is, that a gradual elevation should have taken place whereby the sea was forced to recede to its present limits, and the estuary to yield to the encroachments of the land.

In the Records of the Geological Survey, No. 1 (1870), I have already contrasted the present conditions of the two areas within which the Ganges and Irrawadi respectively debouch. I will therefore very briefly touch on the arguments whereon I rely to establish the fact that, whereas the area of the Bengal Sundribuns is one of depression, that of the Gulf of Martaban and the Delta of the Irrawadi is one undergoing elevation. That the area covered by the Delta of the Ganges is one of subsidence, is accepted as established by the sections exposed in wells and borings near Calcutta, whereby we find that Calcutta is built on a thickness of some 60 to 80 feet of Gangetic deposits of partly fluviatile and partly marsh origin. Let us now endeavour to estimate the condition of the Delta of the Irrawadi, as to whether it is rising or subsiding. First of all there is the striking absence over the entire area (with the exception previously described near Pantanau) of any deposit homologous with the upper alluvium so widely spread in Bengal. The Delta is everywhere composed of the older clay; and the entire absence in the actual river channel of any newer fluviatile group of beds, as met with in

Bengal, appears nearly as good proof of the stationary or rising condition of the Irrawadi Delta as the presence of this important group in Bengal is of the subsidence of the area occupied by it. The conditions of the Delta of the Irrawadi correspond very closely, however, with the conditions which must have preceded the deposition of the newer alluvium in the Gangetic Delta; and all that is wanted besides time, to make the Irrawadi Delta a counterpart of that of the Ganges is, that it should be subjected to an equal amount of subsidence at such a rate as to allow of the growth, *pari passu*, of the newer or river alluvium over the surface of the subsiding land. Of this there is no trace, and subsidence is therefore not going on. The alluvial matter which, in the event of subsidence of the delta, would become effused over the country, building it up at top in a ratio approximating to the rate of subsidence, as we see has taken place in Bengal, is in Pegu swept out to sea, and being spread far and wide in the troublous Gulf of Martaban, goes to form a portion or continuation of the older alluvial bed, the growth of which, though checked within the delta by its elevation beyond the waters of the gulf, yet is continued beneath those waters, and follows unchecked the ordinary laws of growth of such deposits. It is impossible, where the elevation of such a tract as a delta is gradual, to point to any actual proof of such process more tangible or satisfactory than that above given; but the greater inclination of the dark band of clay previously noticed as preserving a greater dip to the South, than either the surface of the land or the existing river, is, as far as it goes, in favour of an elevatory movement of the whole country whose minimum effect is felt in the delta. Along the Arakan Coast, the elevation of the littoral concrete and in places corals, above the present tide limits, all point in the same direction, *viz.*, to a moderate elevation of the whole country in a recent period, and which there are no grounds for supposing to have yet ceased.

(b). Sands and gravels.—The older alluvial clay just described, rests in Pegu on a considerable deposit or bottom bed, as it may be considered,

of sand or gravel, varying much with locality, and made up of partly the detritus from the nearest rocks, and partly of gravel derived from more distant sources. At Nioungdon, at the top of the tideway, this bottom bed consists of clean sand with a few small quartz pebbles sparingly dispersed here and there through it; and it is the presence of this underbed of sand which so greatly favors the abrasion of the channel of the Nioungdon stream, and is the indirect cause of the broad shallow, just below the junction of the stream with the Irrawadi, which forms so great an obstacle to navigation. Higher up the river a few miles above Monyo, on the opposite bank, a large stretch of gravel and boulders is exposed, which is about the lowest point to which these very coarse gravels reach. There is here a small village named Shway-gyeing (gold-scratching), from the fact that a little gold-dust is occasionally obtained by washing the sands and gravels of the river bed here. The returns are, however, insignificant, and the gold obtained is in the finest possible state of division. Above this spot coarse gravels, as a rule, underlie the clay wherever it is cut through, an excellent example of which may be seen in the steep bluff opposite Prome. At this spot the gravel is some 30 feet thick, and its surface is not less than 60 feet above the flood level of the Irrawadi. The gravel here consists of well rounded lumps of the hardest silicious schists with a good deal of fossil-wood, equally well rolled and rounded. Two to 3 inches may be taken as the average size of the larger and more plentiful pebbles, but a few occur larger. The largest noted by me was about 6 inches in length of a hard trap rock, though such fragments are rare in it. At this spot there is no clay above it, partly from its having been denuded, and partly perhaps from the gravel of this spot being of unusual thickness. Under Thaiet-mio the gravel is still coarser, and contains large logs of silicified wood, well rounded and worn; but these have not travelled far, being derived from the denudation of the sand containing this wood, at sites only a few miles from the river on either bank. On the opposite bank, under the old fort of Miaday, boulders of a large size occur well rounded, of the hardest silicious schists, many being from 6 to 9 inches across, mixed of course with smaller sized ones and pebbles, in a somewhat irregular fashion.

These coarser beds at once suggest two questions, *viz.*, whence has this coarse shingle been derived and how transported. The hard masses of silicified wood are of course of local origin, as I shall presently show, but whence came the other ingredients? It is not only along the course of the river that these large boulders are seen. They are sparingly, and in some spots I may say profusely, scattered over the low outer hills in Western Prome, especially along the course of the Maday and Than-ni streams, ranging to a height (by a rude guess) of some 150 or 200 feet above the present stream level. They occur scattered over the hill sides, and are clearly beyond the power of the present surface drainage to move save by the force of gravity, as the gravel whereon they lie is acted on and removed by degrees in the ordinary process of denudation. The existence of these boulders and shingle scattered over the lower hills of Western Prome, clearly points to their having been there outspread at a period anterior to the formation of the present surface features of the district; and the difficulty of supposing their being scattered over the hill sides by any fluviatile action, is an additional argument for the marine origin of the group to which they belong. I doubt the capacity of any of the existing streams, to transport rolled pebbles 3, 4 or 6 inches in diameter; still more do I doubt the ability of such rivers, to wear down into rounded boulders, the hard silicious schists of which this gravel is so largely made up. Of course, as the existing streams and rivers traverse a country, which, to judge by the remnants still lying on the hill sides, was once covered with these well-worn boulders and gravel, their beds are full of such materials; but I greatly distrust the power of any such streams to have ever produced or transported such shingle.

The source whence these hard silicious rocks were derived, was for a long time a mystery. I felt it probable that they were derived from the hardest beds among the altered rocks of the Arakan Yomah, (the Eastern Yomah containing no rocks whatever of this character); but it was only after some years' search, that I found a bed of precisely the character of some of the hardest and most peculiar of the silicious rocks of this bed. The hill of Yethaydoung is situated between the Maday and Thanni streams, very steep and in part completely scarped. It consists of a harsh sandstone belonging to the Triassic rocks; but on the crest of the hill this sandstone is intensely altered, so as to assume the appearance of a harsh quartzite. Where this induration is most displayed the rock is broken up, brecciated, and much seamed by thin veins of quartz. The colour of the hardest and most altered portions is brown or yellowish-brown, with little vuggy cavities lined with small quartz crystals. This rock might easily be set down as a vein-stone, if judged from a small specimen; but it is seen to be merely a local alteration of one of the silicious beds of the Triassic group; though what can be the cause of the appearance produced is far from clear. The most probable explanation that suggested itself to me on the ground was that the baking and brecciation of the rock was produced by the passage of a dyke of serpentine, directly under the hill, the position being not very far out of the line connecting a long dyke of serpentine North of it with the mass of Nattoung serpentine to the South. One thing is certain that from local sources, such as Yethaydoung hill, and other spots within the boundary of the Triassic, and other altered rocks of the Arakan Yomah, the bulk of the coarse gravel and boulders strewed over the Western portion of the Irrawadi valley must have been derived. I have already stated my conviction that mere river action is inadequate to account for the formation of much of the shingle and boulders found in the Irrawadi gravel, and inadequate also to their transport, marine action being the only alternative, and one which seems precisely to meet the conditions present.

Along the skirts of the Pegu Yomah a broad belt of sandy deposits occurs, lateritic in places, occupying the position of, and replacing the coarser gravels to the Westward. These sandy accumulations acquire great importance to the South, where the Pegu Yomah sinks down, and the Miocene strata composing it become shrouded from view beneath this detrital talus. For some 35 miles North of Rangoon, these detrital beds almost conceal the older deposits, which only here and there betray their existence beneath them, as in the cantonment gardens in Rangoon, and, as previously stated, where the Syriam Range finally disappears, on the banks of the Hmanwon channel. East of Gnah-putau on the Bassein river, a considerable area is covered with these arenaceous bottom beds, as I regard them, of the older alluvium, and also along a tract of country stretching Northward from Bassein which Mr. Blanford describes in these words, in a MSS. memoir on the district :—" In the northern portion of the district, and as far south as the neighbourhood of Bassein, a considerable tract of low hills skirting the higher range is composed of gravel and sand of considerable thickness. This formation includes a bed of laterite usually covered to some depth by a sandy deposit, and cropping out at the small escarpment which in most places rises from the flat alluvium of the delta. A similar laterite and gravelly deposit covers a considerable area east of the Bassein river in the neighbourhood of the town of Bassein." In this northern part of the Bassein district, these sandy beds attain a greater importance than elsewhere, and I think it not unlikely that these vast accumulations not only here, but along the flanks of the Pegu Yomah likewise, are mainly derived from the denudation of the incoherent beds of the fossil-wood group soon to be described.

(*c.*) *Laterite.*—In Pegu laterite occurs somewhat sparingly, and as a strictly subordinate member of the older alluvium. It is most common within the elevated talus of sandy detritus which fringes the Pegu Yomah, and it likewise occurs in similar situations along the Arakan Yomah, but less frequently. It occurs in the elevated ridge of ground whereon the ancient city of Syriam stood, below Rangoon; and an incoherent form of laterite is now in process of formation, out of the older or red alluvial clay, where in sections, such as in the sides of wells, it is subjected to atmospheric action, not that all parts of this deposit are subject to this conversion, but such only whose composition is favorable to the change. The term '*laterosis*' might, in fact, be conveniently adopted, to imply the process which in India has from its effects on such various rocks, caused such a variety of opinions and speculations regarding the origin of laterite; and I would use the term as simply implying the conversion of any suitable rock into laterite by the addition to it of iron, or the formation or development in it, through atmospheric action, of the hydrated peroxide of the metal, so familiarly seen in the glaze, which covers all lateritic rocks, whether the iron be extraneously introduced or originally contained in the rock. In the typical laterites of India, this iron cement is a prominent ingredient, often sufficient to permit of the rock being smelted as a source of the metal, and on its presence largely depends the value of the rock for a building or road material; but in Pegu the type of laterite is much poorer in this respect, and good laterite in an economic sense is much scarcer. In many places, however, along the Western slopes of the Pegu Yomah laterite is found of fair quality underlying the sandy soil of the Engdine Forest, where its position is that of a basal member of the older alluvium. On the Eastern side of the Pegu Yomah laterite is generally wanting, and its occurrence is exceptional, save close to the frontier, where a good deal of laterite occurs, but which, as I shall presently show, belongs to another geological group than that of the alluvium I am at present concerned with.

Passing, however, beyond the strict limits of Pegu and crossing the Sittoung River, good typical laterite, undistinguishable from the Midnapore rock, is found in great force, forming a continuous belt of high ground almost scarped as regards the abruptness of its margin towards the Sittoung, and forming a plateau of variable breadth thence to the foot of the hills, and which covers ground not as yet explored. This is the lateritic belt which I have already described as shown in

Dr. J. MacClelland's sketch-map, and it may be roughly estimated to rise abruptly from 50 to 60 feet above the alluvium of the Sittoung valley. The now deserted military station of Sittoung, was situated on a steep bluff of this rock overlooking the river; and a little below this, the deposit sweeps away back from the river, and runs with a slightly sinuous and somewhat indented outline to Kyekto and thence to Martaban. From Sittoung the deposit runs with a very straight boundary, modified only by the denuding action of streams which traverse it, as high as Kyouk-kyee, a distance of sixty miles; beyond which it is continued in a less regular manner for some twenty-five miles more. Still further North and for a considerable distance along the hills opposite Tonghoo, a very similar lateritic barrier extends along the plains; but this I shall hereafter allude to more particularly, as it pertains geologically to an older group than the laterite of Sittoung and Shuaygheen.

I have described this laterite as a basal member of the older alluvium of the province; but perhaps it would be more correct to describe it as a shore or marginal deposit of the basin wherein the wide-spread alluvial clay accumulated, and as the equivalent, so to say, of that rock. At the time of its accumulation, the waters of the Gulf of Martaban stretched up what now forms the Irrawadi, Sittoung and Salwin valleys; and the drainage from the then peninsular-like land, now constituting the Arakan, Pegu and Poungloung ranges, contributed towards the formation along the coast-line of the sandy talus or bank, which now intervenes between the level plains and the hill country. The Pegu range, consisting wholly of soft sand and shales, rather deficient in iron, has contributed to that sandy detritus, which fringes the plains of the Sittoung valley to the Westward, and wherein pebbles and gravel are scarce, and laterite as a rule wanting. East of the Sittoung, however, the Poungloung hill ranges composed of metamorphic and altered rocks, many of them rich in iron, have contributed not only a coarser pebbly detritus but the precise elements, silicious, argillaceous and ferruginous, requisite for the production of typical laterite; and the above described laterite bank is simply the littoral accumulation of débris brought down under ordinary conditions of denudation, and identical in its age and mode of accumulation with the loose sandy deposits on the opposite side of the valley. The accumulation and transportation of the coarse materials forming this laterite bank naturally would be more suddenly arrested than in the case of fine deposits; hence the abrupt scarped outline of the laterite is, in my opinion, to a great extent an original feature of deposition, only to a very partial extent modified by subsequent denudation; and it is probable that this laterite bank at no period extended much beyond the general line of its present boundary, no outliers, or other indications of its former extension, being anywhere seen West of the Sittoung.

Some thirteen miles North of Shuay-gheen on the line of telegraph road is a small bat-cave in the laterite, which has the appearance of having originated naturally, probably through the removal, by ordinary drainage, of some loose and incoherent portion of the lateritic stratum wherein the cave occurs. It is entered from the top by a natural opening, and there is also a 'swallow hole' in the roof which may or may not be of artificial origin; the cave, however, appears never to have been tenanted by any animals save bats, and possess no features of interest whatever.

VI.—Fossil-wood Group.

This group of beds, which I have so designated from its uppermost member, being the bed whence the enormous quantity of fossil-wood so plentifully dispersed through the gravels of the Irrawadi valley was originally derived, at present occupies a very restricted area, compared with its former limits; though from the excessive denudation the group has undergone, it is impossible now to say precisely how far it once actually extended. A glance at the map will convey a better idea than any mere verbal description of the present extent of the group in Pegu; it is sufficient, therefore, to say that West of the Irrawadi these beds are represented by what may be termed a mere remnant in process of removal. South-west of Thaiet-mio these beds occur along a low range of hills and hilly ground, mainly made up of the débris of the group, but wherein here and there portions of its uppermost bed still remain, marked by the presence of large logs of silicified wood, but greatly wasted by denudation and masked by surface débris. From the sandy, incoherent nature of the uppermost bed containing the fossil-wood, it is often not easy to decide if in any particular spot the bed is really undisturbed, or formed of the materials re-arranged; but along the low line of hills stretching in a North-north-west direction, from between a little West of Thaietmio to the Pani stream, the uppermost bed of the fossil-wood group stretches for a distance of about eight miles, though much masked here and there by detritus, resulting from the waste ever present in so incoherent a bed. Three miles North-west of Thaiet-mio occurs another small patch of this sandy upper bed not more than a mile in length, and these are the only remnants now left of this upper fossil-wood bed West of the Irrawadi. From these two patches, or rather from the now denuded extension of the bed of which the above patches are the sole remnants, all the fossil-wood which forms so conspicuous an ingredient of the gravels near Thaiet-mio and Prome was derived; and there is little doubt that the beds of this group extended the whole length of the Arakan hills (that is, along their Eastern flank), though evidence, in the shape of scattered fragments of fossil-wood, does not occur much below Latitude 17°. I do not rely on the occurrence occasionally of a scattered piece of fossil-wood of small size, as establishing therefore the extension of the fossil-wood beds, wherever such fragments are discovered; since small pieces of this fossil-wood are carried about by the Burmese for the purpose of procuring fire with a steel. My estimate of the former extension of the beds in question rests on more general grounds, such as the character of the ground, the extent of the gravels, which probably resulted from the denudation of the group, and the former extension of the fossil-wood group on the East of the Irrawadi, as I think it must be admitted, as far South as Rangoon.

East of the Irrawadi the fossil-wood group covers a very considerable, but irregular and indented area, from the frontier, to a little below the parallel of Padoung. The group has been everywhere so extensively denuded that little now remains of the upper portion; though from the indestructible character of much of the fossil-wood so plentifully distributed through it, the former extension of the group may be traced over an area wherein the greater portion has undergone complete removal. South of the parallel of Padoung no very reliable proofs occur of the existence at present of the undisturbed beds of this group; but its former extension, even as far South as Rangoon, is proved by the occasional occurrence of partly rolled pieces of fossil-wood in the gravelly detritus which to the South covers up the undisturbed beds of the group, and in a measure replaces them along the outer hills. As an instance in point, I may quote the occurrence of a log of silicified wood, some four feet in length, between the Oakhan and Thonsay streams, fully sixty-five miles South of the point where the undisturbed beds of the fossil-wood group at present terminate. The log occurs in a sequestered spot in dense jungle, half embedded in sandy detritus, which I regard as derived from the waste and re-arrangement of the fossil-wood sands in the immediate vicinity; since a log of this size could not have suffered transport from any distance, and there is no reason to suppose, that it is not now in very nearly the same position it originally occupied when the bed wherein it was first deposited was removed by atmospheric denudation. Smaller pieces than the above log are not uncommon, and are to be found even in the immediate neighbourhood of Rangoon. When I first heard of the occurrence of fragments of silicified wood in the low undulating ground near the so-called 'Lakes' near Rangoon, I felt inclined to attribute their occurrence to the agency of the Burmese, who often surround their sacred buildings with posts of silicified wood where the material is procurable; but by examining some cuttings just made, I satisfied myself that moderate sized pieces of fossil-wood of a somewhat friable character actually occurred in the surface gravel and detritus to the Eastward of the Great Pagoda, and the occurrence of such pieces I consider to be conclusive, to the former extension of the group as far South as Rangoon.

In the Records of the Geological Survey of India, Part 4 of 1869, I have divided the present group as follows in descending order :—

a.—Fossil-wood sands.

Sand, in parts gravelly and conglomeratic, characterised by the profusion of concretions of peroxide of iron associated with it. Fossils: trunks of silicified exogenous wood, and locally mammalian bones. In the subordinate beds of conglomerate rolled fragments of wood as above, silicified (that is, mineralised subsequent to their entombment) mammalian and reptilian bones and teeth of cartilaginous fish (*squalidæ*).

b.—Fine silty clay.

Fine silty clay, with a few small pebbles mixed with sand in strings here and there, the whole very fine and homogenous and devoid of fossils.

c.—Mogoung sands.

A mixed assemblage of shales, sands, and conglomerates, the last very subordinate, partaking much of the characters of beds *a*, *b*; a little of the concretionary oxide of iron. Fossils :—rolled wood silicified, mammalian and reptilian bones and cartilaginous fish teeth. Towards the base the beds contain marine shells, and pass into those of the next group.

In the above number of the Records, I have classed these beds as Miocene; but, I think, considerable weight attaches to the view of Mr. W. Blanford, who is inclined to regard them as more recent. In his account of a visit to Puppadoung, an extinct volcano in Upper Burmah, which has burst through beds of corresponding age to those I am describing, Mr. W. Blanford thus expresses himself, Journal, Asiatic Society of Bengal, volume XXXI, page 225. "The period during which Pappá was in action was, therefore, in part at least not later than that of the deposition of beds containing remains of Elephas, Mastodon, Rhinoceros, Hippopotamus, and ruminants. The geological age of these beds has with some doubt been considered to be Miocene, but from their general fauna, and especially from the abundance of bones of Bos and Cervus, a more recent date may, I think, with at least equal probability be assigned to them."

Fossil-wood sand locally mammaliferous.—The sand of which this bed is mainly composed is very fine and uniform, with a little impalpable argillaceous matter intermixed, and occasionally a few small quartz pebbles. In the cart-tracks which traverse this sand, the rock breaks down into a very fine dust most fatiguing to travel over; and in the beds of the streams where the fine argillaceous matter has been removed, a fine silver sand fills the entire channel, with here and there small gravelly banks made up of the peroxide of iron usually associated with this group. On the surface of this sand, where it has suffered least from denudation, fossil trees are often seen scattered; and in many places the profusion of large fragments of fossil-wood in situ, or approximately so, is very striking. Over the whole of the area of this upper sand, fossil-wood is common, in the form of angular unrolled pieces, derived from larger logs by simple fracture through the force of gravity, or spontaneous disintegration and division along original lines of fracture and weakness. Opposite Thayet-mio behind Yettoung (especially near a low hill locally known by the name of 'Chouk-hpew-toung' or 'white stone hill' from the abundance of white quartz pebbles scattered about), I have seen trunks of trees, some 40 or 50 feet in length, stretched out over the uneven surface of the ground, and broken up by mere gravity, as I should judge, into fragments of about four or five feet in length; though from the great denudation this sand has undergone, and consequent displacement of the silicified trees, the more usual condition to find them in, is scattered logs freely dispersed over the surface or encased in modern detritus. Scarcely less plentiful than at the above spot, is this silicified wood South of Shuaybandor and between Shuaybandor and Phoung-yo to the South-east, and also South-east of the point where the Kyeni stream crosses the frontier.

South-west too of Tamagon on the Puday stream, and thence as far as the Myouk-naweng stream, fossil-wood is abundant; though from the great denudation the bed has here undergone, the logs are more broken than elsewhere, though often four feet or so in length.

This wood is generally well silicified, though subject to decompose from absorbing atmospheric water, whereby the more or less hyaline silica is converted into the opaque and earthy hydrate, which readily disintegrates and crumbles away. Prior to silicification, however, the wood had to a considerable extent become decayed, probably from long immersion in water. We may conjecture that the trunks of trees in question floated about till waterlogged in shallow lakes, in which, on sinking, they became mineralized through the agency of springs holding silica in solution; and it seems not improbable to connect the existence of such springs with the volcanic activity which we know prevailed about this time, as indicated by the extinct volcanic vent of Puppadoung. Some unusually well preserved specimens of this wood from the Prome district were taken home by me in 1867, and examined microscopically at the British Museum (by, if I remember rightly, M. Carruthers), but from the decomposition of the wood prior to its silicification, and the consequent obliteration of much of its finer structure, all that could be pronounced regarding its nature was, that the wood was exogenous and not a conifer, as I had surmised might be the case. Dr. Buckland thought the wood resembled tamarind wood, though on what grounds he does not state. The Burmese consider the fossil-wood to be identical with the 'Enjin' tree still living in the district, and some of it they refer to the 'Thiyah' (*shorea obtusa*); but as far as I can judge, there is but one species of fossil exogenous wood in Pegu. Endogenous wood is unknown to me, as derived from this bed. I have seen rolled fragments of it, very rarely, from the modern Irrawadi gravels, which may have been derived either from this bed or one of the lower beds of this group; but in Pegu, fossil endogenous wood is undoubtedly very scarce.

Next to the abundance of fossil-wood in this bed, its most marked peculiarity is the quantity of the hydrated peroxide of iron it contains in the form of concretions, in places so abundant as to have formerly served for the manufacture of iron, which was once largely carried on within the area occupied by this group of beds, especially in the neighbourhood of the villages of Shuaybandor, Kiungalay and Yaybor. The ore occurs occasionally as a band of about three inches in thickness, but more usually in the form of variously shaped concretions one to four inches in length. In the upper sand these concretions are regular and symmetrically shaped, amygdaloidal, spherical, cubical, cylindrical, with both round and truncated ends, discoidal, &c.; and all these forms are clearly the result of segregative action in the recently deposited materials. Of whatever shape, however, the concretions are all very similar in structure, consisting of an external crust of concentric layers of brown hæmatite, surrounding a kernel of pure white or yellowish clay, lying loose and shrunken as it were in the interior. Externally these nodular concretions are roughened through the adhesion of sand; but a slight tap causes the rough crust to scale off, leaving a perfectly smooth surface. Internally these nodules often present a blistered surface, from the mammillary crystallization of limonite. In some of the coarse beds of the group, where the harsh character of the rock has interfered with the regular segregation of the mineral, irregular seams or shrinkage-fissures are seen lined by it (limonite), which on the weathered surface impart a pseudo-slaggy appearance to the sandstone. In some rare instances the segregation of this mineral would seem to have given rise to a botryoidal structure in the sandstone, manganese being then present.

Associated with this sand and forming irregular courses in it, more or less lenticularly arranged, occur some hard sandstones, sometimes very fine-grained, at others a pebbly grit or even coarse conglomerate. No regular position can be assigned in the sand to these subordinate layers;

but the fine hard sandstone often occupies a high position, whilst a coarse conglomerate is not unfrequently met with at its base. Both the sandstone and conglomerate are in places richly charged with shark's teeth of small size; and the conglomerate is usually ossiferous as well, though the occurrence of mammalian bones is capricious and irregular. I am inclined, however, to believe that the scarcity of mammalian bones in Pegu, compared with their numbers in Upper Burmah, is to some extent, if not mainly, due to the fact of the very imperfect mineralisation which many of the bones have undergone in Pegu, and their consequent destruction and removal by atmospheric action when weathered out of the beds wherein they have been preserved. One locality where I was struck by the friable character of the bones which appeared to be far from rare in the rock, though scarce on the surface, is a little to the North-east of Talok and some fourteen miles North-east of Thayet-mio, on the East bank of a small stream not marked in the map. They here occur both in the soft upper sand and also in the lower sand and conglomerate, associated with shark's teeth and small pieces of fossil-wood. Many of the bones at this locality were of large size, and consisted of jaw and limb bones of Elephas, but too friable for removal, and some of which had suffered fracture and had been rolled and rounded prior to deposition in the sands and gravels. The mammalian bones here were certainly associated with shark's teeth; and therefore I judge that this portion of the group must have been deposited under estuary or marine conditions. No shark's teeth or any other fossil whatever has been detected by me in the uppermost sand, which is the main repository of the silicified trunks; and as these nowhere exhibit marks of the attacks of xylophagous mollusca (Teredo, Pholas, Gastrochæna), though, as I have shown, they were in all probability water-logged from long immersion, prior to their entombment and mineralisation, the inference is, I think, legitimate that the marine or estuary conditions under which the lower portion of this group was deposited, eventually gave place to lacustrine conditions, at the period when the highest portion of the fossil-wood sand was being formed. No traces of boring molluscs were noticed by me in the few pieces of fossil-wood contained in the above mammaliferous gravels, of admitted marine origin; but it is reasonable to suppose, that the conditions of a marine gravel bank, containing rolled limb-bones of the larger mammalia, would not be favorable to the presence of wood-boring molluscs, and that to the turbulence of the conditions under which these rolled fragments of wood became embedded, is to be attributed the fact of none of them being perforated or bored.

This upper sand is generally horizontal; but in some places it has clearly suffered disturbance and partial elevation, though the newest group within the province except the alluvium. One of the few instances noticed by me of a decided dip in this group, occurs between Omouk and Lema, nineteen miles East-south-east from Thayet-mio. A bed of coarse conglomerate subordinate to this sand is here seen dipping at 30° to South-east. In this conglomerate, among other bones rolled and in poor condition, I noticed the tusk of a small Elephant, but in too friable a state to admit of its extraction. The following fossil bones occurred to me in the Prome district:—

Ursus ? (Helarctos).	... A single canine tooth.
Elephas. ...	... Lower jaw, tusk, and sundry fragments of limb-bones.
Cervus. ...	... Part of lower jaw.
Ruminant. ...	... Metacarpal bone of a small species.
Emydinæ. ...	... Two species.

To this meagre list I may add the few fossils which have been procured from Ava from a similar position geologically.

Mastodon latidens, Clift.
Elephas Cliftii, Falc. & Caut.
Mastodon Elephantoides, Clift.
Rhinoceros.
Equus.
Hippopotamus (Hexaprotodon) Iravaticus, Falc. & Caut.
Merycopotamus dissimilis, Falc. & Caut.

Sus.	Crocodilus.
Tapir.*	Leptorhynchus.
Ox.	Emys.
Deer.	Trionyx.
Antelope.	Colossochelys.

Silty underclay.—Below the last-described sand occurs a deposit of very uniform character, which from its relation to the most characteristic member of the group, may be termed the under-clay. This bed is a clay of a very uniform silty character, and appears to have been deposited under tranquil conditions; as beyond a very few small pebbles, which are moreover very rare, no extraneous ingredients have been detected by me in the deposit. I do not remember ever detecting either a fossil bone or piece of wood in this bed; and as it is well and largely exposed within the area of the fossil-wood group, it is pretty certain that no such remains occur in it. This is the more singular, from the abundance of silicified wood in the sand immediately above it; and I am inclined to think, that this deficiency may possibly be due to the absence of those conditions, during its accumulation, to which the preservation of the wood in the newer deposit was due; or, in other words, that the means of rapid silicification were not then present, as during a later period. Silicified wood occurs sparingly in beds below this, which, on the supposition of the silica being supplied from springs dependent on volcanic action in the neighbourhood, would seem to imply that the deposition of the bed of silty underclay marked a period of abeyance of volcanic action, during which the supply of silica was arrested, and wherein consequently no silicified trunks were preserved. What few quartz pebbles occur, are found associated with little strings of sand of very insignificant extent. The thickness of this bed may be forty feet or thereabouts; and it is perhaps nowhere better seen than South of Thanat-ua between Alán-mio

* The Tapir is unknown to the well-investigated Sivalik Fauna, as Falconer observes.—"The Tapir alone of the large existing Pachydermata being without a representative," (Falconer's Palæontological Memoirs, Vol. 1, page 296). It may have been therefore erroneously determined by Mr. Clift, as Falconer makes no mention of it among the Ava fossils which he examined and described.

and Kiungalay. It is also well exposed about one and three quarter miles East of Talok, on ascending from the small stream, which I have previously noted as not being shown on the map.

A fair section of the above beds is seen North of Prome, either along the line of the direct road to Dayeng-ga-bhu, or between Dayeng-ga-bhu and Wettigon, a village thirteen miles North-east-by-north from Prome. The ground round Wettigon is low and swampy, merging into forest. The soil is sandy owing to the proximity of the incoherent sands to the North and West of the fossil-wood group. At less than two miles from Wettigon in a North-west direction, a sensible rise in the ground, above the flat champaign country is noticed, and the road enters on the clay bed underlying the upper sand. At little better than a mile this clay gives place to the upper sand, through which the road winds for some three miles or so, through some picturesque ravines and miniature defiles, such as usually characterise the ground covered by this bed. Fossil-wood is not so plentiful here as it is further to the West, where it sometimes occurs in profusion, along the direct road to Dayeng-ga-bhu. Between Wettigon and Kywaythay, a distance of nine miles, and for twelve miles South of Dayeng-ga-bhu, neither villages nor water (save a few pools in the rainy season) are met with; and throughout the entire area of these fossil-wood beds, villages are rarely to be met with owing to the absence of water, or the great depth to which wells would have to be sunk through these porous beds to find it. The clay underlying the upper sand is largely developed or exposed North of Wettigon; but its relations to the upper sand can perhaps be nowhere better seen than North of the Bulay stream, and North-west of the village of Touk-kian-deing. It here occupies a somewhat wide tract of country covered with open forest, and bounded rather sharply to the North and East by the upper fossil-wood sands. It is in several places dug for making pottery, and superficially very closely resembles the ordinary alluvium of the province; but there is this to distinguish the two, that small fragments of fossil-wood derived from the overlying sands, may usually be detected on the surface of this clay, whereas such are never found on the surface of the alluvium. Where, moreover, a large area of this under-clay is exposed and forms the surface of the country, there is an appreciable difference in aspect between it and the alluvium. The difference consists partly in color, the clay in question being entirely devoid of any tinge of red, which is usually present in that portion of the alluvium which otherwise most nearly resembles it, the prevailing tint in one being a yellowish gray, in the other a slightly reddish-yellow. The older clay moreover cracks under exposure to the sun much more deeply than the other, and recals in this particular the regur soil of India, some of the paler varieties of which it rather closely resembles. In this clay in some places rather large nodular concretions of lime, or kunkur, may be noticed, which is wanting, or rare and small in the alluvium in Pegu.*

Another extensive spread of this clay occurs in the valley of the Bulay stream above Lepandoung, a village eleven miles from its mouth. Between this village and Shuaybandor an area of this clay occurs (inclusive of alluvium, which, in parts, is very thick) of seventy or eighty square miles. Along the southern portion of this area, the relation of the overlying sand may be well seen; though extensively denuded, a narrow

* Although this clay has some similarity in appearance to regur, the well-known and productive cotton-soil of India, yet little or no cultivation is attempted on it, and the trees which are met with growing on this clay are all more or less stunted, as though from some uncongenial elements in the soil. How far this is due to the peculiar quality of the soil, or due to its hygroscopic properties and condition, I cannot say; but I think the diminished supply of water caused by the impervious nature of the clay, and the consequent retention and storage in it of but a very fractional amount of the water which falls on it, will go far to account for the impoverished look of the trees growing on it. The three most common trees on this clay are the Touk-kiahn, *Terminalia macrocarpa,* the Shah-hpew, *Phyllanthus emblica,* and the Tay, *Diospyros sp.;* but these do not seem to attain their full size, whilst other familiar forest trees are either absent altogether or few in number and stunted in growth. On the whole, I am inclined to refer the unfavorable appearance of the tree flora to the hygroscopic, rather than to any inherent chemical quality of the clay; and if this is correct, irrigation would probably convert one of the most barren soils in Pegu into one of the most fertile.

strip remains resting on the clay, with fossil-wood in abundance *in situ*, and the associated nodular peroxide of iron. Over the remainder of the area, fossil-wood occurs in scattered fragments, and these far from common. Another small area of this clay, nine miles in its greatest length, occurs near Let-pan-hla on the They stream, which falls into the Bulay stream from the South near Tonk-kian-deing. The most curious physical feature connected with this clay area is, that it forms a sort of blind valley or cul-de-sac, almost surrounded by the overlying sands; the sand, denuded from what now constitutes the clay area, having been removed by the seemingly very inadequate channel of the present Let-pan-hla stream. A narrow belt, moreover, of this sand crosses the stream, and although during rain an efficient escape by the surface channel of the stream takes place, yet at other times, the surface channel of the stream remains dry, the feeble current of water pursuing a course beneath the sandy barrier, and welling forth again only when this belt of sand is passed; yet, along and across the line of this bar or obstruction, must the entire mass of sand which once filled the valley of Let-pan-hla, been removed by the ordinary denuding powers of the now feeble Let-pan-hla stream.

This is by no means an isolated instance of a stream disappearing within the area of these highly porous upper sands, and re-appearing in its proper channel beyond their area. A similar instance is seen in the course of the San stream, which falls into the Kyeenee stream near the village of Ooyeen. Though the channel of the San, or (as it is also called on the map) Kyetyongyee stream, is a broad one, giving evidence of the volume of water it discharges during floods, yet as long as its course lies within the fossil-wood sands, it is ordinarily quite devoid of water; but directly the channel enters the area of the underclay, a copious stream of water bubbles up in mid-channel, which had evidently held its course beneath the surface accumulation of sand which it would seem as though the stream had hitherto failed adequately to clear away.

Lower (*Mogoung*) *sands and shales.*—Below the last described clay, occurs a rather varied assemblage of beds of sand and shale, partaking to some extent of the character of the upper beds of the group, and containing sparingly both silicified wood and mammalian bones, but towards the base appearing to pass into beds containing marine shells and corals (Cladocera).

A section of these beds is seen on the Kyeenee stream above Mogoung, which may be taken as illustrating their general character; and though some of the beds much resembled portions of the higher beds of the group containing bones and fossil-wood, I carefully searched, but in vain, for any trace of fossils.

(*Descending section.*)

	Ft.	In.
Pebbly sandstone, about	50	0
Pale silty shale	3	6
Very false-bedded pebbly sandstone	16	0
Harsh sandstone, rather irregular	0	1
Compact yellowish silt, with a central band of kidney-shaped nodules one to two feet in diameter	2	0
Gravelly sand	0	2
Yellow pebbly sandstone	3	0
Pebbly conglomerate, loose and gravelly, a few feet.		
	74	9

A small but instructive section of these beds is also seen in the Myouk Naweng a little below Tham-bya-gon, where pale silty shales are seen supporting a great thickness of rusty incoherent sand traversed by thin layers of shale and a coarse quartzose conglomerate with clay-galls, and cavernous hollows, coated with limonite. In this conglomerate I found mammalian bones, shark's teeth, and a small log of fossil-wood about two feet long of the same character as the wood commonly found in the upper sand, though less completely mineralised. To the present division of the fossil-wood group may probably be referred the beds rather imperfectly seen in the East bank of the

Irrawadi, close to Keng-yua, above Myanoung. The beds here exposed dip nearly due East, about 30°, and are cut so obliquely by the river that their thickness cannot be very closely measured, and unfortunately the most interesting bed containing bones is the lowest in the section and to a great extent covered by the river.

(*Descending order.*)

		Ft.	In.
1.	Yellow earthy sandstone with irregular concretionary or lenticular courses of fine sandstone, which weathers out from the softer rock enclosing it, somewhat after the fashion of kunkur nodules, which it superficially resembles.		
2.	Harder sandstone of similar character resting on yellow sand containing marine shells	80	0
3.	Brownish clunchy clay passing down into blue clay	30	0
4.	Sandstone like No. 1 passing down into	30	0
5.	Rather false bedded conglomerate	60	0
6.	Yellow sandstone	30	0
7.	Wet sandy clay, (many springs)	6	0
8.	Yellow sandstone with conglomerate courses containing shark's teeth, rolled oysters, chelonian plates, and bones, some apparently mammalian.		

The entire thickness of beds seen here is probably not less than two hundred and fifty feet, though the conditions are unfavorable for accurate measurement. Bed 8 is only ossiferous towards the base, where it becomes concealed by the river. The pebbles in the conglomerate are small, the bulk of the rock consisting of coarse sand, in parts friable, but generally cemented into a hard rock. The shark's teeth are all small and not very numerous.

The above remarks nearly exhaust all the points of interest connected with this group in Pegu, that is, on the Western side of the Pegu Yomah; but a considerable change in some respects takes place in the upper beds of this group in the Tonghoo district (now attached to Martaban) on the Eastern side of the range.

As I have already remarked, there are satisfactory grounds for assuming that the fossil-wood group originally extended as far South as Rangoon, and that sundry traces of its presence beneath the gravelly surface accumulations may be detected along the line of the outer skirts of the Pegu Yomah, after leaving Rangoon, long before the principal remnants of the beds still existing are met with in Eastern Prome. On the Eastern or Martaban side, however, of the Pegu Yomah, the removal of the fossil-wood sand appears to have been more complete; as I not only failed to find any fragments of fossil-wood myself, but ascertained by repeated enquiries that none such were known to occur to the villagers, who are perfectly familiar with the silicified wood or 'Engyn-chouk' from the use which is made of it, as a substitute for flint, wherever it occurs. On nearing from the South, the banks of the Kaboung Choung, which falls into the Sittoung a little below Tonghoo, near Lat. 18°53′, I first heard of fossil-wood, which, I was told, occurred not rarely Northwards of the Kaboung; and I first detected small fragments of fossil-wood within a few miles of the Kaboung on its right or Southern bank, where, however, such fragments are scarce and small. Crossing the Kaboung, at a spot about two miles North-west of Tha-bhet-kway, and fifteen miles West of the confluence of the Kaboung, large masses of fossil-wood are seen scattered over the hill side, some of which are three or four feet in length, and derived apparently from a single huge stem broken in pieces by its own weight, as the soft sand in which it was originally entombed was removed in an irregular manner by atmospheric action. From this place, for a distance of twenty-five miles Northwards, fossil-wood is not rare, at a variety of spots scattered in the outer hills; after which, though the same beds seem to prevail to the frontier, the fossil-wood is absent. As a rule, the uppermost or fossil-wood beds are chiefly met with along the outer hills, giving place by degrees as we proceed West to the underlying beds of the Prome group; but near the frontier, in the Magoo Choung just above its junction with the* Choung-ma-nay

* The names Magoo and Choung-ma-nay are not given in the map, but the former nearly corresponds in general position with the stream called Hso-kay Choung (one probably being an affluent of the other), whilst the Choung-ma-nay is probably identical with the Kyouk-ma-hseng Choung of the map.

Choung, and higher up the stream still nearer the Yomah, that is, within three or four miles of it, large pieces of fossil-wood are seen, showing that much of this ground was overspread by the incoherent fossil-wood beds, though now, next to wholly removed by denudation.

Throughout this area, the rocks are not well seen, being masked by detritus and overspread with dense tree forest. The dips are rather more irregular than is usually the case with the older groups, and from the nature of these upper sands, it is far from easy to say whether or not any material unconformity exists between them and the often highly inclined beds whereon they rest; from analogy, I am, however, inclined to think that there is little unconformity between them, as in the western side of the range, these uppermost beds have participated in the movements which have affected those beneath them, and to which the general disintegration of this incoherent group may be largely due. The area in Tonghoo mainly occupied by these beds may be roughly estimated as not far short of 700 square miles, of which eighty miles is composed of outliers East of the Sittoung, flanking the Poungloung range.

I have already mentioned the great similarity which exists between a tract of country composed of the lower or more argillaceous beds of this group, and an ordinary alluvial plain; and this similarity may be well seen between the Kaboung and the frontier; and were our observation to be restricted, it would often be impossible to decide to which group the beds composing the surface of the country belonged; but in all such cases, we have only to extend our examination, and we sooner or later come to the boundary of the alluvium if moving towards the East, or if in the opposite direction, we soon find the seeming alluvium or clayey champaign country to give place insensibly to the low outlying hills of the Yomah, composed of the same materials. This may be seen throughout the whole country lying North and South of the village of Amot-kyee-kon on the Hswah Choung, where it debouches from the hills; and we may here traverse miles of perfectly level tree forest seemingly alluvial, but which in reality lies within the area of the clayey beds of this group, denuded of its uppermost sands. I am inclined to think that these clayey beds are rather more developed as respects thickness in the Tonghoo district, than they are in Prome, and are perhaps a trifle coarser and less homogenous. One of the best sections I know of these beds is on the main road running from Tonghoo to the frontier, between the villages of Nyoung Kyat and Myohla, where the road descends from the high plateau formed by these clays, to the alluvial plain of the Sittoung, one and three quarter miles South-west of the latter village. The deposit is here seen to consist of a thick bed of sandy clay, devoid of any distinct bedding, and with but a few small pebbles dispersed through it. Locally these pebbles are commoner, as they may sometimes be seen on the surface, weathered out of the clay, though their presence is exceptional. It is commoner to find a little grouty laterite strewed over the surface, and in places the clay itself is converted at the surface into tolerably compact laterite, quite undistinguishable from the laterite pertaining to the newer deposits on the opposite side of the Sittoung further to the South near Shuay-gheen. This leads me to notice one of the most curious and deceptive instance of change of mineral character in the present group that I am acquainted with, though it is of local character and dependant on the conditions under which the deposit here originated.

I have already mentioned the great belt of laterite which is shown in Dr. J. MacClelland's sketch map of the district, and which gives a fair conventional idea of the relation of that rock to the older and younger deposits which it separates, as far as the Southern portion of the Martaban district is concerned; but as a matter of fact, little or no laterite, certainly nothing like a continuous deposit, occurs from North of the village of Puday to the frontier, a distance of 28 miles. Towards the frontier the alluvial plain of the Sittoung is bounded by rising ground, most of it exceedingly flat, arid, and uninhabited in consequence, composed of the clayey beds and superincumbent sands of the fossil-wood group. These sandy beds, however, do not extend south of the Yeng-tha-le Choung, which enters the Sittoung $16\frac{1}{2}$ miles below the frontier. South of this, these sandy beds have been removed by denudation, and the alluvium is thence bounded by the crystalline and gneissose rocks of the Poungloung range. East of the village of Puday, however, a small outlier of the group has survived, on the end of which stands the Kannee Pagoda overlooking the Sittoung, and a little further south a more considerable outlier which stretches below Tonghoo to close on the banks of the Thonk-yay-gat river. These two outliers are, lithologically considered, typical laterite, distinguishable only from the great belt of laterite met with South of Kyouk-kyee, by being in places charged with huge boulders which greatly reduce the lateritic cement wherein they are embedded; but a close examination of these interesting deposits has convinced me, that geologically speaking, they are portions of the fossil-wood group, and the extreme termination of the group to the South, on the Eastern side of the Sittoung, denudation having entirely swept away the group on that side of the river, below the junction of the Thouk-yay-gat in Lat. 18° 53′. The lithological constitution of both these outliers is the same, and to it in part may be due their preservation, when the less coherent portion of the group was removed by denudation. The bulk of the deposit may be described as a sandy clay, differing but little from that met with to the North of the Sittoung within the area of this group; but an additional feature it here presents, is the great number of pebbles contained in it, which weathering out, give the appearance of the country being composed of gravel beds ; where, however,. a section is displayed, it is seen that the gravel is merely a surface accumulation, the result of denudation, which has removed the finer sand and clay and left the surface encumbered with the pebbles originally disseminated through the bulk of the rock. This can be well seen along the line of road between Kannee and Kon-meng-cing and thence to Paday. The same may be said of the road South from Kon-meng-eing to Hlay-my-oung, and thence to the well-known Pagodas at Myar-soh-ni-moung, five miles East-south-east of Tonghoo on the North bank of the Thouk-yay-gat. North of Hlay-my-oung it is not usual to find stones in the clay larger than would be ordinarily called pebbles, and which in the aggregate might be termed gravel; but between Hlay-my-oung and Myar-soh-ni-moung these stones in many spots give place to the coarsest shingle, with pebbles averaging three or four inches in length, and not rarely containing boulders six or eight inches or more long. Where this coarser shingle is most abundant, the clayey element is proportionately diminished, and the rock passes into what may be called a mortar bed of the coarsest shingle cemented into a compact rock by a sandy ferruginous clay or laterite; in fact this laterite, though I have said it belongs to the fossil-wood group, is undistinguishable from the laterite of Martaban to the South, of a newer date, and the reason is doubtless, either that both are derived from the waste of the same rocks in the Poungloung hills to the Eastward, or what may partly be the case, the newer laterite is largely composed of detritus produced by the denudation of the lateritous beds of the present group.

The cause of this great difference in lithological character in these beds, from that anywhere noticed to the Westward, seems to me sufficiently obvious, and lies in the fact that the Poungloung range of hills formed the Eastern shore of that Pliocene, and in part probably Post Pliocene sea, wherein the whole fossil-wood group was deposited; and that these coarse outliers are the remnants of a zone of similar character which fringed its shores wherever they were favorable for its production; and it is quite within the bounds of the probable, that the coarse shingle and boulders I have described as scattered over the hill slopes in Western Prome, especially along the Mudday Choung, may be the débris of a similar local deposit, now too much broken up and denuded to be cognisable as such, but which originally marked the western shores of the Post Pliocene sea, and coincided in general terms with the line of the outer hills of the Arakan range, which would give a breadth of open sea in the parallel of Tonghoo of about 100 miles.

No fossil-wood, to my knowledge, occurs east of the Sittoung, though I am aware that a contrary statement has been made by natives to Major Lloyd at Tonghoo; but after examining the ground for the express purpose, I am unable to confirm the fact. In India I should have at once concluded that a wilfully false statement had been made in the hopes that it might meet the wishes, or supposed belief, of the 'Huzoor,' but there is another and preferable explanation in the present case. The fossil-wood where plentiful is commonly used as a flint, and I have noticed in this district, a man when questioned if he knew of any fossil-wood in the neighbourhood, put on a blank look of not comprehending what fossil-wood was, but when its use was explained to him, as used for procuring a light, at once say, "yes, there is plenty of that stone," which on examination has proved to be a silicious rock, equally useful no doubt, but totally unlike the article sought. Certain it is, I was never able myself, either to find or hear of any fossil-wood being found east of the Sittoung, and none I believe exists there.

Very little if any of the peculiar nodular oxide of iron which so characterises the uppermost bed of this group in Eastern Prome, occurs in Tonghoo, but it would seem to be represented by some irregular tabular masses of manganese ore, which occur in some of the beds of sandstone forming the low range of hills dividing the Yayuay and Seing Choung from the Sittoung. This ore occurs in irregular stratiform masses of an inch or two in thickness, and in irregular nodules often sub-botryoidal in character and of a black color, and is composed, according to an analysis by Mr. Tween, as follows :—

Loss on heating	4 0
Oxide of manganese	28 0
Iron	3 2
Clay and sand	64 8
	100 0

VII.—Pegu Group.

The term Pegu group is proposed for a very important series of beds, intervening between the Eocene or Nummulitic group on the one hand and the fossil-wood group on the other, and comprising the bulk of the Pegu range, and most of the ground intervening between the Irrawadi and Sittoung rivers, together with a considerable tract of country West of the Irrawadi also. Having regard to its superficial extent, it is the most important group in the Province; it is far richer than any other in fossils, and is better defined as a whole as regards its geological age. Although many of its beds are rich in fossils in a good state of preservation, it often displays a great thickness of beds in which fossils are either absent or ill-preserved. From what we know of the fauna, its age may be roughly fixed as upper Tertiary; covering, probably, the whole of the geological epochs named Miocene and Pliocene. No great break being perceptible after the close of the Nummulitic period, to which group its lower beds would seem to succeed conformably, and an unbroken sequence of beds continuing up to the fossil-wood group of presumably newer Pliocene age, there seems good grounds for believing that the Pegu group covers the whole of the above named period, prodigious as it is. In the opinion of Dr. Stoliczka, no effective and satisfactory examination of the fossils of this series can be undertaken till not only have the beds containing them been more thoroughly explored, for fossils specially, than is possible during the exigencies and progress of a first survey, but till a complete collection of the living fauna of the Bay of Bengal is available for comparison, which does not at present exist. It is clear that for comparison and elucidation of a Tertiary fauna a collection is essential of the organisms living in the nearest locality where faunal conditions still exist similar to those prevailing during the deposition of the strata, whose fossils are being investigated. Great as is the thickness and extent of this group, it offers small inducement for sub-division, as there are so few well defined beds in it, capable of being anywhere recognised and taken as tangible horizons. As an instance of this, I may quote the *Cytherea Promensis* bed opposite Prome, which proves one of the richest fossiliferous beds in the group, yet I do not know any other spot where this bed can be identified; and though interesting as a good repository for fossils, its use as a stratigraphical index is absolutely *nil*. If this is the case with a bed more richly charged than usual with fossils, still less does the mineral character of the beds aid us in correlating distant sections; and all that I can therefore offer in the way of sub-division of this group, is the somewhat meagre arrangement of it into lower and upper; the lower embracing the Sitsyahn shales, so called from a village of that name, eight and a half miles above Prome, and the rest comprised under the term Prome beds, embracing everything between the Sitsyahn shales and the fossil-wood group.

Sitsyahn shales.—The base of the Pegu group would appear to consist of a thick deposit of shales, with a little sandstone very subordinately developed. It is seldom that any good sections of these beds are seen, but the shale is exposed in several places along the boundary of the Nummulitic group, which it seems to overlie in conformable sequence. In the Thamula section of the Nummulitic group, a soft sandstone takes its place; but this is, I believe, a local substitution of a sandstone at this particular spot for the shale which is usually found overlying the Nummulitic group. From its character, this shale forms a rather level tract or a gently undulating country, but one intersected by rather deep beds of streams, in the banks of which it may usually be seen exposed. On the banks of the Irrawadi, however, around Sitsyahn it is unusually well exposed, and though not very distinctly stratified, yet the immense thickness of it is clearly seen. As the Nummulitics on which this group rests, do not come down to the river at this spot, and it is nowhere else so well displayed, no estimate can be formed of the entire thickness of this lower division of the group; but I think that close on four hundred feet are here seen, and probably twice that amount would not be an overestimate for the entire thickness of this division. The Sitsyahn shale is a blue, somewhat clunchy clay, with very little appearance of bedding save towards its upper portion where sandstone courses begin to come in. When dried, it is of a very pale color, and cracks and falls to pieces spontaneously, as some of the Nummulitic clays likewise do, a habit which depends probably on the homogenous and purely argillaceous character and fine state of division of the materials composing it. It bears a strong resemblance to some of the shales of the Nummulitic group, though, I think, rather paler in color, a similarity which may be referred to its probable derivation from the same area of denudation as the older Nummulitic clays. It is, as far as I know, entirely unfossiliferous, and along the long expanse of this shale below Sitsyahn, I failed to detect the slightest trace of any organism whatever, though the character of the rock would seem to be well adapted for the preservation of fossils. In the very similar clays of the Nummulitic group, fossils are nearly as rare; and though fossiliferous in places, many of the clays higher in the present series exhibit a similar deficiency; but the complete absence of any fossils whatever through so great a thickness of rock well adapted for their preservation, is an undoubted feature of this Sitsyahn shale. Even where a large expanse of the shale is uncovered, its bedding is scarcely perceptible, but can be estimated from the occasional presence of irregular layers of fibrous marl, or by layers of hard yellow marl traversed by shrinkage seams or septaria cracks filled by carbonate of lime. The fibrous marl is clearly a cotemporaneous sedimentary bed in which the presence of lime has permitted the development of this fibrous structure, at right angles to the planes of bedding, the result of a sort of crystallizing process, dependant on the composition of the layer affected, and in which the amount of lime varies from that present in an ordinary marl, to that of a tolerably pure limestone.

Prome beds.—Above the Sitsyahn shales a vast series of beds comes in of shales and sandstone, many of which contain fossils in abundance. These beds rest conformably on the Sitsyahn shales, which are merely separated from them as a convenient sub-division; and it appears that this group in like manner passes conformably up into the fossil-wood group, though it may prove that this conformity was not universal and that in some parts elevation and denudation of the present group were taking place simultaneously with the regular and conformable deposition of the overlying group in others. I have named these beds 'Prome' beds from the fact of one of the best sections I am acquainted with occurring in the river bank opposite and above Prome. Of these I here give a section in ascending order, partly measured and partly estimated. The value of this section, however, is not in its accuracy of detail, as the oblique angle the beds form with the river is greatly opposed to correct measurements or to minute details respecting the beds comprised by it, and the ground is not favorable for such, but in the great thickness of beds which are here seen superimposed on the Sitsyahn shales, and the general position in the series which the beds themselves hold. Though many beds of this group are fossiliferous, yet there is great difficulty in comparing sections at distant points from the absence of beds comprising characteristic fossils; but this section is of use so far, in enabling us to fix the general position in the series of such fossiliferous beds as those opposite Prome, or such non-fossiliferous ones as the Sitsyahn shale.

Above the Sitsyahn shale then, in conformable and ascending order, we have the following section of beds which I group into an upper (B) and a lower (A) division:—

	ft.	in.
A.—Massive argillaceous sandstones in thick beds	575	0
Beds (probably shales) not seen	50	0
Massive grey sandstone	3	0
Shaly beds (not seen)	100	0
Shaly sandstones	35	0
Beds not seen	125	0
Grey sandstone somewhat shaly	12	0
Carried over ...	900	0

Brought over ...	900	0
Grey sandstone in rather flaggy beds	12	0
Beds not seen	12	0
Hard grit	2	0
Beds not seen	60	0
Soft yellow sandstone	5	0
Soft beds not seen	75	0
Hard sandstone	8	0
Blue shales, with yellow sandy layers and marly concretions ...	150	0
Hard sandstone, with grey sandy shale partings	30	0
Blue shales, with sandy beds at intervals	130	0
Blue and yellow shaly sandstone	3	0
Yellowish shale	9	0
Hard sandstone	2	0
Soft shales (ill seen)	20	0
...	1,418	0
B.—Compact marly sandstone, softer at base (cardita and cytherea)...	5	0
Soft beds (ill seen)	60	0
Sandy beds resting on soft yellowish sandstone	40	0
Hard gray sandstone	2	0
Soft beds (ill seen)	250	0
Gray arenaceous shale in two and four inch beds, with hard spheroidal bands at base	70	0
Yellow sandstone	10	0
Compact sandstone, with large spheroidal concretions (arca, crabs, &c.)	5	0
Hard yellow sandstone	50	0
Yellow sandstone, rather softer	12	0
Hard yellowish shelly sandstone	3	0
Hard do., with casts of Pelecypods	1	0
Dark blue shales, rather slabby	30	0
Grey sandstone	3	0
...	541	0
TOTAL A+B ...	1,959	0

The channel of the Irrawadi here intervenes, causing a break between the section above given and its continuation in the opposite bank. Whilst, however, the precise thickness of beds represented by the gap thus caused cannot be determined, it is certain that the beds which come next in sequence, below the town of Prome, present the same facies as regard their fossils as those opposite the town, and that the whole may fairly be classed on the evidence of their included fossils, as one group. Considering that the present bed of the Irrawadi toward the frontier seems to mark a line of weakness, disturbance and crushing, as evinced by the condition of the strata at many places in its bed, it is not necessary to assume any very high figure as the thickness of the beds represented by the gap; but for any exact estimate there exist no data whatever. The most important beds in the section, however, which, I think, must intervene at this place, are some very fossiliferous blue shales which in the Records (Vol. II, part 4, page 80,) I have termed Kama clay, from its being fairly exhibited on the bank of the Irrawadi under the important town of Kama 18 miles above Prome. They are also seen in many spots East of the Irrawadi, and may be generally detected at once by the numerous well-preserved fossils they contain, though in other respects they much resemble the unfossiliferous Sitsyahn shales at the base of the group. Blue shales appear to have been largely formed in these seas during the whole of the Tertiary period (without going earlier), as they occur largely throughout the Nummulitic group, largely at the base of the newer Tertiary group immediately succeeding to the Nummulitic limestone, and higher again in the series, in the case of the Kama clay in question, which latest extensive development of the shale is far richer than the others in organic remains. The character of the deposit is one of deep, still water, favorable to the tranquil accumulation of the finest sediment, embedding foraminifera and minute and well-preserved pelecypoda in the positions and attitudes occupied by them during life. The number of species, however, is not large, nor are the individuals so numerous as are sometimes met with in the coarser sandstones of the group.

The following genera have been noted in the Pegu group, but they usually occur in particular beds, and are absent from great thicknesses of strata, where they might be looked for. Those marked* are common :—

* Arca.	* Tellina.	Toredo.
* Pecten.	Pectunculus.	* Cardium.
Cardita.	Venus.	Ostrea.
Placuna.	Corbula.	Pinna.
Cytherea.	Anatina.	* Thracia.
Murex.	* Conus.	Mitra.
Concholepas.	* Natica.	Rostellaria.
Dentalium.	* Trochus.	* Turritella.
Orbitolites. 2 sp.	Ancillaria.	Cypræa.
Balanus.		Hemifusus.
(Corals) * Flabellum.	* Turbinolia.	* Cladocera.

A few small crabs are not uncommon in some beds, but are as yet undetermined. Echinoderms are scarce and not well preserved.

Above this Kama shale occurs, a very thick series of sandstones and shales, which do not present any bed sufficiently well marked, either by mineral character or fossil contents, to serve as a serviceable horizon for the division of the group; neither for the same reason can isolated sections of this part of the group be collated, and an idea gained of its total thickness. These uppermost beds of the group pass, as already stated, into beds which, from containing mammalian bones, I have included in the fossil-wood group; and an uninterrupted process of deposition seems to have gone on under similar marine conditions through the whole series, save only perhaps as respects the highest bed of the fossil-wood series, beneath which if anywhere, and here but very doubtfully, can any break in the sequence of beds be looked for.

There are some slight means, however, of judging of the position of some of the highest beds of the present group, as, for instance, the occurrence of a species of *Turritella,* hardly distinguishable from one now living on the coast, which seems, where it occurs plentifully, to mark a high position in this group; and the same may be said of a species of coral (*Flabellum*) which first appears in the *Cytherea Promensis* bed at Prome, but seems to range as high as the above-mentioned *Turritella.* Characteristic of this *Turritella* horizon and the passage beds into the fossil-wood group is another coral (*Cladocera*), very commonly seen in hard sandstone, and the commonest and best marked fossil in them, although by no means an abundant species anywhere.

Except in the Kama shale, foraminifera are scarce throughout the beds of this group. A single specimen of an Orbitolite was found in the *Cytherea Promensis* bed, opposite Prome, which, when perfect, might have been the size of a shilling, but with a thickness no greater than cardboard. A careful search, however, failed to discover a second specimen. Another species of Orbitolite forms the characteristic fossil in a hardish sandstone on the bank of the Irrawadi, a little above the lime-hill; but unfortunately the position of the bed is not very clear, neither does the fossil occur anywhere else that I know of. A perfect specimen must have measured five or six inches across, with a thickness of not more than the tenth of an inch, and these organisms are, in parts of the rock, packed together so closely that the section of them on the surface suggests the idea of a cross-cut through a bundle of little pancakes.

Echinoderms are of extreme rarity throughout this group, save in a bed which I shall presently describe, whose position is quite problematical. The occurrence, however, of a species of *Pseudo-diadema* is remarkable from the Cretaceous affinities which, in the opinion of Dr. Stoliczka, it would seem to indicate—a view supported by the very Cretaceous aspect of many of the squaline teeth so abundantly found in many beds of the group. These fossils (*Pseudo-diadema*) are met with at a few spots only in Eastern Prome, some four or five miles South-west of Zen; but I was unable to discover the precise bed from which they were derived. They are collected by the natives in their hill clearings, and in streams after rain; and are called by them 'fossil betel-nuts.' From their perfect preservation and mode of occurrence, they are, I doubt not, derived from some soft shaly band out of which they weather and get revealed from time to time by the plough or heavy rain. One very perfect and quite unweathered and unrolled specimen was picked up by a servant of mine on the surface of a thick bed of blue shale in the Paday stream below the village of Nyoung-beng-khyeng, 40 miles East-south-east of Thaietmio; but a careful search did not reveal any other fossils in the bed in question; still, I am of opinion that the fossil was really derived from some little arenaceous marly vein or pocket in the shale whereon it was picked up. Associated with the *Pseudo-diadema* and in the same mineral condition, indicating a ferruginous marlstone as matrix, occurs a species of *Lucina,* well preserved with both valves united, and a few other ill-preserved shells.

Now, the position of the beds which contain the *Pseudo-diadema,* and the shark's teeth which seem identical with those found in the Cretaceous beds of South India, corresponds, as far as I can judge, to the upper portion of the Prome group; the general facies of the fauna of which group is decidedly suggestive of an age younger than the Miocene, rather than older. Are we then to believe that characteristic Cretaceous forms survived in these seas down to Pliocene times; or that an unestablished outlier of Cretaceous beds exists among those of the newer group? I confess my own view would lead me to adopt the former supposition; but the question is too important a one to be settled on the slender evidence before us. Some years since, among a few fossils forwarded by me to Dr. F. Stoliczka, from quite another locality, was a *Terebratula* which Dr. Stoliczka considered as very Cretaceous-looking; but this was from a village, Tamabeng, on the Pegu River, and can have little or no bearing on the question of these Zeu fossils. The locality is, moreover one, where, from its greater proximity to the edge of the basin of deposition of the Tertiary sea on the East of the Pegu Yomah, we should expect, if any such existed beneath, to find older beds brought up. It may be observed, too, that beds of undoubtedly Cretaceous age occur on the Western side of the Arakan Yomah, if not within the actual Irrawadi basin; so, there is no inherent improbability of the extension of these cretaceous beds into Eastern Prome, though what is known of the distribution of these rocks in Arakan does not seem to favour the idea, but this will be treated of hereafter. I may now pass to the description of what I have termed the Nga-tha-mu beds, whose exact position with respect to the Prome group is doubtful.

Nga-tha-mu beds.—A remarkable patch of beds, somewhat recalling in general appearance the Porebunder beds of Kattiawar, occurs on the Arakan coast, but is nowhere to my knowledge seen anywhere else. These beds embrace Koranji island in Lat. 16° 30′ 50″, together with a small portion of the mainland near the village of Nga-tha-mu, whence their name is taken. The most characteristic bed is a calcareous sandstone, or soft, rather earthy, limestone of a very pale brown or cream color, containing four species, of as many genera of echinoderms, the most common being a species, of *Lobophora,* very close to that now inhabiting the adjoining coast, and a species of *Echinolampas* (near *E. affinis*), and one pelecypod, a rather small species of *Amussium.* Koranji island consists of beds of thin calcareous sandstone, having a high dip, West-by-north, nearly; to which it may partly owe its protection from the force of the seas which break violently on it, but are received by the sloping beds up which their force is gradually expended. A deposit of this sort must have had a far greater extension formerly, but denudation has, save at this one spot, removed every trace of it; and to the mechanical advantage possessed by beds dipping seawards, I should largely attribute the existence of this isolated patch of rocks, by no means hard or especially adapted to resist denudation. On the mainland they are entirely isolated by a low swampy channel, running into the Ngayot creek. Just opposite the northern extremity of Koranji island some beds of earthy bluish sandstone come in vertically along the shore, seeming to underlie the other rocks, and containing a few ill-preserved fossils, *Arca, Cardium,* &c. On the mainland, a large *Carcharodon* tooth was picked up, seemingly derived from the earthy limestone, and which much resembled a tooth I found in the sandstones six miles below Thayetmio on the opposite bank of the river, and which would seem to be high in the Miocene group. Small squaline teeth are numerous throughout the upper portion of the Miocene group, and in the basal members of the fossil-wood sands, but I have only seen two specimens of this large *Charcharodon* (some two inches long), which must consequently be somewhat rare.

At the mouth of the Nga-yot creek, small shark's teeth are not rare; and from the same earthy calcareous beds I obtained two conical fish teeth, some fragmentary crustacean claws, and the ossicles (palatal or dermal) of some species of Ray. On Koranji island I procured a small reptilian tooth, with cultrate-edges, smooth, and mottled yellow longitudinally. Fossils are, however, very scarce save the two echinoderms abovenamed; and in places a small foraminifer which accompanies them. I shall allude elsewhere to this calcareous rock, which is well suited for economic purposes, though rather out of the way as regards its geographical position.

VIII.—The Nummulitic or Eocene Group.

This important group is largely developed in Pegu, extending from the frontier, to Pooriam point, a rocky spit running into the sea at the mouth of the Bassein river, the most westerly branch of the delta of the Irrawadi. Within the limits of Pegu, this group is confined as far as is at present known to the West bank of the river. Towards the frontier these rocks form a regular belt of country intervening between the Triassics to the West and the newer Tertiaries to the East; but South of the point where the Triassics disappear, the precise extent of the Nummulitic group to the West is uncertain, from its joining, if not blending with, the altered rocks of the Southern portion of the Arakan hills, which are almost devoid of organic remains, or present so few as to be useless for any purpose of sub-division of the group, or even for estimating its geological age.

For these altered rocks of the Southern region, I have, therefore, been forced to accept a provisional classification and name, calling them Negrais beds, from their being very characteristically displayed about Cape Negrais, at the Southern termination of the Arakan range. These beds probably include, could we only establish the fact, members of the Eocene group, with a large preponderance of beds of an older group of Cretaceous age—the southern extension of beds which, in the Sandoway district, we can declare on meagre, but unquestionable fossil evidence to be Cretaceous.

It is, however, certainly not among the altered rocks of the Southern portion of the Arakan range (the Negrais beds of my present classification) that any hopeful attempt can be made to separate these two groups, Eocene and Cretaceous, from one another, partly from the alteration the beds have been subjected to, and the consequent obliteration therein of any fossils they may have formerly contained (and to some such cause it seems impossible *not* to refer the general unfossiliferous character of the limestones within this area), and partly to the wild forest-clad and uninhabited character of the hills which quite debars one from effecting anything like a close examination of them.

On the frontier line, going West, the Nummulitic group is first met with at sixteen and a half miles from the river, and attains a breadth of seventeen miles. A few miles to the South of this point the breadth diminishes to eleven miles, but soon again widens to fourteen miles, whence it again decreases, till at the Thalaydan stream the breadth is only one and a half mile, this diminution being partly produced by the outcurving of the beds to the East, and the denudation by the river they have thereby been subjected to. Still going South, the breadth increases somewhat, and at Akouktoung, the celebrated carved rocks four miles below the Thalaydan stream, the group is four miles broad. South of Myanoung the extent of the group becomes somewhat irregular and uncertain, being covered and masked on the East by a thick deposit of sand and gravel; while on the West its extent cannot be satisfactorily defined, from the ambiguity attaching to the altered rocks of the Negrais group, and the difficulty of separating them from the Nummulitics.

I must now preface my remarks on the geology of Western Prome by a brief sketch of its main physical features, as an intimate connexion subsists between the geology of the district and the physical arrangement of its surface. This is well seen in many places, and could be readily enough detected on a good map, but the orographical details of our only map are so inadequately given, as to mislead the eye and render necessary a somewhat tedious review of the chief points in question. Western Prome viewed from across the Irrawadi presents the appearance of an undulating country covered with low hills, with a few hills distinctly more prominent than the rest from amidst which they rise in quasi isolation. Prominent among these is the so-called Lime-hill below Thaietmio, a mass of Nummulitic strata forced up through the newer Tertiaries, and forming a conspicuous landmark for the district. Towards the frontier there is also a very prominent range, which crossing it about three miles west of the river, extends down to within some six miles of Thaietmio, where it terminates. To the Westward, higher ranges are seen, but at this distance their arrangement is not clearly made out. I shall presently show how along this distant line of hilly country the boundary of the Nummulitic group corresponds with certain well marked physical features of the surface.

Opposite Prome is a fine range of hills, backed by a confused mass of hilly ground, the whole gradually sloping down into the plains at the back of Padoung. Proceeding West from the river, at almost any spot between Prome and the frontier, we notice along a certain line, a change in the physical configuration of the surface, which line coincides with the Eastern boundary of the Nummulitic group, and although it may not be of such a character to arrest the eye in the unfrequent and limited *coup d'œil* which the country affords, yet, when looked for, it is usually found to be present, either as a distinct range, or else in the contrast afforded between a more or less elevated tract of hilly country, and the lower ground into which on the East it slopes down.

West and South-west of Thaietmio stretches a belt of low hills, much scored by ravines and made up of the fossil-wood beds already described. The axis of this belt of country runs in a slightly curved line, with its concavity facing the river, from the village of Pima-khon, fourteen miles West-north-west from Thaietmio to Alayua, midway between Pulo and Kama, giving a length to this tract of twenty-five miles, by a breadth varying from six to ten miles. Leaving this belt of ground in a Westerly direction across the Pani (Punnee) stream, the character of the country gradually changes in accordance with the fact of our descending somewhat on to the lower beds, beneath the fossil-wood group. Across the Pani stream in place of the incoherent fossil-wood sands, we come on to not very dissimilar beds, but in which marine fossils are pretty common; and which, from the abundance in spots of that shell, may be termed *Turritella* sands; and these beds are either very high in the series of the Prome group, or perhaps correspond in part with the Mogoung sands, intervening between the Prome and fossil-wood groups. The beds of the previously described Prome group, from the ease with which they disintegrate, give rise to an undulating or hilly country, with usually very little display of rock at the surface; but in some places, where thick beds of shale form the surface, the ground is more level, and deeply cut by stream channels, as exemplified West of Sitsyahn, above Prome. Such is the general arrangement of the ground in Western Prome; occupied by beds newer than the Nummulitic group, and embracing the whole country between the Nummulitic boundary and the river.

Sixteen miles West of the Irrawadi stands the frontier village of Phoungaeing, and looking Westward from it, the eye encounters a forest-clad range, which, crossing the frontier from the North, extends down South for nearly eight miles, and affords in its bolder outlines and denser vegetation a pleasurable contrast to the lesser ranges to the Eastward. Along the Eastern foot of this range runs the boundary of the Nummulitic group, which I will follow out in some detail. Between Phoungaeing and the range to the Westward flows the small stream, which after a somewhat tortuous course, flows into the Irrawadi, three miles above Thaietmio, running for its entire course through beds of the Prome group, or through some considerable spreads of alluvium. In the stream, near Phoungaeing, blue shales are seen, which I consider as at the base of the Prome group, and corresponding with those seen near Sitsyahn, and much the same shales are seen some miles further to the South overlying the Nummulitic group. On ascending from the small stream to the range, the blue shales are left behind, and Nummulitic limestone is found forming much of the higher parts of the ridge, and the face of its Eastern slope, the rock dipping at a high angle East-north-east. Eight miles South-south-east, from Phoungaeing, is the village of Pimakhon, situated on the verge of the sandy tract previously noticed; and two miles North-west of this village, the range I am describing terminates in some confused hilly ground, of the ordinary character and elevation of the neighbourhood. A small stream here intersects both the Nummulitic and Prome groups, affording a tolerable section. On the North bank of the stream, where it cuts the tail of the range, the Nummulitic limestone is seen in its wonted position on the hill side, dipping about 80° between North-east and East-north-east, but much broken up into loose masses as it approaches the stream. The limestone tails down, however, in a sort of spit to within some twenty yards or less of the bank of the stream, when it disappears, and would seem to die out, as it certainly does not reappear on the opposite bank, where sandstones and shales are alone visible. Lower down the stream to the Eastward, a great thickness of bluish shales without fossils, comes in, which I consider as identical with the Sitsyahn shales, and which are here nearly vertical and much disturbed. On the South bank of the stream, in the spot where the Nummulitic limestone, if continued, might be expected to appear, sandstones only are seen, some of which display carbonaceous markings; and one bed was an intensely hard grit, containing small shark's teeth, and the cast of a large *Cerithium*-like shell, the size and proportion of the living *Terebralia telescopium*. Between these presumedly Nummulitic sandstones and the overlying shales, I could detect no break, and I believe the explanation of the absence of the Nummulitic limestone from this section, is due simply to that rock at this spot dying out, a similar instance of which I shall presently describe.

West of this range flows the Pani stream, for about seven miles below the frontier, in a sort of trough, or what may be considered as an irregular synclinal of Nummulitic strata. West of the Pani stream, Nummulitic limestone occurs plentifully at many places near the river, not only developed largely on the surface of the ground, but as a distinct ridge, which, though not continuous, may be traced with occasional breaks for about twelve miles. The limestone of this ridge is the same bed as that described near Phoungaeing, and like it, ends or commences abruptly about one and three-quarter miles South of the frontier village of Geing-yai, lying eight miles West of Phoungaeing. It is certain that the limestone terminates at this spot, as does the ridge likewise, and cannot be traced farther North; but the country is so wooded that it is quite possible this may be the result of denudation. Considering, however, the section near Pimakhon and another I shall presently describe, I am inclined to refer the disappearance of the limestone, less to denudation than to the dying-out and original limitation of the rock. From this Northernmost point of this rock, its general bearing is about South-east-by-south for a distance of twelve miles, when it dies out on the flank of a low spur at a point almost midway between Thambula and Pyengeing (or Pimaeing), a village thirteen miles South of Phoungaeing. A little above this a section is seen in an affluent to the Thambula stream, which throws much light on the Pimakhon section, and the somewhat abrupt disappearance of the limestone there as I have already described.* A stream here intersects the Nummulitics a little above the termination of the Nummulitic limestone which dies out on the slope of a very steep and precipitous ridge, of which it may be regarded as constituting the core. Climbing this ridge, the limestone is seen confusedly arranged, but seeming vertical, and striking across the small stream here intersecting the group. In the stream below this limestone, blocks are plentiful, but I traced them up till they ceased without at first detecting the Nummulitic limestone *in situ*. Retracing my steps I soon found that no thick massive bed of limestone existed here, but that the limestone seen on the hill above and in the bed of the stream, occurred as thickish slabs or courses of rock in a bed of yellow shale, which fully accounted for the confused arrangement of the rock on the flanks of the hill, and how from its subordinate

* The map is here somewhat incorrect, as in it, Pyengeng is represented as separated from Thambula by an unbroken range, the water from the former village being represented as flowing South into the Mahton near Choung-kwa, whereas in reality it flows North and then West from Thambula, through a gorge in the Nummulitics falling into the Mahton below Tautabeng, several miles above Choung-kwa.

position in the bed of shale, it might any moment thin out and disappear. The Nummulitics are here nearly vertical or dipping to the North-east. Below the limestone some harsh sandstones come in, having the appearance of having been subjected at some period to intense pressure. Below these harsh sandstones, yellowish shales come in containing carbonaceous layers but no fossils. Above the Nummulitic limestone, or the yellow clay representing it, blue shales come in vertically, quite devoid of fossils as near Phoungaeing, and much crushed and disturbed. I may here briefly describe the few ranges which here traverse the Nummulitic area.

Crossing the Pani valley in a Westerly direction from Mibouk, the first range of any importance is the one formed by the Nummulitic ridge, which, commencing near Gengyai terminates between Thambula and Pimaeing. This range is in places of considerable height, but not equal in this respect on the whole to the next range to the Westward. This second range crosses the frontier West of Gengyai and runs down with a somewhat curved outline towards Thambula, near which village it approaches the last range, and when that dies out, holds on in its place as it were, some eight miles further, to the Mahton stream. Behind this to the Westward, is another less regular range, and the arrangement of these ranges slightly *en echelon* to the Nummulitic boundary is a noteworthy feature, as the boundary corresponds with the strike of the Nummulitic beds, which strike, in the absence of faults, might *primâ facie* be supposed to govern the direction of the main ranges. This perhaps to a certain extent it does, but not entirely so, otherwise the *en echelon* arrangement of the hill ranges above described would not exist.

Another feature of the Nummulitic area is its greater elevation, than the ground to the Eastward occupied by the newer Tertiaries, as marked by the sensible descent experienced when crossing the boundary between the two from West to East. This feature is well seen when journeying from Laidi on the Than-ni stream to

Nioungain, where the Nummulitic belt is crossed almost at right angles by the road, and is nearly seven miles broad. After leaving the Than-ni stream, the road at once ascends, and for five and a half miles continues over an elevated strip of country, covered with somewhat sparse forest, and devoid of water. Very little rock is seen, from the readily disintegrating character of the beds of the Nummulitic group. At one and a half mile west of Nioungain, the road suddenly descends into the low country at the village of Lendon (not in the map) by a distinct fall, and this seems to be commonly observable along the Nummulitic area to the Eastward. South of this point the ground is broken up, and so covered with impenetrable forest that little can be seen; but to the North, a few roads run along this elevated Nummulitic area, giving glimpses of the general features here described though much obscured by forest. A very similar section of country as that above described, is seen seven miles to the North of this, on the road running West of Nyoung-ben-kweng. The following is the section of the Nummulitic group seen in the stream near Thambula in descending order.

MIOCENE.

	Ft.	In.
Greenish gray earthy sandstone, shaly in places, but mostly massive, over	100	0

NUMMULITIC.

	Ft.	In.
Nummulitic limestone	10	0
Soft sandy and shaly beds (ill seen)	65	0
Hard yellowish argillaceous sandstone	1	0
Soft beds (ill seen)	80	0
Fine greenish gray silty sandstone, micaceous, rather slabby, with some shaly partings	6	6
Pale shales	1	6
Dark shales and soft beds (ill seen)	75	0
Carried over ...	239	

Brought over ...	239	0
Hard grey sandstone with marly lumps	2	0
Soft shales	30	0
Sandstone, silty in parts and irregularly bedded	1	0
Soft shales	70	0
Hard marly band	0	9
Soft shales	50	0
Silty sandstone	2	0
Dark shales	20	0
Hard sandstone	1	0
Dark shales resting on hard sandstone	26	0
Soft beds (ill seen)	90	0
Fine massive greenish sandstone	10	0
Soft beds	25	0
Massive earthy sandstone	5	0
Pale clunchy shale	4	0
Nummulitic shale	0	9
Pale clunchy shale	11	0
Nummulitic shale	0	9
Dark shale, flaky below	4	0
Flaky sandstone	1	6
Pale shales, somewhat silty	2	0
Shales dark and clunchy	11	0
Pale earthy sandstone, shaly at base	1	6
Hard sandstone	0	9
Soft shales with a little sandstone	35	0
Flaggy sandstone	3	0
Flaggy shales	20	0
Hard sandstone	1	0
Greenish sandstone with soda efflorescence	80	0
Greenish shales ditto ditto	50	0
Massive sandstone	3	0
Shales pale and silty	20	0
Massive sandstone, with a few beds of shale	175	0
Pale shaly beds	90	0
Thin bedded silty sandstone	1	0
Arenaceous shales, with carbonaceous markings	50	0
Pale arenaceous shales with rusty laminar concretions and carbonaceous markings	5	0
Dark brown shale, clunchy at base	80	0
Compact bluish sandstone with some carbonaceous matter ...	1	0
TOTAL ...	1,223	0

This section, though not everywhere well exposed, and lying in a small and somewhat tortuous stream, gives, nevertheless, a good general idea of the beds of the Nummulitic group, and may be thus generalized:

	Miocene.		
	Clay and sandstones		
	Nummulitic.		
1.	Nummulitic limestone...	10	0
2.	Shales and sandstones; shales occasionally Nummulitic ...	658	0
3.	Massive sandstones with some shales and much soda efflorescence in places	328	0
4.	Shales and sandstones, the shale with some carbonaceous markings	227	0
	Total ...	1,223	0

The limestone at the head of this section is, as far as can be judged, the highest bed of the Nummulitic group: and its variable thickness, for in many places it must be from sixty to a hundred feet thick, is quite in accordance with that general irregularity of development which, as I have already described, causes it in places to thin out abruptly and disappear. There can, however, be little doubt that this topmost bed of the group is the same bed which can be traced at intervals from near Phoungyi to the Pyengma stream in the Bassein district, a distance in a direct line of two hundred and twenty-four miles. That it is not more largely met with than it is, seems partly attributable to its irregular development, and partly no doubt to the extensive denudation it has undergone during the most recent times and subsequent to the formation and arrangement of the general surface features of the ground at present. Below the bed in the above section there comes in a great thickness of sandstone and shales, which are perhaps best seen in the pass East of Mendoon; but I did not measure the beds, as I saw no means of correlating them satisfactorily with the above section. The low hills Southwest of Choungkwa on the Mahton belong to this portion of the group, and the ridge between Choungkwa and Thambula may in part belong to it. The summits of this ridge from a distance present a somewhat striking appearance, the peaks consisting of smooth bosses of naked rock weathering in much the fashion of granite, in tor-like masses. This is due to the mineral character of some of the prevailing sandstones of this portion of the group. These sandstones are compact, thick bedded, of a yellowish or grey color, not very hard, and are usually more or less argillaceous in constitution, and it is this compact earthy sandstone which is prone to weather into rounded bosses or blocks, often of huge dimensions, the surface of which is clean and free from vegetation, save where a fissure permits some stunted tree to take root.

Some of these beds contain hard nodular concretions, of from three to fifteen inches in diameter, of an almost subcrystalline texture, which impart the aspect of a conglomerate to the bed containing them; they are, however, merely nests of finer and more calcareous material than the surrounding rock, and of innate, not extraneous origin. Small Nummulites occur low down in the group in some shaly beds; but I could detect no other fossils whatever.

Below these sandstones comes in a great thickness of blue shales. These are well seen about Gwaygi (or Gyeng-gay) eight miles South-south-west of Choungkwa on the Mahton. These shales are massive, that is, the bedding is not readily recognisible save where sandstone beds intervene. The rock is unctuous, tough, and clunchy, and of a rather dark indigo blue, quite a distinct tint from the Sitsyahn shales, at the base of the newer Tertiaries; but this characteristic dark hue is not always present, some of the beds being lighter in color, and at the same time more tender and friable. The whole of this portion of the group is, however, very homogeneous in general character, and most provokingly deficient in fossils, the only organic remains noticed by me being a few cycloidal scales near Gwaygi, but these were very rare, and could not be preserved, from the breaking up of the shale containing them into minute fragments on drying. These shales and the argillaceous sandstones which overlie them must represent a prodigious thickness of beds, by a rough estimate not less than three thousand feet.*

The following section in the Hlowa stream embraces some beds probably lower than any mentioned above, though there is no means of properly correlating the beds. It is far from clear in this section where the Nummulitic group commences, and a certain margin for this uncertainty must be allowed. The beds are, where the section commences nearly vertical, but lose this character, as we ascend in the section. The junction of the Nummulitics with the Triassic rocks, is I believe, a faulted one; and my colleague, Mr. Fedden, in speaking of this very section alludes to "something very like a fault," though I cannot precisely identify the beds which he considered it to separate. The section now given is that alluded to in the Records of the Geological Survey of India, Part 2, 1871, page 37, and is a continuation along the bed of the Hlowa stream of the rocks below the point where I assumed the Triassics to terminate along a fault.

Section of lower Nummulitic rocks in Hlowa stream above the village of Yuathit, in ascending order:

Triassic strata.—

	Ft.	In.
Nummulitics—		
Hard sandstones (ill seen)	44	0
Shales (ill seen)	600	0
Blue friable shale, with numerous bands of sandstone ...	145	0
Ditto with shales predominant...	81	0
Carried over ...	870	0

* These sandstones form both banks of the Mahton stream where it approaches the Nummulitic boundary, and from their mode of weathering into precipitous slopes entirely obstruct the valley on either bank for any animal save men and goats. Horses and carts are forced to take to the channel of the Mahton, fording backwards and forwards from bank to bank, as the nature of the stream compels them; and in the rains the river path is of course impassable and all traffic suspended. A good road might be easily made at a small cost along either bank, which would prove a great boon to the people, and which, if carried along the East bank, would avoid the formidable crossing at the junction of the Hlowa stream with the Mahton.

Brought forward ..	870	0
Hard blue sandstone	3	0
Shale and sandstones, former predominant	12	0
Hard blue sandstone	2	6
Shales and sandstones, latter thin, former predominant ...	250	0
Blue friable shale with harsh blue and grey sandstone ...	51	0
Blue shale with sandstone courses	17	0
Blue and grey harsh sandstone and shales, former predominant	173	0
Blue and yellow shales, with hard sandstone courses, in regular beds, one to four inches	16	0
Pale bluish gray sandstone	1	0
Blue and yellow shales as above	78	0
Yellow shale, with hard blue sandstone courses	25	0
Shaly beds (ill seen)	103	0
Blue shale	1	0
Hard grey argillaceous sandstone, rather shaly	1	6
Sandstone in one and two-inch beds	51	0
Grey shale and shaly sandstone	5	0
Blue and yellow shale	65	0
Shale and sandstone (ill seen)	85	0
	1,810	0
(Here comes in the village of Yuathit, below which the section is merely estimated, not measured.)		
Hard sandstone	7	0
Greenish grey flaggy sandstone and bluish grey arenaceous shales, with carbonaceous markings	45	0
Dark shales with a few nodular courses of indurated marl, with a few sandy bands here and there	275	0
Fine pale greenish sandstone, massive above, less so below ...	45	0
Ditto more flaggy	50	0
Blackish grey arenaceous shales	255	0
Pale greenish grey arenaceous shales, and greenish and yellowish grey sandstone in intercalated thick beds, fine grained, compact, and with carbonaceous marks and rippling ...	180	0
Massive argillaceous greenish sandstone, with an amylaceous fracture	100	0
Ditto with shales, thin bedded	200	0
Dark shales, with a few sandy beds	200	0
Ditto, but the sandstone more thickly bedded, and less regularly dispersed, ripple marks in places	190	0
Grey massive sandstone, thick bedded	260	0
Massive sandstones, thick bedded with occasional beds of shale	500	0
	4,117	0

Beyond carbonaceous markings, I noticed no fossil whatever; many of the beds however are badly seen, and the chief value of the section consists in showing the astonishing thickness of this early Tertiary group. It must, however, be remarked that in the total absence, from this lower portion of what I have designated the Nummulitic group, of all fossil evidence as to its age, it is possible that some of the beds may be of a greater age, though this cannot with certainty be either affirmed or denied.

At the point where the above section is taken, the Nummulitic group is wider than almost anywhere else, its width being thirteen miles; opposite Myanong the width is only ten miles, and at Henzadah not more than two.

South of Henzadah and in the Bassein district the Nummulitic beds are much covered up by surface detritus, and their width inconsiderable. South of Ngaputau, near Thamandewah, a considerable outcrop of Nummulitic limestone is seen, and Long Island in the Bassein river, and much of the ground to the Eastward consist of unaltered Nummulitic strata. At Pyengmakhyoung, West of Long Island, Nummulitic limestone occurs near the bank of the stream; and Pooriam Point, thirty miles still further South, consists of Nummulitic sandstone; so that from the frontier to the gulf of Martaban, the beds of this group constitute a belt of ground flanking the Arakan hills on the East for their entire length. West of the Arakan range Nummulitic limestone occurs in two spots near Kyeantalee, but the question of what rocks the Arakan range is mainly composed of, I shall presently discuss under another head. In a manuscript report dated 1862, Mr. W. Blanford makes the following remarks on the Long Island beds: "Extensive areas of low hills composed of rock also occur to the East of the river, especially in the neighbourhood of the sea. Pooriam Point, for instance, is composed of a peculiar white or whitish green argillaceous sandstone which, although containing Nummulites, appears to be one of the highest beds of the Nummulitic group in the district.

This bed recurs on Long Island and in several places farther North, the most Northerly locality noticed being near the village of Kya-bon, South-west of Nga-theing-kyoung, where considerable quantities of the stone are extracted for the purpose of carving into images of Gaudama." This stone, which is locally used in Southern Pegu in place of the crystalline marble of which images are made in Upper Burma, is called '*andagu kyouk*' or image-stone, and extends a little higher than stated above; the most Northerly point known to me being in the bed of a stream falling into the Nunga-thu-khoung, near Endeingon, some twenty-six miles North of Nga-theing-kyoung, and in about the parallel of 17° 45′. It is merely exposed here in the bed of the stream, and it is possible Mr. Blanford's words may allude to the furthest point to the North at which quarries of it are worked. As the beds here are much masked by gravelly accumulations, these beds probably extend still farther to the North, but I am acquainted with nothing analogous to them in the Prome district, and am inclined to regard them as local deposits which never extended much beyond the district of Bassein. Their position with regard to the limestone is doubtful, but they probably come in above it and constitute the highest member of the group.

Between Gyo-gon on the Kyet-toung stream and Shan-gha-yet a thick bed of soft argillaceous sandstone, evidently one of the Andagu kyouk series, rises up in the jungle in the form of rounded blocks which the Burmese term 'Amwa-ko theing' and regard as a herd of elephants turned to stone. The peculiar mode of weathering of the argillaceous beds of this group is due to their composition, which causes them to crack spontaneously and desquamate under atmospheric action. This habit of the rock may be conveniently termed the 'amylaceous,' from resembling the manner in which starch shrinks and cracks in drying; and it is a similar tendency, in some of the finer and more homogeneous beds of this division, to break up into cuboidal masses and desquamate spontaneously at exposed corners, that interferes with the use of the stone for ornamental carvings, for which purpose its fineness of grain and softness would seem to recommend it. For internal work, however, in places protected from the weather, it would probably answer well. The 'Andagu kyouk' selected by the Burmese for carving purposes, is a very homogeneous, cream-colored rock, which is thus described by Mr. Blanford:—"The stone is obtained from the quarry in blocks generally about eighteen inches high, by a foot broad at the base, and four or five inches thick. These are said to be sold to the image carvers at the price of fifteen rupees the hundred. The rock is very soft, resembling chalk in consistency, and its extraction and carving are easy." An unusually light and pure specimen from near Endeingon was found by Mr. Tween to be composed as follows:—

China clay	76	0
Silica (insoluble in sulphuric acid)	23	4
Soluble matter, Lime, &c. (no iron)	0	6
	100	0

West of the Arakan range, I have no certain knowledge of the occurrence of these 'andagu-kyouk' beds; but near Kyeantalee, in a swampy spot on the South bank of the Kyeantalee river, near Sande, an outcrop occurs of a white argillaceous rock which may represent a bed of this group, the more probably so, from its occurring near a small outcrop of Nummulitic limestone, close to Pandua (a village not on the map).

Having described the arrangement and extent of the Nummulitic group along the flanks of the Arakan range, it only remains to add a few words regarding an outlier of this formation which at one time attracted considerable attention on account of a small deposit of coal which it contained, but which did not fulfil the expectations entertained regarding it. A full account by Dr. Oldham of the operations undertaken to test the economic value of this discovery is published in the

Selections from the Records of the Government of India, No. X, for 1856, which I need not here further allude to.

Ton-doung, or the Lime-hill, as it is commonly called, is situated some five miles below Thaietmio, at a very short distance from the Irrawadi on its West bank. Viewed from a distance it has the appearance of a single hill considerably higher than the low ridges in its neighbourhood, its height being estimated by Dr. Oldham (loc. cit.) at less than eight hundred feet. On a closer view, the hill is seen to consist of three distinct ridges or divisions, a small ridge to the south, which, from facing the village of that name, may be called the Penthaling ridge; the central or main ridge, which, from the abundance of limestone on it, may be called the Lime-hill proper; and some hills connected with it to the North, the most conspicuous of which from the river is the small ridge crowned with a pagoda, and a very much higher hill, which from Thaietmio has the appearance of being the most Westerly shoulder of the Lime-hill, but which in reality is separated from it by a deep gorge through which the cart road from Thaietmio to Penthaling passes.

The Penthaling ridge is a low one, but well defined and with exceedingly steep sides. It is ranged at rather an oblique angle with the Lime-hill proper, along the South flank of which it dies off, giving rise to a small valley, at the mouth of which, on the bank of the Irrawadi, several lime-kilns are ranged. This valley marks precisely the course of the Penthaling, or most Southerly of the faults connected with the Lime-hill, the general direction of which must closely coincide with the course of the small stream flowing down the valley and falling into the Irrawadi just below the lime-kilns. The Penthaling ridge is composed of soft sandstones and conglomerates belonging to the newer Tertiaries, and from its excessive steepness and the loose pebbles scattered over its surface is very difficult to ascend or traverse; but an excellent section of the beds composing it is displayed in the river bank above Penthaling. Just below the spot where the above-mentioned small stream enters the Irrawadi, the lowest bed seen is exposed on the river bank and within a few yards of the Penthaling fault, which is, however, quite masked by recent sedimentary deposits. This lowest bed is a soft sandstone, dipping 70° to South-south-west, or directly away from the fault, which strikes nearly West-north-west from the river; and it contains numerous specimens of a coral (*flabellum*), also seen abundantly opposite Prome, and marking a high position in the newer Tertiary group. Above this sandstone stratigraphically, there comes in a thick series of sands and conglomerates which I am inclined to refer to the lowest portion of the fossil-wood group. One of the highest beds seen close to the lime-kilns above Penthaling village is a thick bed of conglomerate. This conglomerate is very hard, pebbly, and ferruginous, the included pebbles being covered with a dark glaze. It is almost devoid of fossils, but I have detected mammalian bones in it, though such are extremely rare. Near Penthaling it dips West-by-south, but as we approach the Lime-hill along the river bank, the lower beds veer gradually round from West-by-south (dip), through South-west, to South-south-west; which dip would seem to be the result of the mechanical intrusion of the mass of the Lime-hill brought up along the previously mentioned Penthaling fault.

The Lime-hill proper, or main ridge, is a barn-shaped mass of Nummulitic strata brought up by faults through the newer Tertiary beds which form the surrounding country. The hill impinges on the Irrawadi, but the Nummulitics do not come down to the bank, being faulted off from it by the interposition of a narrow band of the sandstones of the newer group. On the summit of the hill, Nummulitic limestone occurs *in situ* in sundry spots, and on its southern slopes either *in situ* or in masses undergoing removal by ordinary denudation. Standing near the river at the mouth of the small valley which intervenes between this and the Penthaling ridge, an enormous block of this limestone is seen conspicuously perched half way up the hill side, the remainder of the bed having here suffered removal. To the North, this ridge is so steeply scarped that the limestone is brought to the edge of the summit and thrown down, forming great shoots on the hill-side perfectly visible from Thaietmio. From the bottom it is removed to the kilns at the village of Ton-doung-ua; whilst from spots along the southern outcrops of the rock, it is broken up and placed in rough sleighs and thereon conveyed to the plains by means of bullocks and buffaloes.

It was in a ravine, or small stream which had deeply cut down into the shales and sandstone underlying the Nummulitic limestone at the western extremity of the hill, that the coal was first discovered in 1855 by Captain White, at that date Assistant Commissioner of Thaietmio. The irregularity of the seam was, however, fatal to its economic value, some idea of which may be formed from the following brief extract from Dr. Oldham's memorandum: "The best seams of bright coal were found suddenly stopped off by masses of clay imbedded in the general seam, or forming lenticular masses in the coal: layers which in one place were bright, jetty coal, passed, within a few inches' space, into earthy shale; and the whole bed which, when first seen, looked a very promising bed of 4 feet in thickness, was broken up into thin and irregular patches of coal mixed with clay."

The block of Nummulitic strata forming the Lime-hill proper is clearly cut off to the north by a fault parallel to the Penthaling fault, which would seem to run directly under the scarp of the hill, and to be covered by the talus of fragments and detritus from the rocks above. What appears from Thaietmio as the Western shoulder of the Lime-hill, is in reality a separate hill cut off from it by the above, or Ton-doung, fault; the gap separating the two being concealed from view at Thaietmio by this hill standing somewhat *en echelon* to the Lime-hill.

The fact of Ton-doung being brought up between the two faults I have named above, is sufficiently clear; but it is not equally certain whether the Pagoda ridge, or the Westerly ridge above-named, is also brought up in the same manner as the Lime-hill, or is merely elevated to a greater degree than the other newer Tertiary strata by the upheaval of Ton-doung, but without any through-faulting. I am much inclined to think that they are faulted, but there is hardly sufficient evidence to sustain the case. It is not, indeed, certain whether the rocks constituting the Westerly hill of Ton-doung, or the Pagoda hill on the East of it, belong to the Nummulitic or to the newer Tertiaries. A fair display of sandstone and shale is seen on the road section, in the valley separating Ton-doung proper from the Westerly hill opposite it; and a similar display of beds is seen on the ascent to the small Pagoda to the Eastward; but there is nothing to clearly indicate the age of the rocks. With this problem in view, I was inclined to consider, when on the ground, the rocks in question to belong to the Nummulitic series, and the hills in question therefore brought up by faults, as the Ton-doung hill itself. This I judged from the somewhat abrupt rise of the ridges in question, and their apparent connexion rather with the Ton-doung mass, than the newer beds through which Ton-doung had been forced up; but I do not hold the view with any confidence, or regard it as supported by any evidence of a reliable sort. Exclusive, however, of the Pagoda ridge and the Westerly extremity of Ton-doung, the age of which is open to question, the whole country round consists of beds of the Prome group, or of the more recent fossil-wood group, the former of which contain numerous fossils, though not usually very well preserved.

IX.—Negrais Rocks.

The term 'Negrais' was originally applied by me some years ago to a series of beds stretching Northward from Cape Negrais along the Arakan range and coast, and was then regarded by me as probably embracing the lowest beds of the Nummulitic group. No fossil evidence has since then been obtained; and I shall therefore retain the term with a somewhat extended application, making it embrace all the rocks met with in the above district older than the Nummulitic, and newer than the Triassic. It is by no means certain that some of the rocks which I have included in this group may not really be, as I at first surmised, of Eocene age; but as there is no adequate proof of this, it is fruitless attempting to solve the age of any members of this group. From the general absence of fossils in the lower portion of the Nummulitic group and a similar deficiency in the beds I am now referring to, any attempt to demarcate the limits of either group must more or less rest on empirical and general reasons, than on valid and particular ones; and the same difficulty is no less felt, as regards the relation of the present group to the older one in contact with it, than as regards that which immediately succeeds it. In the Northern part of the Sandoway district, beds of Cretaceous age (Cenomanien) come in and extend down as low as the parallel of Kyeantulee. It is therefore highly probable that these beds are continued down, along the coast, and included in the Negrais rocks; though from causes already specified, it is not easy to determine whether these consist mainly of beds properly referable to the Eocene or to the Cretaceous.

My original restriction of the band within narrower limits than I now adopt, was based on the belief of its unconformity to a series of beds which I now include in it—an opinion founded mainly on a section seen between tidemarks at Satwah, which I then supposed to indicate unconformity, but which I now consider capable of being otherwise explained. At Satwah a great expanse of pale and dark gray shales, with traces of carbonaceous matter, and occasional nodular concretions of limestone, occurs, planed down between tidemarks, and forming rocky patches and reefs off the coast here. These beds have a general South-east dip, and some of them are suggestive of ash-beds, though they contain no extraneous fragments. On the exposed edges of these shales, blocks of a very different mineral character are scattered, of too great a size to have suffered transport from any considerable distance. These blocks are of a cherty nature, and some of them not less than one hundred feet in circumference. It does not, however, appear to me necessary to regard them as relics of an unconformable bed, but simply as remnants of beds once intercalated among the beds whereon they rest, and being almost beyond the power of the waves to destroy, have subsided into their present position from contorted portions of strata now removed by denudation. The extreme disturbance to which these beds have been locally subjected, and the very partial development of such silicified masses as those in question, renders such an explanation of the seeming unconformity here seen, even more probable than the more obvious interpretation first adopted by me. Were it not so, and did a real unconformity exist between two groups about the level of high-water-mark, or between tidemarks, it would seem strange that no undoubted illustrations of such unconformity are elsewhere seen along the coast. Yet at only one or two spots do such instances occur of apparent unconformity, and these are not in my opinion incapable of another explanation, and are quite insufficient to enable us to separate the somewhat miscellaneous assemblage of beds comprehended under the present title. Should, however, real unconformity be established (which, without admitting, may be very possible), the newer of the unconformable beds must of course be regarded as belonging to the Nummulitic group, the lower, to the Negrais band as at present characterised.

The difference in mineral character in the Negrais rocks is very great. In some places flaggy and massive sandstones occur quite unaltered and dipping at moderate angles, whilst in places sections are exposed of highly altered shales and sandstones; and in some spots the sandstone is seen converted into a cherty rock seamed with silica and evidently subjected to alteration of an intense kind. In a less degree, this is precisely the capricious sort of sub-metamorphism which Mr. W. Blanford described as prevailing among portions of the Nummulitic strata in the Bassein district, a feature which makes it difficult to separate that group from the rocks I am now describing. The alteration to which the beds of this region have been subjected would seem, judging by its effect, to be of two sorts, perhaps rather marking different periods and degrees of intensity, than different sources. There is that wide-spread sub-metamorphism which, though somewhat capriciously exerted, yet extends over wide-areas, and affects a great thickness of beds, and is manifested by an induration and slight change in them, such as we may conceive to be the first stage in the process of ordinary metamorphism. This process is a wide-spread one, and the shales and sandstones subjected to it nowhere lose their character, but are simply indurated and altered to a variable extent by its action. There is in addition a more restricted and energetic sort of metamorphism which is seen along the coast, in the intense and often abrupt alteration of beds of sandstone into cherty masses of a harsh and intractible character. This sort of alteration seems mainly dependant on the abundant presence of silica, which has permeated the rock, and to a great extent replaced its original constituents; and this I believe is most completely effected where the rock originally contained a considerable amount of lime, many of the most silicious masses seen along the coast giving the impression that the rock was originally highly calcareous, but wherein now silica has almost entirely replaced the lime. I may here remark that Dr. Oldham has shown me some fossils forwarded by Captain Fryer from some part of the Sandoway or adjoining districts, the most remarkable of which were silica-casts of that curious shell, *Magilus antiquus,* now found living on the coast, which prove that the effusion of silica by means of springs is still going on in this neighbourhood; and I have little doubt that such silicious springs played an important part in that particular sort of metamorphism I am here alluding to.

The following sketch of the beds seen in crossing the Arakan range from East to West between Nyoung-ben-thah, in the Kyouk-khyoung-gyee district, and Yay-pot, on a feeder of the Gwah (Khwá) stream, will illustrate the general character of the present group; but unfortunately, from the entire absence of fossils or highly characteristic beds, there is no means of collating one section with another, or of grouping satisfactorily the beds seen in them :—When well within the hills, proceeding in a Westerly direction, the first rocks passed over in descending order are blue slaty shales of great thickness, with a dip to the East. These shales are soft and silky, and contain numerous beds of blue limestone varying from a few inches to a few feet in thickness. This limestone is fine-grained and sub-crystalline, breaking with a conchoidal fracture, blue on its freshly broken surface, but weathering to a pale yellow or nankeen color. It is rather silicious and hardened, and though a very promising-looking rock for fossils, a close search failed to discover any traces whatever of organic remains in it. About the same horizon, only farther to the North, I noticed beds of flinty limestone, of lithographic aspect, which seemed equally devoid of organic remains.

After passing these shales with limestone, and descending a spur into the Kappong stream, but still on the East side of the range, we come on a group of coarse thick-bedded silicious sandstones, with harsh silicious or jaspery shales, and thin-bedded silicious sandstones intermixed. The whole of these beds are intensely hardened and silicified. One very thick bed has a peculiar appearance from containing irregularly shaped earthy portions, which decay and leave great angular hollows three or four inches across. Some dark blue thin-bedded slaty shale also occurs, associated subordinately with the silicious beds, as though here foreshadowing the approaching deposition of similar shales in much greater force, which are seen, as above mentioned, to overlie these silicious beds. After leaving these silicious beds, no very clear section is seen. The dip appears, however, to remain Easterly till the axis of the main range is crossed.

The axis of the range here consists of a great thickness of beds of a very homogeneous clay, of a reddish or pinky yellow color, and obscurely bedded. It is much broken up and comminuted as though through severe pressure, but little altered, and neither to the Eastward nor Westward are its relations with the other rocks well seen. After crossing the axis of the range, the succession of beds was not well seen; and though I did not remark the silicious beds to be so prominent as on the East of the range, I am inclined to believe that the same beds as are met with in the East are again crossed on the West, in a reverse order, that is to say, that the range forms a great anticlinal, the prevailing dips on its Eastern side being Easterly, and on its Western side Westerly. On the West, however, there is (locally at all events) greater irregularity in dip and strike than on the East; and I have there noticed beds with an East and West strike, or nearly at right angles to the prevailing one of the range. Much allowance must be made for imperfect observation, as all one sees of the rock is such glimpses as can be obtained along the narrow path threading these forest-clad ranges. When well past the main range, the road descends and runs over a thick succession of the but little altered sandstones of the Kyouk-gyee (big stone) stream. Part of this rocky stream is quite impassable for elephants, and the nature of the country may be imagined from it requiring four hard days' marches to accomplish the distance from Nyoung-ben-tha to Yaypot, though these villages are in a direct line only fifteen miles apart.

A little south of Phon-sa-khyoung, near Matha on the coast, a good section of beds of this group is seen; but their proper place in the series can hardly be determined owing to the want of any sort of geological horizon in the group, either lithological or otherwise. I am inclined, however, to place them high in the series, and above the vast series of sandstones seen above Yaypot, in the bed of the Kyouk-gyee stream.

Section near Matha (ascending). The beds veer round from 15° to South-by-west, to 45° to West-by-south.

1.	Dark arenaceous shales, with faint carbonaceous markings and stringy beds of sandstone much contorted and squeezed about	300
2.	Harsh thin-bedded sandstones in one and two inch beds, with shaly partings and a few beds five and seven inches thick	85
3.	Beds similar to the above, but one and two feet beds predominating	23
4.	Very thin-bedded sandstones not averaging half an inch, with a few one and two inch beds, interspersed ...	69
5.	Thicker bedded sandstones in from nine to twenty inch beds	52
6.	Similar to the last, but thinner bedded	49
7.	Thin-bedded shaly sandstones	99
8.	Thicker bedded sandstones in from nine to twelve inch beds	46
9.	Thin shaly beds	30
		753

The section here becomes confused, but thick beds of sandstone come in, which seem identical with the sandstones commonly seen along the coast, and which I will now describe. Along most parts of the Arakan coast, from Negrais upwards, a group of sandstones occurs, thin bedded and massive, but presenting no very prominent mineral character, or affording any fossil. These sandstones are very little altered, generally not at all, and usually dip at moderate angles and with much less show of disturbance than other and older beds along the coast. It was such considerations as these which induced me at first to consider them as basal members of the Nummulitic group, and though I now include them among the Negrais rocks, I do so more from the absence of any satisfactory means of determining their age, than from any evidence that the position at first assigned them was incorrect. Obviously, however, in a case of doubt, it is better to include them in a group the age of which is uncertain, than to assign them a position in a well-defined group, to which though they may belong, there is no direct evidence of their so doing.

The massive beds at the base of this group are everywhere most conspicuous and of a peculiar greenish hue very characteristic of this rock, which hue, however, in some places towards the North is changed into a bluish tinge. The rock is a very fine-grained argillaceous sandstone, rather compact, but where exposed to the action of the sea, its surface usually presents a honeycombed or cancellated appearance, the result of a peculiar mode of weathering, the *modus operandi* and proximate cause of which is somewhat obscure. Subordinate to the thick-bedded greenish or cancellated sandstone, as it may be conveniently termed, occurs an irregular, and almost in places stringy bed of conglomerate, a prominent feature connected with which is its great irregularity and capricious mode of occurrence. It nowhere forms a marked bed, save perhaps near Ywot-pa, but dies out and re-appears along a certain horizon as an integral constituent of the cancellated sandstone, in places forming a stringy course in it, reduced in places to little more than a sprinkling of small pebbles in a sandstone matrix, whilst in other places it would seem to expand into a thick mass of conglomerate, though such instances are very local and circumscribed in extent.

This is the conglomerate, I think, which is so largely developed in the hill behind Phoung-do; if so, it nowhere else attains the same importance. To this bed may also be referred the masses of conglomerate seen on the shore opposite Ywot-pa, where they stand quite isolated between tidemarks, and are so compact as to have resisted the full force of the waves on an exposed coast.

This conglomerate is in places almost a pseudo-breccia, the fragments composing it being but imperfectly rounded. The included fragments are all small, rarely half an inch across, and usually much smaller, and mainly consist of a comminuted dark blue or cream-colored shale highly indurated, the latter variety only effervescing very feebly with acid. Quartz fragments are here very subordinate and small. This conglomerate is very soon lost sight of, going North, and may be said to cease almost at once as an independent bed, though re-appearing here and there at intervals. It may be recognised, for instance, a little North of Yaytho stream on the coast between Broken Point and Kyoungthah (Chougdar). The rocks along the shore here are thick-bedded massive sandstones, mingled with which a thin string of conglomerate occurs, rather irregularly, composed mainly of small white quartz pebbles with a little shaly detritus as elsewhere. Some few miles South of Matha, strings of fine conglomerate are noticed in the sandstone, and still further North, between Kyouk-kyon and Gwah, considerable bands of a coarse conglomerate, made up of shaly and cherty fragments, are dispered through the sandstone, all which represent, probably within narrow limits, what may be called a common horizon. These thick-bedded sandstones are often tilted up at high angles, but are more usually seen either horizontal or dipping at low angles. In addition to the cancellated form of weathering, the rock is sometimes seen with a tendency to divide into polygonal fragments, the fissures separating which seem to originate spontaneously, the nucleus of each fragment retaining the original green or bluish hue of the undecayed rock, while the fissures are represented by yellow bands, as though the result of chemical rather than mechanical causes.

Nowhere is the variable character of the beds of this group better displayed than along the coast immediately North of Cape Negrais. Below the point where the Ywot-pa stream falls into the sea, beds are exposed very similar in general character to those already given in the section near Matha, higher up the coast. These beds contain crushed carbonaceous trunks and branches, and dip at angles varying from 10° to 40° East-by-north. South of these beds, thin shaly sandstones, quite unaltered, come in, dipping 15° West-by-north. Nearer Negrais, a thick series of dark shales, with subordinate beds of cherty limestone, comes in, displaying signs of having been subjected to great mechanical strain as well as to chemical alteration. This latter is displayed in the numerous veins of fibrous calcite and fibrous quartz which traverse the rock, the former attaining a thickness of a couple of inches, the latter rarely attaining half an inch. Some of the shale where the veins are most numerous is of a deep black color and very hard and glossy, and I can convey no better idea of the lumps of this rock scattered along the shore than by comparing them to lumps of black putty, which they precisely resemble. A little nodular soapstone is also found scattered here and there, and the occurrence of this mineral, together with its invariable associate, the fibrous vein-quartz, points to this being a focus for that peculiar metamorphism which has so generally affected this group. These shales constitute the low ridge, which here forms the axis of the range, where crossed by the pass leading to Ywot-pa, but on which, from its forest-clad nature, little is seen of the rocks passed over. It is here that the "mud volcano" of the charts of this coast is situated, a complete misnomer, as it has no connection with volcanic action properly so called, and neither lava, ashes, nor other volcanic rocks are seen about it.

This "mud volcano" is situated on the hill side, where it rapidly slopes down to the shore, and within a stone's throw of the sea. A narrow footpath exists along the coast here, on the East of which at one spot a small mound of loose pulverulent shale rises a few feet in height, and about thirty feet at most in diameter, over which any one might walk without having his attention arrested by any peculiarity. This mound is the "mud volcano." A very similar instance is seen near the shore near Ngan-khyoung, and my remarks on one will be equally applicable to both. This mound consists of a greenish shale, very much comminuted and mixed with fragments of veins of calcite, from the thickness of cardboard to one or two inches. These fragments have evidently resulted from the spontaneous dehiscence of the compact shale they originally traversed; and this is seen in the constitution of the thicker veins, which are formed by the union and anastomosis of numerous smaller veins, wherein portions of the shaly matrix are seen enveloped and preserved. A very little hydrated peroxide of iron in small lumps is seen lying about, but nothing else to indicate any peculiarity, still less volcanic action. The form of the low mound suggests a certain amount of intumescence or upheaving of the clay having taken place, but in the case of the Ngan-khyoung 'volcano' this is less seen, and I am inclined to pronounce the 'mud volcano' in either case as *the vent for a very feeble discharge of marsh-gas.* In the rains, when the surface was plastic, a feeble ebullition of gas would be quite adequate to produce the low mound in question, which on drying would present the incoherent heap of shale fragments I have described; the combustion of the marsh-gas at some period or other from burning grass, probably attracting notice during the night to the locality. We have here, on an extremely minute scale, a repetition of the phenomena which have produced the 'volcano' on Ramri Island; and which I may remark has nothing volcanic about it, the emission of flame being probably due to the ignition of a copious evolution of marsh-gas. It is not necessary to enter more fully on this subject here, as I shall elsewhere describe the manner in which marsh-gas is evolved at many points in Pegu on about the same parallel as the Ramri 'volcano,' only on opposite sides of the Arakan range.

South of Kyeantalee several small outcrops of limestone occur, in none of which can organic remains be detected, and some of which limestone has been much altered. On both sides of the Kyeantalee river near its mouth small outcrops occur of limestone quite unaltered. But whether all of the above limestones are subordinate to the Nummulitic group, is not easy to say; I am inclined to think not; and I only include them in the present group as a provisional arrangement, till something more definite is known of the relations of the Nummulitic and Secondary rocks in Arakan. In Pegu, the utter absence of fossils along this horizon and the alteration induced in the rocks themselves, no less than the nature of the ground, all unite to prevent the formation of trustworthy conclusions; but in Arakan, though the nature of the country is perhaps no more promising than in Pegu, yet there seems some probability of fossils being discovered in the Secondary rocks, which seem, moreover, less altered on the Arakan than on the Pegu side of the range. Most of the outcrops of limestone throughout the Southern portion of the Arakan Range, both those alluded to above along the coast, and those met with occasionally in the hills, present the appearance of subordinate beds among the shales and sandstones of this group; but there are some cases where limestone occurs in such extensive masses as to favor the idea of their being continuations of the thick bed of Nummulitic limestone, which occurs on the East side of the range, and such may be their character though not yet established on fossil evidence. First of these in importance is the limestone a couple of miles or so East-north-east from Baumi, on the Arakan Coast, about Lat. 17° 18′, forming a low ridge striking North-north-east from the margin of the mangrove swamp, where it terminates towards the river, and soon disappearing in the forest-clad ground in the interior. It is only approachable by a small boat up a tidal creek traversing the mangrove swamp, after three quarter flood. The rock is massive and subcrystalline, with an apparent dip of 20° to 50° to East-south-east, as far as the cyclopean masses in which the rock lies enables us to judge. It is of a blue or gray color, and generally devoid of fossils; in some of the blocks corals are seen, but none have hitherto been obtained, capable of being determined. Its thickness is probably not much under one hundred feet. Above the limestone (as well as the ground enabled me to judge) occurs an intensely hard ferruginous conglomerate, characterised by numerous quartz pebbles. Below the limestone comes in a very hard silicious sandstone like a quartzite, of a gray color on its freshly fractured surface, but weathering red, and then displaying the original thin layers of sand, which in the aggregate form the thick-bedded rock before us. Near

Satwa, a little boss of limestone which may belong to this bed is exposed in the jungles, and is used for lime by the villagers in the neighbourhood. This rock is a white and somewhat argillaceous rock, not well seen, but with an apparent dip to the East. Strewed about in the vicinity are a few pieces of conglomerate, like that associated with the Baumi limestone; and a little to the South, in a line indicating a lower position stratigraphically, stands a huge fang of harsh sandstone very similar to the Baumi rock. The distance of this spot from Baumi is about thirty miles, and though I know of no other outcrop in the interval, I am inclined to regard both outcrops as belonging to one bed. Great as the thickness of the limestone is at Baumi, it is much isolated most probably by denudation; and I failed after a careful search to detect any traces of it on the opposite side of the Baumi river, nor were my enquiries among the Burmese more successful. Another enormous isolated mass of limestone of very similar character, occurs on the On-ben stream, a tributary of the Gwah river. It is situated in dense tree forest away from any village, and I failed to detect any organic remains in it. In some pieces of limestone, however, said to have been brought from this spot, I noticed what I regarded as foramenifera and bryozoa, but I did not satisfy myself that the rock was Nummulitic. There is, however, small question that the Baumi and On-ben limestones are the same bed, and as the former may ere long be quarried for the requirements of the Akyab district, it is probable that some fossil evidence of its age may be then forthcoming.

About a mile South-south-east from Kyeantalee, a cave occurs in a huge mass of hard compact sandstone almost as quartzitic as that underlying the Baumi limestone. The cave is a low chamber with a narrow passage through which it is necessary to enter on the hands and knees, and, as far as I could judge, seems to be of natural origin, though it would seem to have no reference to the natural bedding of the rock. The entrance is situated in the face of a huge mass of rock, and a rude ladder is required to enter it. There is nothing in the composition of the rock to explain the origin of the cavity, and I am inclined to consider it due to marine action, and to have been enlarged from some original small fissure or hollow in the rock by means of waves and tidal action, when the face of the cave stood not far from low water mark.*

X.—Mai-i (Cretaceous) Group.

No rocks of Cretaceous age can be proved, as far as our present knowledge goes, to occur within the limits of Pegu, though, as I have remarked, it is by no means improbable that some of the beds included in the Negrais group may be of this age; but the occurrence of beds of this age in the adjoining district of Sandoway is too important to be passed over without reference. The occurrence of rocks of Cretaceous age on the eastern side of the Bay of Bengal was first established in 1872, by the discovery near Mai-i, in the northern part of the Sandoway district, of a single specimen of *Ammonites inflatus* Sow. The specimen was found in the bed of a small stream, and had evidently weathered out of the shales in which the bed of the stream lay, but curiously enough, it was unaccompanied by any other fossil whatever, though I devoted a day to the careful examination of the spot. The specimen was not perfect, but of its identity with the Cenomanien *A. inflatus* Sow, Dr. Stoliczka, to whom I submitted the specimen, had not the slightest doubt. The Sandoway district, which stretches from Mai-i to Gwah, a distance of one hundred and twenty-four miles, belongs to the province of Arakan, and on this account no less than from the wild, uninhabited, and inaccessible character of the greater portion of it, has received only a very cursory examination, sufficient to give a general idea of its geological structure and relation to the adjoining districts of Pegu.

* This cave is tenanted by great numbers of a Rhinolophine bat which Dr. Dobson identifies as Phyllorhina larvata, Horsfield, of a dark slaty hue, as in the Khasi Hill race.

There is, in fact, but one single road through the district, along which the traveller can move with any freedom, or along which any intercommunication takes place. The channels of the larger streams afford an uncertain and tedious means of penetrating some distance within the hilly region bordering the Arakan range, but from its uninhabited character, the country must remain for years closed against anything like a close examination. With the boundary running through such an almost sealed country as the above, both that separating the Cretaceous group from the rocks whereon it rests to the North, as well as the boundary between it and the Tertiary groups to the South, and the extraordinary scarcity of fossils in all the groups, it may be surmised, that any present attempt to define the extent and relations of these groups must be almost hopeless. It will suffice therefore to say that Cretaceous rocks extend down from the Kyouk-hpew district in latitude 19° 30′ certainly as far as Kyeantalee on the coast, a distance of ninety-four miles in a straight line. Throughout this long tract of country I am aware of no fossils having been met with, save the above mentioned specimen of *A. inflatus* Sow, but the occurrence here and there at intervals of some peculiar beds, seen associated near Mai-i with the beds from which *A. inflatus* was derived, renders the extension of the group thus far, as certain as it can be in default of any fossils whatever.

How far the group extends south of Kyeantalee is uncertain, as a much greater amount of alteration and disturbance is found in the rocks along the coast South of Kyeantalee than North of it, in the Sandoway district; all, therefore, that can be affirmed is, that it is very possible that some of the altered rocks and out-crops of limestone met with between Kyeantalee and Cape Negrais, may be of Cretaceous age, rather than Nummulitic, to which group the balance of evidence would perhaps tend to refer the bulk of the hill rocks of the southern portion of the Arakan range; but in default of precise evidence in the form of organic remains, these rocks of doubtful age must remain classed as I have already done, in a provisional group (Negrais) intermediate in position between the Cretaceous beds and the Tertiaries.

One bed which I regard as belonging to the group which contains *A. inflatus,* is a limestone of a light cream color, in places exhibiting a somewhat speckled or flea-bitten aspect, from the dissemination through it of sublenticular crystalline particles, some of which may possibly be of foraminiferous origin. The rock is argillaceous, very homogeneous in grain, occasionally seamed with calcite, and breaks with a subconchoidal fracture. I think it probable that there are more beds than one of this character, as in one place a thin bed of it was seen intercalated with the shales of this group, whilst at other spots where the rock was much more largely developed, its relation to any other beds was not so perceptible. The first spot where this rock occurs, commencing in the North of the Sandoway district, is four miles South-south-west of Mai-i, where it constitutes a small hill not two hundred yards in circumference, on the edge of some paddy-land, bordering a tidal creek. It is here quarried and burnt for local use, but a brisk demand for lime would soon make serious inroads on the amount of rock here exposed. About twelve miles South-south-east of this, a much larger development of what I take to be the same bed occurs at some distance up a small stream not laid down in the map, but which may be termed the Kamah stream, from the name of the village situated on its banks. The spot being somewhat out of the way and unapproachable for elephants, was not visited by me; but from samples of the rock it is, I consider, identical with that at Mai-i. It is too inaccessible to be of any present practical value, especially as the same rock occurs more favorably situated elsewhere.*

* The Kamah hill, formed of this limestone, is celebrated for a large cave tenanted by great numbers of a recently described frugivorous bat, Macroglossus speloeus Dobson, the same species as that inhabiting the farm caves near Moulmein, and I believe some others in Burmah. (*Vide* Journal Asiatic Society of Bengal, Vol. XL, Part 2, 1871, and Proceedings A. S. B. for August 1872.)

The next spot where this limestone occurs largely is a few miles South-west of Ki-ben-ziaht, a village on the Tan-loay stream, not quite half way from Maii, to the mouth of the Sandoway river. It here occurs in considerable quantity in undulating ground, but its relation to any other beds is not seen. Thus far I think there is little doubt that these outcrops are all portions of one and the same bed, re-appearing at intervals and probably discoverable at more spots than my hasty examination enabled me to detect, but whether or no the same bed is identical with some outcrops of rock of very similar mineral aspect farther South, is not equally clear. For instance, close to Tonghoop, a small outcrop of limestone is seen which may belong to this bed, and North of it, about three miles, some limestone, which probably is the same; it is seen in the bed of the stream up which the road winds; and again farther South another outcrop occurs five miles North-west of Sandoway. Between Sandoway and Kyeantalee, limestone occurs at several spots, but usually more or less sub-crystalline in character, and not so argillaceous as the Kamah rock. At Sanday, four miles above Kyeantalee, on the opposite side of the river, occurs an argillaceous limestone which may belong to this group, but which I have already noticed, from its close juxta-position to a small outcrop of Nummulitic limestone, as the probable representative of the argillaceous 'Andagu kyouk' of the Eastern side of the range. Besides the above limestone there is another peculiar kind of rock which may be used to trace the extent of the Cretaceous group, to which it would seem to belong, to the South. This peculiar rock, which is first met with about two and a half miles North-east of Kyeantalee, is a greyish, rather earthy sandstone, which in places exhibits a pisolitic structure, from the dissemination through it of small globular concretions of carbonate of lime and iron (with a trace of magnesia according to an analysis by Mr. Mallet) which rarely exceed the size of a small pea. These concretions, which must be considered as of cotemporary age with the rock, and the result of segregative or crystalline action previous to its consolidation, are sparingly distributed through it, and very irregularly likewise, much of the rock being quite devoid of them. On decomposing, these concretions leave holes containing a little powdery oxide of iron, and impart to the earthy sandstone the aspect of an amygdaloidal trap; indeed, the deception is so perfect that it requires a careful examination of the bed to realise that it is a simple sedimentary and not a volcanic rock. At several spots between Kyeantalee and Mai-i this very remarkable rock occurs, and though seen but at intervals may, from its very marked and peculiar character, be taken as conclusive to the extension over the above country of the Cretaceous beds, of which, I believe, it is a member. East of Mai-i the beds of this group attain a great thickness, though some of them may belong to older members of the Secondary series. The prevailing dip is East-north-east, and the rocks are mainly hard, massive sandstones, with some dark shales interspersed. In these shales, in some places, flat concretions of limestone occur, both blue and pale-gray, rarely more than six inches across, and from one to two inches in thickness. In none of these beds have I noticed any fossils, though I somewhat carefully examined some of these calciferous shales above Lyndi (Lyng-dee), on the Mai-i river, where they seemed to promise to yield some sort of organism, but without success.

XI.—Axial (Triassic) Group.

The term 'Axials' was originally proposed by me for the group of altered rocks constituting the main Arakan range. It was, however, subsequently established that the altered rocks so designated consisted of two groups of very different ages,—an older group, which there is now reason to know is of Triassic age, to which the term Axial is now restricted, and a younger group of beds, not improbably of Cretaceous age, or younger, to which I have applied the term 'Negrais,' as already described.

The Axial group, as now restricted, embraces a very large series of beds of very varied mineral character, most of which have undergone a certain degree of alteration, not usually amounting to what is generally understood as metamorphism, though locally the process has gone further and produced true metamorphic schists; and this would seem to be confined to the immediate vicinity of the largest display of serpentine associated with this group. The Axials occupy a well-defined area, and constitute the central core or axis of the Arakan range towards the frontier. On the frontier they form a broad, regular tract of country, which, measured at right angles from the crest of the range, is a little over twelve miles in breadth on the Eastern or Pegu side of the range, or fifteen miles measured in an East and West direction along the frontier line. The entire width of the group here cannot be fixed, as the boundary has not been examined on the Western side of the range, but from the proportion of pebbles of this group in the bed of the Mai-i river above Lyndi, I am inclined to think that the Western boundary will be found to coincide generally with the valley of the Gamon stream,—an important tributary of the Mai-i river, and that the entire breadth will probably be found not to exceed twenty miles. From the frontier the group extends South as far as the Than-ni stream, a distance a little short of fifty miles, but is nowhere known to occur South of that stream. The impracticable nature of the ground is such as to preclude any close acquaintance with the rocks along their Western boundary, but to the Eastward I regard this group as faulted against the Nummulitics, the fault dying out or disappearing to the South, together with the Axials themselves, beneath the disturbed beds of the Negrais group. In this view the Axials form a wedge of strata, which though governed by the same forces which have produced the chain of Arakan hills, as previously described, yet have been also brought up by a fault through the newer strata, through the effects of which they have become juxta-posed to the Nummulitics on the East, to the exclusion of the Negrais or Cretaceous beds met with to the South and West; and to this element of upheaval, through faulting, superadded to that general process and method of upheaval wherein the entire range has originated, the greater elevation of the hills towards the frontier is probably due. I am aware of the well founded and laudable jealousy which exists in the minds of many geologists touching the introduction of faults which are incapable of ocular demonstration; but it is possible to carry this to the opposite extreme, and reject the simpler explanation of a faulted boundary, in favor of a system of most complicated geological re-actions, which have to be admitted if the simpler view is rejected. Admittedly it is in most cases a balance of probabilities, and in this instance I consider the balance tends to indicate a fault. The case may be thus stated: On the East of the range outside of the Axial area a belt of Nummulitic rocks comes in. These Nummulitic rocks extend South far beyond the termination of the Axial group, and to the East they disappear beneath the newer Tertiaries. At their junction with the Axial group they are highly inclined, the beds of both groups being alike packed together, squeezed, and contorted by the forces whereby the Arakan range has been produced. South of where the Axials disappear, these beds pass down, without any break that I have been able to detect, into the Negrais group, which in its turn passes down, as far as can be at present seen, into the Cretaceous group, so largely developed in the Sandoway district, on the Western side of the Arakan range. It seems, therefore, that there is no bed which can be identified either as the basal member of the Nummulitic group, or of any of the older secondary rocks underlying it, though at the same time there is no proof that the junction of the Nummulitics and Axials was not one of original unconformity; but if this is assumed, there is the difficulty of accounting for the absence of the Cretaceous group of Sandoway from the Eastern side of the range, and the general geological features and history of the country must be borne in mind fully to estimate the gravity of this objection. To make this clearer, let us consider the general character of a few cross sections of the range, which may thus be epitomised.

Anywhere below the point where the Axials terminate, the transverse section of the Arakan range displays a great series of beds arranged more or less in anticlinal fashion, consisting of altered rocks (Negrais group), the lower beds of which are very probably of Cretaceous age, and on which, on the Eastward, unaltered or generally unaltered Nummulitic strata repose. These Eocene strata are not recognisable on the Western side of the Arakan range towards its extremity, being there either denuded or included within the higher portion of the Negrais group; but where the alteration appears to have been less felt, the highest bed of the group and its most characteristic one, the Nummulitic limestone, occurs, near Kyeantalee, and presumably at other spots in the position which would *primâ facie* be assigned it, away from the main range, on the coast. Every section, then, across the range South of the Than-ni stream may be considered identical in respect to its broader geological features. North of the Than-ni stream it is very different. The Axials here come in as a tongue-shaped promontory wedged among the newer groups. On the East the Axials are in immediate contact with Nummulitics, the beds of both groups standing at a high angle. On the West in place of Nummulitics there is a great thickness of rocks of undoubtedly Cretaceous age, some of them perhaps older, with, it may be presumed, Eocene rocks above them, but far to the Westward, beyond the scope of my present remarks. Another point which I would prominently bring forward is, that this spit of Axial rocks is not coincident in its direction with the axis of the range. The Western boundary of these Axials is not so closely known as regards its details, owing to the difficulties of the ground, as is desirable, but it is certain, that after impinging on the Than-ni stream it sharply recedes along the watershed which separates the Than-ni and Maday streams. Whilst, therefore, the Axial group occupies the axis of the range at the frontier, these beds do not to the South coincide with the axis of the range, but run down obliquely from it till they cease out altogether at the Nummulitic boundary, which keeps well to the outer hills. Weighing, then, the fact of the Axials being juxta-posed on either side of the range to such different rocks, and the oblique arrangement of the axis of the area of that group to that of the range, and having in view as well the age of the group in question and the evidence of orderly deposition which seems to have prevailed from the termination, at least of the Secondary period down to the present time, I think we are justified in regarding the boundary of the Axial group as a faulted one (at least on its Eastern side), and the elevation of this portion of the range towards the frontier along a line of fault as a distinct process, supplemental, perhaps, but differing both in kind and degree from that to which the general formation of both the Arakan and Pegu ranges is due, as previously described.

The alternative explanation of the juxta-position of the Axial and Nummulitics through either denudation of the older beds prior to the deposition of the newer, or the overlap of the latter over the former, though not impossible, is too unsupported by evidence, and, as I think, too opposed to the general tenor and succession of geological conditions, as they seem to have obtained over this area during the period in question, to require to be discussed at length; and the subject will best be considered when we are in possession of some knowledge of the relations of the Axial and newer groups, on either side of the Arakan range, at a higher parallel of latitude than that we are at present restricted by.

The best characterised portion of this group is what I have designated the upper Axials in my sketch of this group in the Records of the Geological Survey (vol. iv, for 1871, page 36). At the base of this upper division occur the only two beds wherein I have detected fossils, though I am sanguine of future researches in this group revealing a richer fauna, when a wider area of these beds comes under observation. This upper group extends from the frontier down to the point where the Axials disappear on the bank of the Thanni stream. These beds are first seen along the West bank of the Moo stream, and are well displayed in a feeder of the Moo, near Kondeing-zu or (Kondeing-keng), and thence on to Khyoung-tha. The beds near Kondeing-zu are in places vertical, or with a high dip to West-by-north; between this and Khyoungtha the high dip is maintained, but is reversed, varying from 70° East-by-north to 70° as an average East-by-south. Near Khyoungtha the dip is less, and small anticlinal folds are indicated by a few reverse dips; hereabouts also a little limestone is seen lying about in the stream in the form of large boulders, which, though I did not discover it in situ at the time, I now recognise as the limestone at the base of the upper Axial division. The rocks along the Moo stream are much distorted, but I imagine they form part of the sharp synclinal fold, whose axis passes somewhere about the village of Kondeing-zu, and which is cut off by the boundary fault close to the Moo stream.

At Khyoung-tha these beds are left, when the ascent of the hill or ridge is commenced, which separates Khyoung-tha from Pathi. No good section is seen on the steep hill sides, but the beds passed over are thick-bedded grits, with rusty and glazed surfaces, especially the coarser and more conglomeratic beds. The prevailing dip of these beds is East-by-north; but this is occasionally seen reversed, as though from small local foldings. The beds are much indurated, and seamed with calcite, and seem to extend to near Pathi. The village of Pathi is situated on a feeder of the Mahton stream; and directly this small stream is crossed, and the eastern branch of the Arakan range gained, running up to the frontier peak of Kyeedoung, a different description of beds is at once met with—softish subschistose beds, wherein the calcite veins are replaced by viens of quartz very sparingly distributed. It is only in the stream that a view can be got of these beds, as they decompose readily at the surface into a clayey soil, covered here with dense virgin forest, the unchallenged domain of the elephant, tiger, and other large game. Very similar beds to these are seen further South on the ascent to the Arakan range by the little-used path, from Leppandeing and Wetto to Maii; but I know of no good sections of either these subschistose beds or the overlying silicious grits. In none of the above beds have I noticed any fossils. I will here therefore give the best section of the upper division of the Axials I am acquainted with, commencing with a bed which I take as the base of the division from its containing a few fossils, and thereby affording a recognisable horizon for classifying the group.

Section in the Hlowa stream (ascending).

LOWER AXIALS.

Dark and greenish flaggy shales	Seen over 300 feet.
Sandstone and shales	
Dark thin-bedded shales, with carbonaceous markings	

UPPER AXIALS.

a.	Thick-bedded shale passing into dark massive arenaceous shales, with hard nodules interspersed. (*Cardita* and small indeterminable gasteropoda)			110	0
b.	Dark blue shale, with a few sandstone bands	17	0		
	Rubbly limestone conglomerate, with a little blue shale, bedding indistinct	10	6		
	Hard, coarse conglomerate, with a little fine sandstone ...	5	9		
				33	3
c.	Shales and sandstones in thick and thin beds	188	0		
	Fine thin-bedded gray argillaceous sandstones, with shaly partings	34	0		
	Ditto thicker-bedded	4	6		
	Thick-bedded sandstones in one and two feet beds, with shaly partings	64	0		
	Coarse, hard, subporcellaneous grit	5	0		
	Thin-bedded shales and sandstones and one six-inch bed ...	68	0		
	Conglomerate	3	0		
	Shaly beds	21	0		
	Hard argillaceous subporcellaneous sandstones	102	0		
	Shaly beds	102	0		
	Massive argillaceous subporcellaneous sandstone ...	34	0		
	Shaly beds	21	0		
	Hard subporcellaneous sandstone	3	0		
	Shaly beds	5	0		
	Massive thick-bedded gray white-speckled grits ...	25	0		
	Ditto ditto, but in thinner beds	129	0		
	Shaly beds	25	0		
	Thick-bedded subporcellaneous white-speckled grits ...	43	0		
	Ditto, but in thinner beds	12	0		
	Dark shales and sandstone	51	0		
	Bluish gray subporcellaneous sandstone	21	0		
	Dark sandstones and shales	129	0		
	Dark shales	45	0		
	Creamy blue subporcellaneous sandstone	5	0		
	Sandstone and shales (ill seen)	215	0		
	Massive white-speckled grit	11	0		
				1,364	6

d.	Shales and sandstones in from six to eighteen-inch beds ...	475	0		
	Massive greenishgray sandstone	4	0		
	Shales with a few thin sandstone beds	172	0		
	Shales with a few thick sandstone beds	475	0		
	Sandstone with a few shaly partings	43	0		
	Very massive blue and gray sandstone	52	0		
				1,221	0
e.	Dark harsh shales and dark thin-bedded sandstone, none over four inches	154	0		
	Massive argillaceous sandstone	5	0		
	Dark hard shales and sandstones as above	319	0		
	Ditto, but thicker-bedded	25	0		
	Ditto, but thinner-bedded as above	129	0		
	Shales and sandstones	344	0		
				976	0
f.	Pale massive sandstone, gritty and in parts conglomeratic	103			
	Pale gritty sandstone thin-bedded, gray and creamy ...	12	0		
	Ditto massive	6	0		
	Hard gray sandstone	26	0		
				147	0

At this point the faulted boundary of the group would seem to come in, but it is not very clear, and may in reality be a few hundred feet higher.*

The above section may be thus epitomized :—

		Ft.	In.
	LOWER AXIALS.		
	Shales and sandstone (seen)	300	0
	UPPER AXIALS.		
a.	Cardita shales	110	0
b.	Halobia limestone, shales, &c.	33	3
c.	Freckled grits, &c.	1,364	6
d.	—Shales and sandstones	1,221	0
e.	—Ditto ditto	976	0
f.	—Sandstones, &c.	147	0
		3,851	9

* This fault was also remarked by my colleague Mr. Fedden in his notice of this section, but his account does not enable me to correlate his observations with my own with any great closeness; but it is certain that, theoretical considerations apart, my colleague's views of a fault crossing the section here tallied with my own, though arrived at quite independently of one another.

The really characteristic portion of the group is that embraced in sub-divisions *a*, *b*, and *c*.

a.—These shales are exposed just below the mouth of the Thayet stream, a small feeder of the Hlowa, and are here characterised by a species of *Cardita* which is not rare in them, and not unfrequently presents both valves united. A few small gasteropods are also present, but Dr. Stoliczka has been unable to specifically determine any of them; neither have these fossils been noticed elsewhere.

b.—This bed I have termed the Halobia limestone, though at this particular point it does not contain that fossil; but I have little doubt that it is one and the same bed. The limestone here seen is a mixed rock, partly shale and conglomerate and partly a rubbly limestone. It contains here a species of echinoderm, though not in a condition to be identified, and it is the presence of this fossil elsewhere which helps to identify this rather variable bed. In the small stream near the Than-ni stream, almost where this group ceases out, a thickish bed of grey limestone occurs, which may be identified with bed *b* of the Hlowa section by the occurrence in it of numerous specimens of the same echinoderm, but not sufficiently well preserved for specific identification. This is the same limestone which I have described as found between Kon-ding-zu and Khyoung-tha, near the frontier, and though it would seem to vary much in mineral character, it may generally be found where this upper division of the group is well exposed. North of Nattoung, and some one and a half miles South-west from Thabie-gaing, a small outcrop of what I take to be this limestone is seen on the crest of a low hill in which a few specimens were obtained of a shell which Dr. Stoliczka considers to be *Halobia Lommeli*, a characteristic fossil of the Triassic group in the Himalayas of Spiti. In the Pyagyee, a small feeder of the Maday river, this limestone is seen, of various tints of pink and yellow, and occasionally converted into a white crystalline rock, which change is probably induced by the near proximity of the large mass of serpentine of Shynbaiahu hill. An outcrop of this rock also occurs near the Mahton, about one mile North-west of Lepangaing, where it appears to strike West-south-west, and three miles North-east of this outcrop is a large patch of lime-stone forming a low hill, the dip not being well seen, whilst two and a half miles South of the first outcrop is another large mass of limestone which forms the summit of a hill. The ascent to this last mass of limestone lies over typical upper Axial strata, and I believe all these three outcrops belong to one and the same bed. Although the limestone would here seem to be more developed than farther to the South, I noticed no fossils in it, which is, I think, due to the greater amount of alteration the rock has here undergone. At various other spots traces occur of this bed, but nowhere has it yielded fossils capable of determination (save at one spot), and that only the single species of Halobia above named.

Whilst, therefore, this limestone is the only bed of the group which has yielded any reliable evidence of its age, meagre as that evidence is, the next division (*c*) of the group is the most important as regards the peculiar petrological character of its beds, which enable us to recognise them with confidence wherever met with. The characteristic beds of this division, which embraces over thirteen hundred feet of beds, are white freckled grits and conglomerates, not usually very coarse (though here and there coarse beds, almost pseudo-breccias, occur), and cream-colored argillaceous sandstones, often having a sub-porcellaneous appearance, or sometimes something of a lithographic look. Small white quartz pebbles abound in the finer conglomerates, but the coarser conglomerates are mainly composed of argillaceous subschistose rocks, which suggest the idea of their being derived from beds of the lower division of the group, though this is probably fallacious. The coarsest beds I have anywhere noticed occur in the Shu (Shoo) stream above Sabatan. In the lower part of the Shu, an enormous thickness of beds is fairly exposed, but greatly disturbed and faulted towards the boundary of the group.

Higher up the stream the dip is more regular, always high, but varying from North-east-by-east, round to East-north-east. Some of the sandstones are hard, and have strings of quartz pebbles irregularly disseminated through them, the pebbles sometimes, however, being accumulated in bands. In one spot I noticed among the finer ingredients a well rounded quartz boulder six inches in length in one of these conglomeratic sandstones; but such instances are rare. Some of the coarser beds up this stream are, however, of such a character as to overtax my power of adequately describing. One of the most remarkable, and which will explain the type of the rest, was just below a spot where a wall of rock crossed the stream, rendering it impassable for elephants. The bed in question was a sandstone of ordinary appearance enough, save that embedded in it were large angular fragments of a subschistose rock belonging to some older group. Many of these included fragments were nearly a foot in diameter, and, as far as I could judge, were truly derivative fragments, and not (as occasionally is seen) fragmentary portions of a rock cotemporary with the beds which seem to enclose them. The bed was not in other respects very conglomeratic, nor were these fragments very numerous; and I suppose the appearance, however created, was due to causes extremely local. I nowhere else noticed any similar bed to this, and the general character of the coarser conglomerates of this group is that of a rock composed of partially or well-rounded fragments, with a rather sparing amount of matrix, and in places only displaying a tendency to the angularity of a breccia.

XII.—Moulmein Group.

A very brief notice of this group must suffice, as it nowhere occurs within the limits of Pegu, but is restricted to the west bank of the Sittoung, where it spreads southward into Martaban and Tenasserim. The term 'Moulmein' was first applied to these beds by Dr. Oldham in a Report of his on the coal of Thaietmio and the Tenasserim Provinces, published in the Selections from the Records of the Government of India, No. X, page 33, in 1856. Dr. Oldham there divides the rocks which cover so large a portion of Martaban and Tenasserim Provinces into a lower division, which he terms the "Mergui" series, well developed in the South, and an upper or "Moulmein" series, largely developed to the North, and the most conspicuous member of which is the massive limestone which forms so picturesque a feature in the country round Moulmein and the Salwin valley. The entire thickness of these two divisions is placed at about 9,000, and the age of the whole fixed as Palæozoic, the Moulmein beds being provisionally placed in the "lower carboniferous group of European geologists." Since Dr. Oldham's account of these beds was written, nothing has been added to our knowledge of them, save that, from the evidence of a few fossils procured from Zwah-ga-byn, a limestone hill forming a prominent landmark above Moulmein, and popularly known as the 'Duke of York's nose,' the limestone in question may certainly be pronounced of the age of the Carboniferous Limestone of Europe. Dr. Oldham remarks that this limestone is more sparingly developed to the South than in the Martaban district, but it is probable that the limestone met with in the Mergui Archipelago belongs to the same formation. It is by no means certain how far this rock extends to the North in British territory, the Yuuzalin district being quite unexplored; and the grey limestone, worked in the hills North-east of Tonghoo, seems rather to occur as a subordinate member of the next group, and is moreover trifling in its development in comparison with the Cyclopean masses of the rock in the Salwin and Attaran valleys. Beyond the British frontier however in this direction, it would seem to be largely developed, forming large tracts of country in Karen-ni and towards the sources of the Salwin. The most marked feature of this limestone is its mode of occurrence in steeply scarped hills, the sides of which overhang, as may be seen in the case of the hills near Moulmein, which rise abruptly from the low inundated plains between the Gaine and the Attaran rivers, and exhibit the precise appearance of what they undoubtedly were at no remote geological period, sea-girt rocks, such as still stud the Mergui Archipelago, and which from their position in low-lying alluvial plains even now, during the rains, are approachable only by boats, through a mimic freshwater sea. The exploration of the caves in these hills has been suggested in the hope of acquiring the relics, and enlarging our knowledge of an extinct local fauna, such as, in Europe, has so often rewarded cave-research; but I consider that, as regards all caves similarly situated to those near Moulmein, the chances are much against finding anything to repay the labor expended, as, if I am correct in regarding these insular masses of rock—such as contain the Dumathat or Phaienku ('Farm') caves—as at no remote period rocky islands in the sea, it is improbable under such conditions that they ever afforded retreat to any vertebrata save the edible swallow or a few bats. In the case, however, of caves situated in limestone rocks at a greater elevation, and consequently not like the others guarded by the surrounding sea from approach, the case is different; and such caves hold out promise of a rich harvest to future explorers. I am not personally acquainted with any such in British territory, though some well known, but jealously guarded ones, of large extent exist beyond Tonghoo to the North-east.

It is probable that, with these Moulmein beds, representatives of the underlying Mergui group are also to be met with, associated together throughout the Yunzalin district and wherever the newer Moulmein beds occur east of the Sittoung; but the country is almost entirely unexplored and its constitution unknown save towards the edge of the Sittoung valley.

It is probable that this group may prove to be metalliferous, as it is traversed by the same series of granite and elvan dykes, as the older crystalline rocks of the district; and these may not improbably be connected with the development of the ores of tin, lead, iron and copper occurring in Martaban; but speculation on this point is best deferred for the present. The lead ore at Tonghoo occurs in the next group; but my impression is that both this group and the next will equally be found to be the repositories of the metallic deposits of Martaban, whether these should ultimately prove of economic value or not.

XIII.—Martaban Group.

The term 'Martaban' is applied, for convenience merely, to this group from its large development in Province Martaban. Of its age we know nothing, but petrologically considered it is a group of true crystalline rocks, undistinguishable in character from the ordinary gneissose rocks of Bengal.

Near Martaban, I have had specimens of schorl-rock brought to me, and fragments of schorl crystals of not less than 3 inches in diameter, which the natives who picked them up evidently supposed might have some connection with coal! Micaceous schists are common, but in Martaban (speaking from an extremely limited acquaintance with the ground) hornblendic rock would seem less abundant than in the same group of rocks in India.

To this group, I have no hesitation in referring much of the so termed granite of the country lying to the East of the Salwin, and I am far from certain if all the 'granite' constituting the singular hills described by the Revd. C. Parish, in the Journal of the Asiatic Society (Vol. XXXIV, for 1865, page 135) does not equally belong to it, rather than to an intrusive rock or true granite. I fully admit that lithologically this Kyoukgyee and Kyiktyo rock is a perfect granite, but from the identity of it with a similar granitoid rock, which is undoubtedly a member of the schistose group of crystalline rocks, I am led to suspect a similar relationship for it.

The connexion of a granite or granitoid rock with a distinctly schistose group of beds may be seen on the road from Tonghoo to Layto, where the schistose and crystalline characters of the beds are seen to give place insensibly to the granitoid habit, huge masses of the latter type of rock being seen weathering out of the softer beds of the former character. I am not sufficiently familiar with the area of this granitoid rock to pronounce confidently that none of it is true granite, but I am greatly inclined to question if any is. True granite undoubtedly occurs in the district in the shape of granite dykes which traverse beds referred by me to the 'Moulmein' group, and *a fortiori* of course the present one likewise; but no conclusive evidence has yet been produced that the largely developed granitoid rock of Kyoukgyee, Kyiktyo, &c., is really intrusive, and till this is produced, I do not consider its mere lithological aspect as sufficient for the purpose. This view, however, is avowedly put forward from an extremely limited acquaintance with the area occupied by the rock in question and in view of the extremely deceptive appearance which the more massive members of a gneissose group occasionally assume, presenting the appearance of a true granite, though essentially not so, if we correctly restrict that term to a rock of intrusive origin. In the ordinary acceptation of the term, however, this rock may be termed granite, and the peculiar manner in which it occasionally exfoliates gives rise to the picturesque hills so well depicted by Mr. Parish's pencil.

From the little I saw of the relation of the Martaban and Moulmein groups, I judged that, in places at least, the former constituted the higher hills, whilst the lower country was occupied by the latter; but my opportunities were too limited to allow of safely generalizing from such data, neither can I say if the last group rests immediately on the present one in Martaban and the Yunzalin district, or if any representatives of the 'Mergui' group of the Southern provinces intervene, as is probably the case. The denudation, however, has been enormous to which these Palæozoic beds have been subjected, to which is due the curiously isolated fashion in which so many of the hills and ranges composed of them stand in the vicinity of Moulmein and elsewhere.

XIV.—Intrusive Rocks.

Under the head of 'intrusive rocks', serpentine is the only one which anywhere attains any considerable development in Pegu; and with it I shall consider the curious steatite veins of the Arakan range, not because they are themselves of intrusive origin, but because it seems not improbable that they may be the result of those forces chemical or metamorphic which attended, whether as cause or effect, the intrusion of serpentine among the rocks of the Arakan range.

The occurrence of a bedded trappean rock has already been noticed among the Miocene rocks of Eastern Prome, but being a regularly intercalated member of that group, I shall not farther advert to it here.

Trachyte.—About four miles, or rather less, East-by-north from the small village of Byangyee on the Bassein river, some fourteen miles South of Ngaputau, occurs a large mass of rock known to the Burmese of the neighbourhood by the name of 'Chouk-talon,' or 'the single stone,' which marks the site of a hidden treasure, according to these imaginative and credulous people. This rock, which has the appearance of a very irregularly shaped and imperfectly rounded boulder, of hardly less than 6 feet in its greatest diameter, consists of a greenish purplish trachyte weathering to a dark brown color, and containing small crystals of glassy felspar and olivine. Considering the dimensions of this rock, and that nothing like it is anywhere known in the province, one would be, in a more Northerly latitude, tempted to regard it as an erratic, though in that case we should undoubtedly be led to expect some other companion blocks likewise; but this explanation will clearly not serve here. This 'Chouk-talon' fragment is exposed in the bed of a small stream, the only rocks seen in which are the unaltered shales and sandstones of the uppermost division of the Nummulitic group. These beds are seen dipping at low angles in close proximity to the block of trachyte and seemingly unaltered, or not very appreciably so. What the trachyte rests on is not seen, owing to its base being surrounded with the ordinary detritus filling the bed of the stream. Close to the block, a few fragments of trachyte are seen lying, which have scaled off from it from atmospheric action; but no other traces of the presence of an intrusive rock occur in the neighbourhood. One small fragment, however, I noticed of pale shale, little bigger than the palm of my hand, which was somewhat hardened and jaspery, and one side of which had a somewhat baked aspect, as though it might have formed part of the wall of a dyke; and this, I believe, is the key to the curious occurrence of an isolated mass of trachyte in the midst of unaltered Nummulitic strata.

My idea is, that the 'Chouk-talon' is the remnant of a pipe of trachyte, or the stony plug filling a pipe-vein up which a trachytic effusion had taken place, and to the small diameter of which, the little disturbance or alteration in the shales traversed by it is due. All the circumstances considered, I know of no other alternative to the explanation above given, nor do I know of any nearer locality, where any similar rock occurs, than Barren Island, in the Bay of Bengal to the South, with which focus of volcanic activity it may not improbably have been connected. A straight line from Barren Island to Puppa-doung, the former an active volcano, the latter at present in a sate of quiescence, measures 614 miles. At 100 miles from Barren Island, but ten miles to the Eastward of that line, is the volcanic mass of Narkondam Island, whilst at 293 miles from Barren Island and fifteen miles to the Eastward of the same line, comes in the above mentioned trachyte plug of Chouk-talon, being almost midway to Puppa: whence I think we may conclude that Puppa is the most Northerly known point of that volcanic zone to which Barren Island pertains.

Serpentine.—In Pegu, serpentine occurs in three distinct localities, or localised areas, all situated on the Eastern side of the Arakan range and among the outer ranges of hills. The only exception to this rule known to me is the occurrence of serpentine in minute quantity on the North of Shuaydoung, and more plentifully on its Southern flanks close to the actual dividing range, but Shuaydoung marks a focus of exceptional disturbance, geological and physical. Within the limits of Pegu, serpentine nowhere occurs on the Western slopes of the Arakan range; but in the Sandoway district of Arakan, it must be largely developed in some parts of the valley of the Maii river, to judge by the quantity of pebbles of this rock seen in the bed of the river about Lyndi. The first mass of serpentine South of the frontier is that which constitutes Bidoung hill, five miles South-by-east of Pathi. Descending the Mahton from the North, Bidoung hill has the appearance of being almost isolated from the main body of the Arakan range, so much so that it is not clear, at the distance of a few miles, on which side of the hill the Mahton will flow. On reaching, however, the Northern flank of Bidoung, the Mahton turns somewhat to the East, and flows through a gorge of serpentine rock, bare, sterile, and picturesque, with Bidoung on the right and a somewhat smaller peak of similar character on the left. The serpentine area which is here traversed by the Mahton extends some five miles in a North-by-east or North-north-east direction, with a mean width of perhaps two miles; and in addition to the main stretch of this rock, a small ridge runs down from it along the East bank of the Mahton to nearly opposite the village of Kaingi, though without appearing in the bed of the river. This is the largest single mass of serpentine in the province, and has produced greater alteration in some places among the rocks in contact with it, than I have elsewhere observed. This is especially the case on the flanks of Bidoung hill, where, as the boundary of the serpentine is approached, the rocks for a short distance from the junction become converted into gneissose and chloritic schists. Even here, however, this effect is local, and is much less visible on the East of the Mahton along the minor range opposite Kaingi than on the flanks of the larger mass of Bidoung. I think it probable, however, that this may partly be due to the composition of the beds in contact with the serpentine rather than to any more occult cause, since, *cæteris paribus,* the behaviour of beds so circumstanced, and the kind and degree of metamorphism produced in them, would mainly depend on their composition, and this probably explains why at one spot a perfect metamorphic schist is produced, whilst at others a less degree of change is observable. I did not notice any veins of serpentine in connexion with the bulk of the rock of which Bidoung is composed, and the same remark applies to other localities where the rock is largely developed; any veins, if such is their character, occurring subordinately among the stratified Axial strata, as on Shuaydoung and the Hlowa stream. In the Hlowa stream the serpentine forms a bed or dyke among Axial strata, the precise position of which in the group is not clear. It occurs considerably above the Theyet stream, where the section of the upper Axials commences, and is probably intercalated among beds lower in the series than those in the above section. It is no doubt connected with the occurrence of serpentine on Shuaydoung, which in this locality seems to be very sparingly developed compared with other places. South of the Hlowa a little serpentine in the form of rolled pebbles occurs in the Shu (Shoo) stream, and in the upper portion of the Nga-wet stream above Kwon-doung. I did not detect the rock in situ in either stream, but it might have been derived in the Shu stream from small veins in the altered Axial strata rather high up, where considerable disturbance is seen. In the Nga-wet stream I failed to find any likely source for the pebbles seen in the channel, and as in both these streams the pebbles did not increase in number or size as the channel of the stream was traced to its source, I am disposed to think that these pebbles may have been derived from the mass of serpentine, to the South, on the banks of the Maday stream, full proofs existing of the free transport of boulders from farther sources than this, at a time anterior to the final excavation of the present river courses, as I have already described of the boulder drift found at high levels along the course of the Maday and this part of Pegu generally.

We now approach the second area of serpentine outbursts, presenting three distinct foci of activity, though all ranged in close proximity to the Axial boundary, and in part coinciding with it. The first and most remarkable display of this rock is seen just above the village of Letpangon on the Maday. A wall of serpentine here crosses the stream and appears to divide the Axial from the Nummulitic group. In the Axials, above the dyke (if such is its nature), the utmost confusion and alteration exists, especially a little way up the stream, where some limestone occurs, which is doubtless the Triassic limestone (*b*), but so altered as to present no trace of any organisms whatever. Below the dyke and along the boundary, the utmost mechanical disturbance prevails among the newer strata, but nothing like the alteration seen among the Axials, and it seems clear that whilst the action of the serpentine on the Axials caused or coincided with a notable amount of metamorphism among them, the action of the serpentine on the Nummulitics was almost purely mechanical in character and its effects. This 'wall,' as I have termed it, has every appearance of being a dyke stretching on either side of the Maday, for about five miles in extreme length, but nowhere exceeding a quarter of a mile in breadth, and in some places south of Letpangon not attaining more than one hundred and fifty yards, if so much, where steeply scarped by a small feeder falling into the Maday stream just above it. It runs in a slightly curved line, and at either end terminates abruptly without any indication of further continuance. The next stretch of serpentine comes in some four miles further South, forming a hilly inaccessible tract of country, of which the peak of Shynbaiahn-toung marks the termination to the North, and the higher and more conspicuous peak of Nattoung, the termination to the South. Shynbaiahn-toung is reached up the Alaychong stream in which the usual upper Axial beds are met with, and the Axial limestone, in parts altered and even converted into a white crystalline marble. Shynbaiahn hill consists wholly of serpentine, with much steatite in the shaly beds which are here seen in contact with that rock. At Nattoung, Axial beds are passed over, which are probably lower in the series than those to the North, and are continued some distance up the base of the hill when serpentine comes in and forms the entire summit. Viewed from a distance, Nattoung seems an ordinary conical-shaped hill, with nothing particular to distinguish it, but it is in reality inaccessibly scarped on three sides and can only be ascended on one side by a most precipitous path. It is certain, however, that it marks the termination of the serpentine to the South, as no fragments of that rock find their way into the Thanni stream which flows but a little to the South. In the Thanni stream and on the road South from Alaydoung village, which runs over Nummulitic rocks a little way out from the Axial boundary, no alteration whatever is perceptible in the newer groups, though they have undergone much disturbance and mechanical violence. A few miles South of Nattoung and about two miles West of Laidi on the Thanni stream occur the two small hills of Thytsi-doung aud Hnor-doung.* These are both small peaks of serpentine capping altered strata, which I formerly regarded as belonging to the Axial group, but which are now included in the Negrais group.

These patches are insignificant in extent and separated by altered rocks, but midway between these a very small patch of serpentine occurs a few yards only in diameter. Thytsidoung is the last of the more considerable outbursts of serpentine at this locality; but a little further south, a little serpentine is seen on one of the low hills North of the Booyoo stream, but its extent is very limited. It is very probably

* Near this hill my colleague Mr. Fedden has noticed a little "Trap." After examining the spot, however, I felt unwilling to consider the rock as distinct from those around it, though I was in doubt whether to regard it as connected with the serpentine, or with the altered Negrais group, and the result of the close proximity of the serpentine to some of the more homogeneous shales of that age. It has much the appearance of a trap, but there is little of it seen, and bearing in mind the massive potstone-like aspect assumed by some shale beds along the serpentine junction, I am inclined to regard it rather as a product of metamorphism, resulting from the serpentine, than as a properly intrusive trap.

a vein traversing the altered rocks, and is here associated with steatite veins, whence the name of the hill on which it occurs, Kangutoung (steatite hill).*

The third and last area of serpentine outbursts is situated along the outer hills West of Henzadah, where twenty-one distinct patches of this rock are ranged within a strip of country twenty-six miles in length. The first and largest display of this rock is a broad belt of it crossing the Nungathu stream; the last and smallest is situated nine miles west of Ngatheingkyoung. The serpentine occurs in the form of small hills separated by altered sandstones and shales, and ranged along the outer margin of the hills. No dykes or veins are seen here, nor is the alteration and disturbance so great as where the rock is more largely developed to the North. South of this, no serpentine whatever is known to me. The serpentine at all the localities above described, and that met with on the West of the range, and also near Lyndi, everywhere presents the same appearance, and this great uniformity of mineral character would seem to indicate community of origin. In color it varies somewhat from a pale to a rather dark, but not dull green; and it would yield an ornamental stone but for the fatal defect of being everywhere seamed by cracks which traverse the rock irregularly in every direction, the largest and soundest-looking blocks falling into numerous polygonal or slabby fragments under a few smart taps from a hammer.

Soapstone (*Kangu in Burmese).*—This mineral which is used by the Burmese for writing on black boards, is largely imported into Pegu from Upper Burma, but occurs at a variety of spots in the Arakan range, chiefly, though not exclusively, on its Eastern side. It is a common accompaniment of serpentine, and in some cases seems to be directly produced by the presence of that rock, and as one of the results of its action on the stratified rocks in contact with it; but it also occurs in

* Nearly every well marked hill has a distinctive name among the Burmese; not one in a hundred, however, is recorded in the map.

places where no serpentine is known to occur. Whatever relation, however, it may bear to the serpentine above described, it is the result of chemical segregation, in veins which traverse the altered sedimentary rocks, of both the Axial and Negrais groups. It is everywhere accompanied by a curious variety of quartz, fibrous in structure like satin spar, and the intimate connexion between which indicates their cotemporary origin. I did not notice any in the vicinity of the Bidoung serpentine, but to the South it is commonly found in the vicinity of that rock, and in some places is distinctly the result of a metamorphic process in the argillaceous beds along the serpentine boundary. This is very clearly seen at the foot of Shynbaiahn hill, West of the village of Alaykhyoung, South of the Maday. The rocks here are the upper Axials, and shaly beds are seen within a few feet of the actual serpentine boundary. In these shales occur beds of from six to twelve inches in thickness, of what may be termed almost a claystone, which breaks with a clean fracture and dull earthy surface, and is a bedded rock altered by its close proximity to the serpentine. In some places this earthy rock is seen to pass into steatite of the ordinary character of that usually found in veins, with its lustrous surface planes and quasi-foliated structure like pure spermaceti. The relation here of the pure mineral to the earthy layer wherein it occurs, is sufficiently clear, but its more usual mode of occurrence is in the form of veins, where its segregative origin is even more clearly seen. In this form it is not uncommon along the margin of the serpentine at a variety of spots within the whole of the area marked by outbursts of that rock, and is also found among the altered rock towards Cape Negrais. It occurs here along the shore among altered shale, and again a few miles East of Kweng-bo, thirty miles North of Cape Negrais, among sandstones, which are indurated and disturbed, but at neither of which spots are any intruded rocks visible. At this last locality the steatite occurs in veins traversing sandstone (an unusual thing, an argillaceous rock being the more usual matrix) lenticularly intermixed with the peculiar fibrous quartz, but not averaging an inch in thickness. In these veins the steatite is a little in excess of the fibrous quartz, but the two minerals are very intimately united, the lenticular masses of the former being often enveloped with a layer of the latter, and portions are sometimes seen presenting almost the appearance of a conglomerate of steatite kernels, some no larger than hemp seeds, enveloped in a paste of fibrous quartz. These steatite kernels have, however, nothing to do with a mechanical origin, but are bounded by lustrous burnished surfaces, much resembling the silken-sides produced in shales by pressure, but in this case of quite another character, and the result of the peculiar chemical composition and mode of origin of the mineral—the smaller and purer portions of which being those with most lustrous surface. There is no place, however, within the limits of Pegu where the mode of occurrence of this steatite is so well seen as in the adjoining district of Sandoway; and as from the greater number and thickness of the veins here, the spot may be regarded as a focus of the peculiar action which has produced these veins, I shall briefly describe it, in place of any of the less noteworthy spots where the mineral occurs to the South, since, save in the greater thickness and number of the veins, the description of one locality will, in all essential respects, stand for all. The precise position of the spot I shall now describe is three miles North-west from Sandoway, or nearly midway between Kau and the Andau pagoda, being rather nearer, if anything, to Kau. I am not sure if the rocks around Sandoway should be referred to the Cretaceous group or to the Eocene, as what little limestone there is in the neighbourhood does not contain fossils, and there is little or no evidence at present to support an opinion one way or the other. In the near vicinity of the spot a good deal of coarse conglomerate is scattered about, and some queer looking septarian masses of compact marl derived from the waste of some shales which have once included them. On reaching the low hill which seems to be the focus for these veins of quartz and steatite, quantities of the vein-stuff are seen scattered over the face of the hill, the débris evidently of veins traversing the rocks at this spot. Most of the veins are of the usual small dimensions, but some veins here are far larger than any noticed elsewhere, being nearly a foot thick, whereas elsewhere they are rarely seen more than a few inches. These veins are composed of the ordinary union of steatite and white fibrous quartz, having more or less of a chatoyant lustre. The steatite is of the ordinary gray or green color, hard and compact in the thicker parts of a vein, but passing into the finer variety usually selected for writing-purposes. The surface of the finer portions of the steatite is smooth and burnished, and the mineral exhibits a tendency to develope curved ends, resembling cloves of garlic or similar bulbs; and this is not the result of pressure, but of an appropriate segregative process during the formation of the mineral, which is also well seen at Shynbaiahn hill. The fibrous quartz is here seen in veins, some two or three inches across, and the thicker veins are composed not of so much quartz or steatite, but of an interlaced mass of small veins which unite to form one of the above dimensions. On the top of a small rise a shallow pit has been sunk a few feet in the ground in search of steatite, around which, among much vein-stuff, large lumps of a black shale are scattered, as though it formed the underlying rock at the spot. I term it a shale, as such I believe is its nature, but in hand specimens it might be termed a 'potstone,' so compact and homogeneous is it, in this respect resembling the massive shale seen at the foot of Shynbaiahn hill.

A specimen of steatite analysed by Mr. Tween gave the following result:—

Water	2·4
Silica	63·11
Oxides of iron and alumina	3·41
Magnesia	30·47
Alkali	a trace.
	99·39

The steatite, at all these localities, is essentially the same, though it varies in color from a pale gray to nearly black, the paler varieties having often a marked tinge of green. The pale gray variety only is sought after and selected for writing-purposes, and is precisely the same mineral as that imported in square sawn sticks from Upper Burmah, where, however, the mines must yield a more massive variety, and in larger pieces than that yielded by the veins of the mineral in Pegu.

XV.—Economic Geology.

The list of economic products connected with geology in Pegu is extremely limited, and some items are included therein more for the sake of completeness than because they are themselves of economic importance. Among articles which may be noticed are the following:—Building-materials, Clay, Coal, Gold, Iron, Lime, Marble, Petroleum, Road-materials, Salt, Steatite.

Building-materials.—Good building-stone is by no means common in Pegu, either such as would be suitable for ordinary edifices, or for such heavier works as quays, light-houses, &c. Some of the sandstones of the Arakan range might be found of useful quality, if not situated at such a distance from the centres of demand and so far from regular water carriage. The stones of both the Arakan and Pegu ranges are not, as a rule, sufficiently excellent, to counterbalance the great disadvantage of their position as regards transportation, or to promise to supply any large demand for works of magnitude. There is, however, one spot on the Arakan coast which has always seemed to me worthy of consideration and trial, if a useful stone for building-purposes, something of the quality of the Porebunder stone, so well known in Bombay, should ever be required extensively in Burmah. The spot in question is Koranji island, where, and on the adjoining mainland near the village of Nga-thamu, a soft calcareous sandstone or earthy limestone occurs, easy to work and unusually well situated for shipment into lighters or small coasting craft. These beds occur on no other part of the coast, but exist here in a position very favorable for working. Koranji island is composed of these beds (which I have already described), and under its lee side a channel exists, having a depth of two or three fathoms at low water, with good bottom of sand or mud. The channel shoals gradually towards the mainland, and is protected by Koranji island on the West or seaward, and by a bar almost dry at low water to the North, but enjoying always a safe and easy entrance from the South, save during the prevalence of the South-west monsoon, when all coasting traffic is given up. Three miles, however, East-by-south from Nga-tha-mu is the large village of Nga-got-kweng, on a well sheltered tidal creek, at the mouth of which (being quite sheltered to the South) shipments of stone of the same description might be made throughout the year.

Clays.—The clay in ordinary use for pottery and brick-making is the ordinary alluvial clay of the province, which receives no preparation beyond mixing with water before it is moulded. A dark-colored seam in the alluvium, which within the tidal portion of the delta is below high water mark, is much sought for by potters for their vessels, but the seam is a thin one, and the clay, save in its darker color, seems identical with the common sort. Some of the upper beds of the Nummulitic group, already described, consist mainly of china-clay, and would answer well for the manufacture of chinaware, being almost free from iron. No practical experiments have as yet been made with any of the clays of Pegu, and so ill directed and unsuccessful have the attempts been to make even good ordinary bricks that I understand the Department of Public Works has even imported Calcutta-made bricks for use in Rangoon. One thing I can assert of my own knowledge, that I have seen bricks about to be used in Government buildings in Pegu, portions of which might be crumbled to powder between the finger and thumb, but this is not because no good bricks can be made in the province, but from the difficulty of securing uniformity of excellence from native contractors.

Coal.—Enough has been previously said regarding the Thaiet-mio coal, to show its trifling economic value, and much the same defects and objections will probably be found to apply to any other outcrops of the mineral, found at any future time in the province. The main objection which would seem to be inherent in these Nummulitic coals, is their great irregularity, not only as regards the thickness of the seam, but as regards its quality also, and this it is reasonable to suppose to be largely due to the different conditions under which these coals have been deposited, and under which the ordinary workable coals of commerce have originated. Another of these worthless fuels occurs near the village of Chouk-kalah, on the Mu stream, three miles South of Tham-baya-deing boundary pillar. This coal was first discovered in a cart-track through the jungle, where the black color of the pulverised rock attracted attention. It is, however, better seen in a stream not far off, where it is seen to dip at 70° to East-by-north. It is in fact, however, a bed of carbonaceous shale, containing a one foot seam of hard bright coal, and a few stringy seams which may make in all a thickness of coal of eighteen inches, an amount quite useless for extraction even were it more favorably situated than it is, it being over thirty miles from the Irrawadi river, where it would have to be taken to.

In addition to actual seams of coal, some of the sandstones contain carbonised trunks of trees, from which specimens of lignite might be procured, very likely to lead to fallacious hopes in district officers, sanguine and anxious for the discovery of a good fuel. Such would seem to be the origin of some of the coal said to occur near Dalhousie, at the mouth of the Bassein river, according to the testimony of my colleague Mr. W. Blanford; and similar traces of lignite have also been noticed in the sandstone beds in the Shu stream above Sabatan, but the economic value of such indications is *nil.*

Undoubtedly, were the lignite in good quantity, in pyritous shales, as under the Nummulitic beds, across the Indus near Kotki, alum might be manufactured; but nothing of the sort occurs in Pegu, where the carbonaceous deposits associated with the Nummulitic group would seem to be absolutely worthless.

Gold.—Gold occurs in the bed of the Irrawadi, but in such fine dust and so sparingly that few engage in the task of washing for it. I am told that it is occasionally washed before Prome, but the only spot where I have witnessed the process is at Shuaygyeing, 'gold scratching' (not to be confounded with the Shuaygyeen on the Sittoung), just above Monyo, where a little gold is occasionally obtained. The gold is found in a coarse gravel-bank, left dry by the river when it subsides after the rains. This coarse gravel is dug out and laid on a sort of hurdle, which permits the fine sand to pass through, the coarse pebbles and boulders being rejected. This sand is washed on an inclined board. The lighter portions being gradually swept down the incline by a stream of water directed over it, whilst the heavy auriferous sand remains and is from time to time collected. This sand is lastly washed in the common wooden hand dish, of circular form, and the gold it contains collected by amalgamation. The profits of this pursuit are small and the labor great, the men not netting probably more than two or three annas a day profit, which must be regarded as a miserable remuneration where the ordinary hire for a cooly is eight annas, or twice that at the rice ports during the shipping season.

Iron.—Iron ore of excellent quality occurs, as already described, in the fossil-wood group in Eastern Prome, and a considerable manufacture of the article was formerly carried on, prior to the British occupation. The manufacture has now, however, entirely ceased, owing to the greater cheapness of English iron and steel, and the more convenient form in which the imported metal is procurable. For further detail on this head *vide* Records of the Geological Survey, Part 4, 1869, page 83.

Limestone.—No limestone whatever occurs on the East side of the Irrawadi river, if we except a few scattered and most insignificant patches of travertin, here and there found among the hills of the Pegu range, and a single outcrop of limestone near the banks of the Myouk-Naweng, all of which in an economic sense are of little or no value. West of the Irrawadi, however, limestone is abundant, being found at intervals along the entire length of the Arakan range; so that it is quite unnecessary that I should specify all the spots where this rock occurs. I shall merely enumerate the spots whence the present supplies of lime are chiefly obtained, and note one or two localities which may be valuable hereafter. Northern Pegu is abundantly supplied with lime from the Lime-hill below Thaiet-mio, lime-kilns being constructed in the neighbourhood of Tonbo village, on the river bank, at the hill itself, and lower down again near the village of Penthalyng. Limestone is also found not far from the river behind Akouktoung hill, and is procurable in any quantity. All this limestone is of Nummulitic age and excellent quality. The mode of extraction is, however, unsystematic and wasteful to a degree. The outcrop of the rock is just dug into, and if the rock is rather slabby, it is simply broken up and extracted in conveniently sized lumps. No order or regularity is observed in opening a pit, hence a great waste of labor with, it may be presumed, enhanced cost. If the outcrop is more massive in character, a large fire is kindled on the bare surface of the rock, by which the stone is rendered more brittle and easier to break up and extract. The only tools used are a few light hammers, a crowbar or so, and a number of wedges both of wood and iron. In the Bassein district most of the lime at present used is procured near Thamandewa and Kyout-thing-bhaw on the Bassein river, a few miles below Gna-putau, regarding which I shall quote the remark of Mr. W. Blanford who examined the locality: "This is by far the most important locality in the province, and perhaps in the whole of Pegu. At Kyouk-theingbhaw several very large masses of limestone crop out from the alluvium on the river bank. The quantity here, though considerable, would, however, soon be exhausted if there were a large demand for lime.

South of the village, Thamandewa, a tidal creek stretches for some miles into the country, and on the South of this creek the outcrop of a bed at least thirty or forty feet thick stretches across the country in a direction nearly South 20° West, for a distance of about a mile, re-appearing at intervals for about a mile further, the most southerly point where it is seen being near the bank of the river bed not far from the village of Tounggale. The quantity is inexhaustible, the quality good, and the access easy, Thamandewa creek being navigable for Burmese boats of the largest size, and probably at high tide, for sea-going vessels." Along the western side of the range, limestone occurs at several places, but so situated, it is of course of no economic value. I must, however, notice one spot on the coast near Baumi, which, I think, may not improbably prove of value, for the supply of lime to the Ramri and Kyoukhpew districts, not because there are no nearer supplies, but because situated on a tidal creek, the distant source is probably far more really accessible, than nearer ones situated inland. The limestone hitherto quarried in the Kyoukhpew district, would appear to have become almost exhausted, and a new site for a quarry is being now sought for. The position of this limestone I have previously described, and need not therefore here point out, and though Baumi is somewhat remote from Kyoukhpew, yet the site unites the following advantages in a greater degree than any other I am acquainted with :—1st, easy access for large vessels adapted for coasting voyages; 2nd, excellence of quality; 3rd, exhaustless quantity.

An analysis of this rock by Mr. Tween gave the following result :—

Carbonate of lime	96·4
Iron and alumina	0·8
Insoluble (silica)	2·8
	100·0

Marble.—None of the limestones found in Pegu, can be recommended for ornamental purposes, especially as superior marbles exist (should any demand arise) in the adjoining countries, as, for example, the well known white marble from the hills near Ava; the dark marbles which might be procured from the limestone hills in Martaban province; and I might add a very neat gray marble, resembling the China marble used for flooring in Calcutta, procurable in the hills North-east of Tonghoo, where the rock is quarried for lime.

Petroleum.—The occurrence of this valuable mineral in Pegu rested for some years on no better foundation than a general impression that it had been found at some spots or was very likely to be found. Within the last few years, however, this doubt has been entirely set at rest by the discovery of 'oil' at more than one locality in Western Prome, in what may in future not unlikely prove remunerative quantity. All these localities are situated on the West side of the Irrawadi, either among Nummulitic rocks or the still newer Tertiaries.

Petroleum has been reported to have been found in a stream among the hills South-east of Namayan, below Prome; but having visited the reputed locality, I am unable to corroborate the statement, though from what we know of the habit of the oil, rising through the beds of the newer group, it would be rash to assert that no escape of petroleum was ever likely to have occurred within the area in question; but it is not to the East bank of the Irrawadi (within Pegu at least) that efforts to discover profitable sources of oil should be directed, from the fact that nowhere on the East bank does the Nummulitic group appear, which would seem to be the source of the Burmese oil, and that consequently a much greater thickness of unproductive beds would there have to be pierced by a boring, or traversed by the oil, than on the West bank, where the Nummulitic group is raised to the surface or may more reasonably be sought for at moderate depths than on the East bank where it is nowhere seen.

The first spot on the West of the Irrawadi where petroleum is reported to have been obtained is at Yenan-doung, twelve miles South-west from Myanoung. A square shaft has here been sunk through

Nummulitic strata, but it was immediately abandoned and is full of water. No details of the experiment are known; but my colleague, Mr. Blanford, in a memorandum on the subject, says that petroleum certainly exists here. A copious evolution of marsh-gas takes place from some cracks in the soil in the immediate vicinity of the shaft, but I did not detect any traces of petroleum; but as my visit was immediately after the close of the rains, any slight traces would be then less perceptible than at other times.

The localities I shall now describe have all been discovered within the last few years, and all in a similar way, by the contamination of the water in the streams, when at their lowest in the months of March, April and May. At such times the running water of the small streams has disappeared and only a few pools are left, or a little water is merely obtainable by digging in the bed of the stream. Where, therefore, there is any petroleum in the rocks through which the streams pass, its flavor is communicated to the water, and its presence thereby revealed when otherwise it would escape detection. The first locality in Western Prome, where a little petroleum was obtained is situated near Padouk-ben, a village about seven miles in a straight line West-by-north from Thaiet-mio. The rocks here are soft earthy bluish sandstones and shales of the newer Tertiary series which here dip at low angles and present no appearance which would intimate the presence of the oil. Several square shafts were sunk at this spot, close to the bed of a small stream, through tender sandstone, to a depth of some twenty feet, and a small quantity of oil was procured, at about twelve feet from the surface, which according to my information did not increase as the shafts were deepened, and the work has, I believe, been since abandoned.

From the fact of the oil being met with at a depth a little below the level of the bottom of the stream (the shaft having been put down a little way up the side of the bank), and considering the porous nature of the tender sandstone, wherein the shafts were sunk, I am inclined to think the oil won was merely a trifling quantity, stored in the rock at about the usual water level of the locality, and that the seam or crack along which the oil may be presumed to have ascended to the surface was not discovered; there is, however, no indication at the surface to enable an opinion to be formed as to the source of the oil, and the experiments here are not likely to be renewed.

The next locality is situated near Banbyin (Pan-pyeng in map), eleven and a half miles West-north-west from Thaiet-mio, on the banks of a stream falling into the Irrawadi a little above Thaiet-mio. The whole country hereabouts consists of beds of shale and sandstone, occupying a high position in the newer Tertiary group, and probably not far removed geologically from the horizon of the beds at Padouk-ben. The whole country between this and Padouk-ben consists of these beds, rolling and dipping at various angles, but presenting no special marks of disturbance. Some way above the village of Banbyin, a little below the main locality, indications of petroleum are seen in the blue shales forming the bank of the stream, and some shafts were sunk here, but without much success. On the North bank of the stream, in some small feeders, and several other spots, indications of petroleum are met with; but as no results have accrued from any of these spots, I will merely describe the main shaft from which a little petroleum has been extracted, but which is so badly situated on the verge of the stream that it has probably ere this been engulphed by the floods. This shaft is situated on the North bank of the stream about a mile above Banbyin on the slope of a steep bank of shale which is here undercut, and in process of removal by the current. These shales undulate at low angles, but just below where they disappear a hard bed of sandstone comes in over them dipping 70° South. The beds are rather crushed beneath this hard band of rock, as though from the sharp flexure they here make, and it is beneath this bed that a little petroleum escapes into the stream. To tap this source was doubtless the reason of choosing so precarious a site for the shaft, which is put down just above it. Above the shaft, the shales are seen saturated with petroleum in their joints and cracks. The arrangement of the ground and the position of the shaft will be at once seen by a reference to Plate II.

The shales here contain fossils of the ordinary Miocene types, *Ostrea*, *Pecten* (2 species), *Conus*, *Cypræa*, *Arca*, *Solen*, *Turritella*, crabs' claws, sharks' teeth, &c.

From this locality a little petroleum has been obtained, and from the evidence of its existence in other spots as well, in the neighbourhood, it is possible that it may be obtained here in profitable quantities. At the same time the geological horizon of these beds is probably not less than 2,000 feet above the source of the oil, and that thickness of beds interposed, would seem an unfavorable circumstance as regards an abundant supply.

The last locality I shall notice is by far the most promising in an economic aspect. It is situated within the area of the Nummulitic group, being eleven and a half miles due West from Prome Pagoda, and three miles above the village of Toungboji, on a small stream falling into the Booyoo stream, which though unnamed in the map is locally known as the Mahn-choung. A dam is thrown across this small stream for the purpose of storing water at Toungboji, and the existence of petroleum would seem to have been discovered in the usual way by its contaminating the water of the Mahn-choung in the dry season.

At the time of my visit in November 1871, four shafts had been sunk in the bed of the Mahn, one of which had been buried by a slip of earth from the hill side adjoining the stream, and two of the others had not struck any petroleum. The second shaft, however, which is the only one that needs attention, had been very successful and had yielded some two and a half viss of oil daily at the depth of 35 cubits, till it became filled with water in the rains, when the supply ceased. In my memorandum on this well at the time I attributed this cessation of the flow of oil into the well to the ordinary action of gravity, the oil welling out from minute cracks in which it lay stored, but which a heavy column of water thirty-five cubits high effectually held in check by simple hydrostatic pressure on the cracks and veins containing the oil, and I expressed a belief that on operations being resumed and the well emptied of water and deepened, the flow of oil would again commence, and this opinion has been, I am informed, fully verified.

The specific gravity of the Burmese petroleums from different localities varies :—

A specimen of light-colored oil from Kyoukhpew showed a specific gravity of	·815
A sample from the locality west of Prome	·847
A sample of the Padouk-ben oil	·909

A very brief extract from the Progress Report of the Geological Survey of Canada by Sir W. Logan in 1863 will suffice to show the essentially different conditions under which the Canadian and the Burmese and Indian oils are produced, the latter originating, as far as can be judged, in early Tertiary strata, the former being developed exclusively in rocks of Palæozoic age.

At page 788, Sir W. Logan thus describes the stratigraphical position of the napthagenous strata in Canada:—"It has already been shown that the petroleum of Canada occurs in two distinct horizons, the one in the limestones of the Trenton group, and the other in those of the Corniferous formation. To this it must now be added that the petroleum of Gaspé probably belongs to an intermediate position, and is to be referred to limestones of Upper Silurian age," the Trenton group corresponding to the English Caradoc or Bala beds of Lower Silurian age, the Gaspé beds to the Ludlow zone of Upper Silurian age, and the Corniferous formation to the middle Devonian of European geology. Paraffine, so largely consumed now in the manufacture of candles, occurs in greatest quantity in the Burmese petroleum of commerce, the product of the wells in Upper Burmah. Paraffine, according to Dana, occurs in the petroleum of Pennsylvania, but the American oils are usually deficient in paraffine. Gesner, however, says that paraffine exists in the Onachita coal of Arkansas to the extent of 143 pounds per ton. The paler oils of Ramri and other parts of Arakan, having a less specific gravity than the commercial oil of Rangoon, are possibly as deficient in paraffine as the American oil, which they so much resemble, but no adequate analysis has ever been made to settle this important point, and the Arakan and Burmese oils are certainly derived from beds of the same geological age, hence their poverty in paraffine should not perhaps be assumed from their outward character.

Road-materials.—Good road-materials are scarce in Pegu, in fact there are none suitable for roads on which heavy traffic is carried on. In Rangoon of course, excellent road-material is procurable, in the shape of ship's ballast, but in the interior of the country soft sandstones are the prevalent material, with a little laterite of usually rather inferior quality. This paucity of good materials for road-making is less felt in a country where wheeled vehicles are usually reserved for agricultural purposes, and the transport of grain across country in the dry weather, when the crops are off the ground, and the carriage of other goods and merchandise is mainly effected on pack bullocks and ponies. The serpentine of the Arakan range would certainly form a good road-material, but it is hardly worth while dwelling on this, as road metal is too heavy an article to bear distant transport, and the roads of Pegu must of necessity be constructed of the materials nearest at hand, however inferior for the purpose they may be.

Salt.—The manufacture of salt, from the feeble brine springs of the province, which once formed a considerable local industry, has now almost entirely ceased, owing to the greater cheapness with which the sea salt manufactured in lower Pegu and even imported English salt, is now procurable. An enumeration of the various localities where brine springs issue, has already been given elsewhere (*vide* Records

Geological Survey, Vol. VI, p. 67), and need not be farther dwelt on, as they now possess no economic value whatever.

Steatite.—The great bulk of the steatite pencils used in Burmah for writing, comes from mines situated in Upper Burmah. An identical material, but not produced in the same size, occurs, as already described, at numerous localities in the Arakan range, and is sought for by the villagers in the neighbourhood, for the same purpose as the imported steatite. In Pegu, however, the veins of this mineral would not usually afford such long sticks as are imported from Ava. These foreign pencils are square sticks, sawn out of the block, with sides of a quarter of an inch or rather less, and from four to six inches long.

Hot springs.—Hot springs, though numerous in Martaban and Tenasserim provinces to the South, are rare in Pegu. The only hot spring known to me in Pegu is in the bed of the Bulay stream, under the village of Kwon-bulay, in lat. 19° 15′, long. 95° 16′. As, however, the spring issues in the bed of the stream, I cannot give its proper temperature, as when I first visited it, the pools were evidently mixed with river water, and the second time I visited it, the site of the spring was entirely hidden by a sandbank. I may as well here record a hot spring close to the head waters of the Sandoway river, discovered by Mr. Bunbury, an energetic officer of police, when in pursuit of some escaped convicts. It is situated about lat. 18° 6′ 20″ and long. 94° 54′ 0″. I attempted to visit the spot in company with the discoverer, but owing to the difficulties of the ground, had to abandon the attempt, the precise locality of the spring is therefore given on Mr. Bunbury's authority. The whole of the upper portion of the Sandoway river is, however, totally unsurveyed and very impracticable. I may also add, that when visiting the lead locality near Tonghoo, I discovered a hot spring, which seems to be little known, near the Kayenchoung. It is situated in lat. 19° 10′ 30″ and long. 96° 35′ 0″. It rises in the bed of a small stream, so its temperature could not be estimated. I had no thermometer with me, but the water, I should say, in the main pool nowhere exceeded 115°.

The position of two springs situated in the valley of the Lepan-bew Choung was pointed out to me; one, approximately in lat. 19° 16' 30", long. 96° 36' 0", the other situated four miles off in a West-south-west direction. The Lepan-bew Choung is not marked on the map, but it is a feeder of the Pyeng-thee-la Choung; indeed if my informant was correct, the Lepan-bew is the stream which runs North of Than Toung, whilst the real Pyeng-thee-la is the unnamed stream shown in the map to the South of Than Toung.

A hot spring with a temperature of 108° rises in the Choung-ma-nay valley, lat. 18° 44' 0", long. 96° 46' 0", between the Choung-ma-nay and Youk-thwah streams. The spring forms a pool of tepid water, and rises through cracks in a hard rusty sandstone, much indurated and resembling an ordinary quartzitic sandstone of the Vindhyans of India, but a member probably of the 'Moulmein' group of Dr. Oldham.

A very hot spring rises in the bed of the Hlay-loo-myoung Choung, temperature 157, lat. 18° 33' 0", long. 96° 51' 0". The Hlay-loo Choung falls into the Hmon Choung from the North, and its course lies through altered and much disturbed rocks traversed by elvan dykes. The hot spring forces its way to the surface at several spots, through a bed of coarse granitic sand which conceals the actual point of issue, which seems to be along a bed of harsh granitoid appearance, probably a highly altered member of the above Moulmein group. Higher up the Hmon valley another hot spring is reported to occur, probably in the Yay-boo Choung of the Map, as '*Yay boo*' means hot spring.

When the whole country east of the Sittoung comes to be examined, a great number of other hot springs will, I believe, be discovered in the inner hills, which I had no opportunity of visiting.

Postscript.—In a note to page 18, I drew attention to the discrepancy between the boundary of Pegu as laid down in the published map of the Province and the Administration Report for 1868-69. Since the note in question was passed for press, I have seen copies of the map, whereon an addition has been made touching this very matter, in the shape of a note by Sir A. P. Phayre, dated the 16th February 1870, that the British boundary properly extends to the dividing range between the Sittoung and Salwin, and not as displayed in the map by Captains Edgcombe and FitzRoy. I am inclined, however, to think that the above note is the only assertion of British supremacy which exists within the area in question. This view is moreover countenanced by a second note being added lower down, below Parallel 19°, announcing the existence there of "Tribes of Christians paying revenue to British Government." The meaning is of course obvious, though 'Christian Tribes' would have been the correct expression, the race or tribal name of the Christians in question being *Karen.*

APPENDIX.

Stone Implements.

The occurrence of stone implements in both Central and Southern India, and Behar, has been known since 1861, when Mr. H. P. LeMesurier first brought them to notice in a letter to Mr. A. Grote, President of the Asiatic Society of Bengal, published in the Proceedings of the Society for that year; and in 1862, a series of similar neolithic implements was figured by myself in the Proceedings for June, page 323.

In October 1866, Mr. R. Bruce Foote, of the Geological Survey of India, figured and described in the Madras Journal of Literature and Science a fine series of chipped or palæolithic implements, from the lateritic deposits of Madras, since when additional information has from time to time accumulated, culminating in the discovery last year by Mr. C. A. Hacket of a fine chipped celt in situ, among the ossiferous gravels of the Narbada, wherein occurs the extinct mammalian fauna of the valley—Hexaprotodon and its congeners (*see* Records Geological Survey of India, Vol. VI, p. 49). One remarkable fact connected with these implements is the precise similarity in form and design which exists between those found in India and those in Europe, though the same variety does not exist in the East, where, from some cause or other, the art was not carried to the same perfection as it at one period reached in Europe; but so far as known specimens of Indian implements allow us to judge, and apart from the indication afforded by the material (flint so commonly used in Europe not occurring in India), it would be difficult to say from shape or manufacture whether any particular implement of palæolithic type had been manufactured in Kent or Kuddapah, or if a particular neolithic celt of greenstone was from the neighbourhood of the Son or the banks of the Shannon. So close is the similarity that there seems no room to doubt a community of origin between the palæolithic races who manufactured and used such identical forms in India and Europe—an observation which has an even more extended application and significance with respect to the dolmens, cromlechs, and stone circles so plentiful in some parts of India, and so identical with similar erections in Europe.

Were there, however, any objectors so hardy as to argue, that such similarity of monuments, both industrial, funereal, and religious, was merely the result of a fortuitous similarity of conditions, it would seem as though a conclusive answer to such a supposition was provided in anticipation in British Burmah. It seems difficult to imagine what differing conditions could have obtained during the savage infancy of our race in Burmah, greater than existed between India and Europe; yet directly we cross from India, properly so called, to the countries lying to the eastward of the Bay of Bengal, we find stone implements no less abundant than elsewhere, but of an entirely different type. We no longer find the familiar Indo-European type either palæolithic or neolithic, but one seemingly autochthonous to the Malayan countries, and both in size, shape, and design displaying considerable divergence from any of the ordinary types of weapons found elsewhere.

The main points of divergence are—1*st*, the frequency of forms possessing 'shoulders,' a peculiarity quite confined to articles from the Burmese or Malayan area; 2*nd*, the cutting edge being usually formed by grinding down on one side, as a chisel and not as an axe; 3*rd*, by the general small size and seeming inefficiency for any rough purpose, though, it must be remarked, that very small and well fashioned weapons are also found in India. A reference to the following Plates will give a better idea, at a glance, of these several characters than mere words can convey; so I shall merely add brief notes on the most remarkable specimens figured.

Plate III, fig. 1, represents one of the largest Burmese celts I have seen, which was picked up in my presence in the bed of a stream falling into the Than-ni Choung, a little South of Nattoung hill in Western Prome. It is roughly fashioned out of a coarse compact sandstone, and, as is the case with several of the other implements, is wrought transversely to the natural bedding of the stone. It is difficult to imagine any purpose gained thereby, and it would *primâ facie* seem as if, in some cases at all events, much ingenuity must have been exerted to obtain a through fracture across the bedding of a rock, as, for example, Plate IX, figs. 1 *a. b.*

Plate IV, figs. 1 *a. b.*—This remarkable implement, figured two-thirds of natural size, was procured by Captain Fryer in the Tavoy district. It is finely smoothed and fashioned out of a very fine-grained slate, and is the largest implement I have seen from Burmah, and of rather unusual type. Figs. 2 a. b. represent a smaller article of the same type and material procured by myself in Pegu, where, however, this type is rare.

A third type of large or medium chisel-shaped tool is exemplified in Plate V, figs. 1 *a. b.* and 3 *a. b.*, Plate VI, figs. 1 *a. b.*, Plate VII, fig. 2, Plate IX, figs. 1 *a. b.* All these are fairly effective weapons, and may possibly have been used without the intervention of handles.

A fourth type, usually of small size, is that of a shouldered celt or chisel; and this form would appear to have been always fixed in a handle. To this type belong Plate IV, figs. 4 *a. b.*, Plate V, fig. 2, Plate VI, figs. 2 *a. b.*, Plate VIII, figs. 2 *a. b.* and 3 *a. b.* A modification of this type consists in the less prominence and squareness of the shoulders and slight corresponding modification of the general outline, as on Plate IV, figs. 3 *a. b.*, Plate VIII, figs. 4 *a. b.*, and Plate IX, figs. 2 *a. b.* and 3 *a. b.*

Another type without shoulders is seen in Plate VI, figs. 3 *a. b.*, and Plate IX, figs. 3 *a. b.*

Figs. 3 *a. b.* of Plate IX approach more nearly than any other in type to certain Indian forms; and weapons of this shape, manufactured of jade, are open to grave question on the score of genuineness (in my opinion), though probably manufactured for sale from an authentic model.

The material of which these implements are generally made, is some hard subschistose rock or fine-grained slate; none of them of the hard green-stone so commonly used for the purpose in India.

Plate VII, fig. 1, represents a remarkable article procured by Captain Fryer either in Sandoway or Tavoy. Its use is not at first sight very obvious, but it is, in my opinion, an armlet or bangle, and the weight and incumbrance of such an ornament in stone is by no means greater than is often borne with by the fortunate possessors of massive brass bangles, or, in some cases, solid rods of tin coiled round the arm like a bandage, as with some of the Karenni tribes.

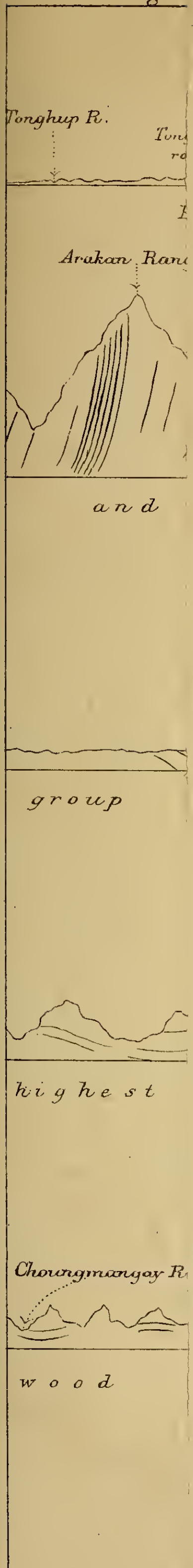
With regard to the probable uses to which the different sizes and sorts of celts were put, much uncertainty must exist, as the very tradition of the tribes who made them has vanished from the existing population of the country where they are found. Some of the implements of middle size may have been used in the chase, or perhaps in the form of a rough tomahawk; for many of them, if fixed in a stout handle and wielded by a powerful arm, would suffice to fell either a man or an animal the size of a deer or hog. The larger ones may have been so used also, or they may have been used to excavate the stem of a tree after the wood had been rendered friable by charring; a process which, if repeated several times, would explain how, with no other than such blunt tools, primeval man was able to fashion canoes of large trees—a matter of infinite labor at the present day, with steel tools in possession, and wherein the Burmese excel, though not so much as some of the savages of Oceania. The small implements were probably fitted lengthwise into a handle and used as a spud for digging holes in the earth for rice or other seeds, as is to this day practised by the Karens in the hills, a small iron wedge being substituted in place of a stone one at the end of a short bamboo handle. For this cultivation, however, on the hills, it is necessary to clear the forest, and this would seem to be an impossibility to men not possessed of steel; but the early cultivators may have raised their scanty crops, as the moderns still do, off banks, left on the subsidence of the annual inundation; and a stone-headed spud would be ample for such a purpose, either to drill holes for the reception of the seed, or to weed up the rank crop of grass, which in such spots would contend for mastery with the artificial crop.

The Burmese call these implements 'Mo-jio,' 'Thunder chain' or 'Thunder-bolt,' and believe that they descend with lightning, and after penetrating the earth, work their way back by degrees to the surface, where they are found scattered about the fields, among the lower hills, usually after rain, or on removing the crops. The true 'Mo-jio' is supposed to possess many occult virtues, and it is not common to find one which does not show signs of having been chipped or scraped for medicinal purposes.

One of the chief virtues of the 'Mo-jio' is to render the person of the wearer invulnerable; and many an unlucky 'Mo-jio' has succumbed to the popular test, which is to wrap it in a cloth and fire a bullet at it at short range. If the man misses the cloth, the authenticity and power of the charm is at once established; if the stone is fractured, it is held to be not a *real* 'Mo-jio.' Other less severe tests are also applied. Fowls, it is supposed, will not venture near rice on which a real 'Mo-jio' is lying. Fire will not consume a house which contains one, (though I never heard of this ordeal being attempted). A plantain tree cut down with one, will not sprout up again; and last, but not least in esteem, is the known fact that the owner of a real 'Mo-jio' can cut a rainbow in half with it. The philosopher may smile, but what civilized people is there in a position of intellectual superiority to justify their looking down contemptuously on the harmless credulity of a simple-minded race? Assuredly not those claiming highest intellectual rank, yet who are still far from having outgrown a debasing belief in miracle, and a slavish fear of the priest.

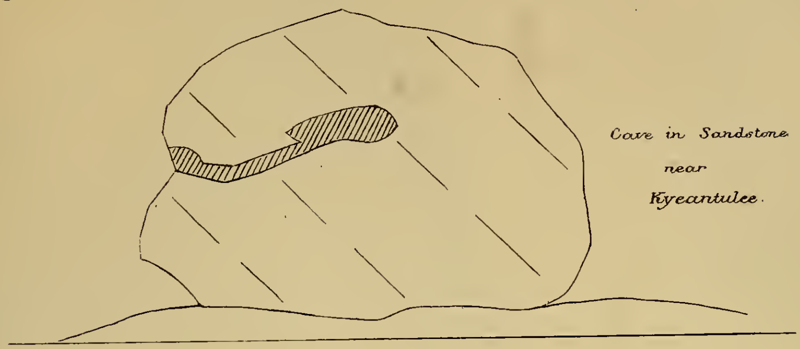
Theobald Pegu.

l.X. Pl. II.

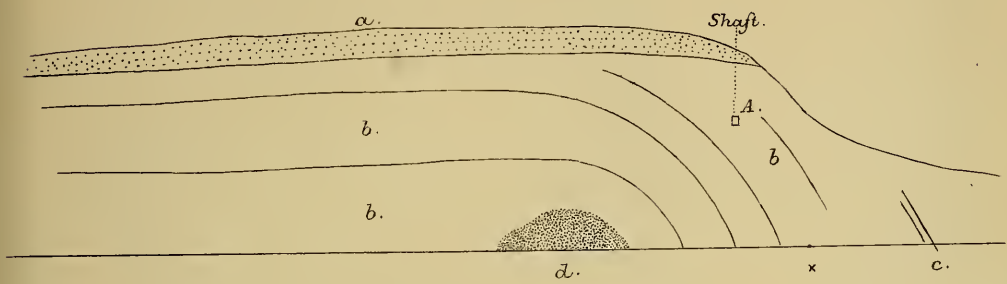


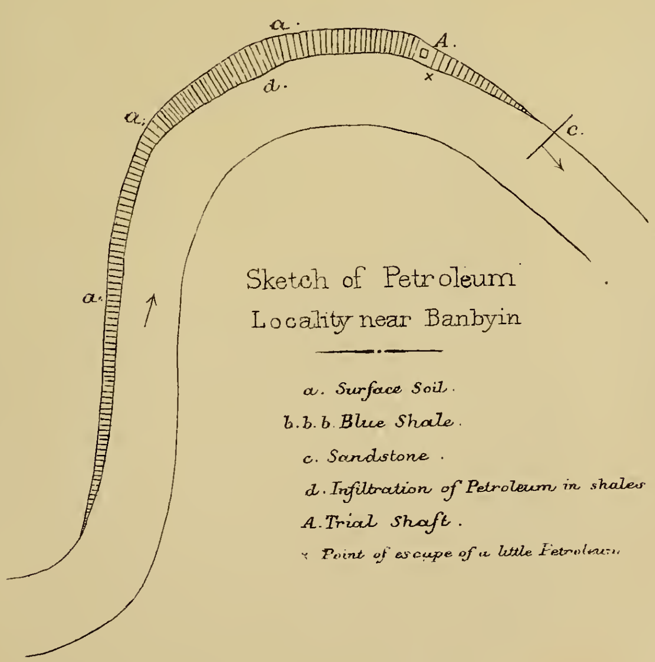
Section from the Arakan coast to the Hills East of the Sittoung

Scale { Horizontal 4 Miles = 1 Inch
Vertical 5000 feet "



Cave in Sandstone near Kyeantulee.





Sketch of Petroleum Locality near Banbyin

a. Surface Soil.

b. b. b. Blue Shale.

c. Sandstone.

d. Infiltration of Petroleum in shales

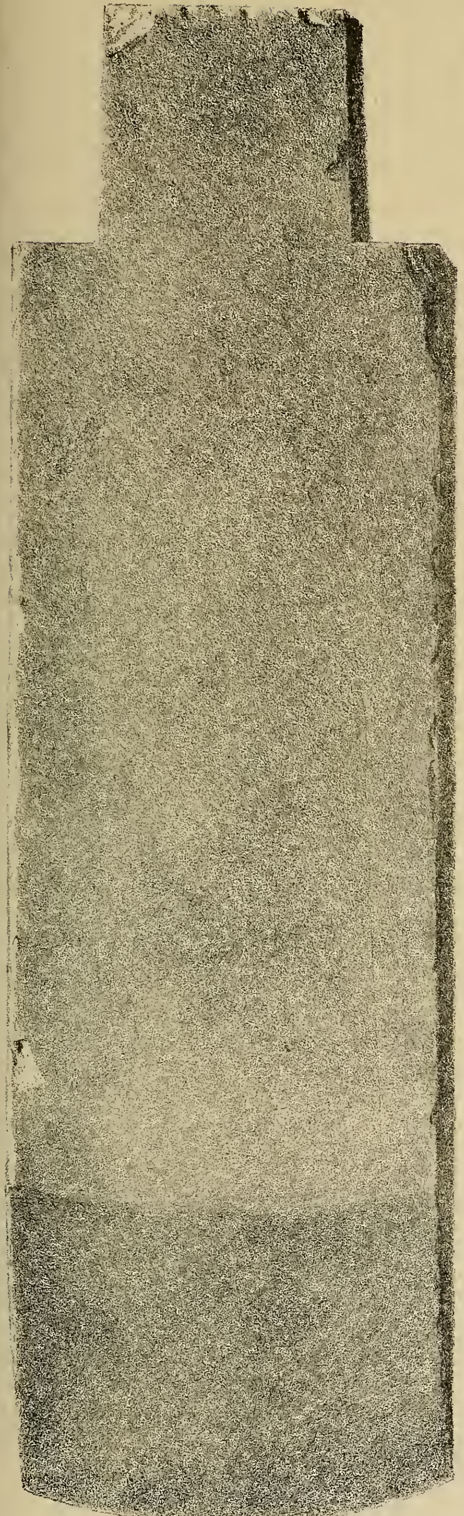
A. Trial Shaft.

× Point of escape of a little Petroleum

1. a

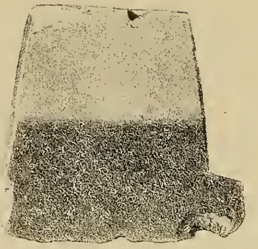
1. b.

Lith. and print: at the Geol: Surv. Office. Calcutta.



1. a.

1. b.

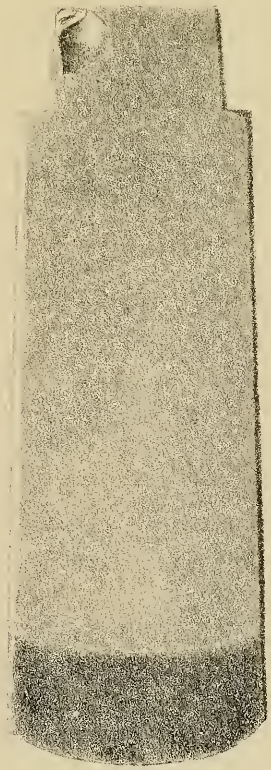


4 a.

4 b.

3. a.

3. b.



2. a

2. b.

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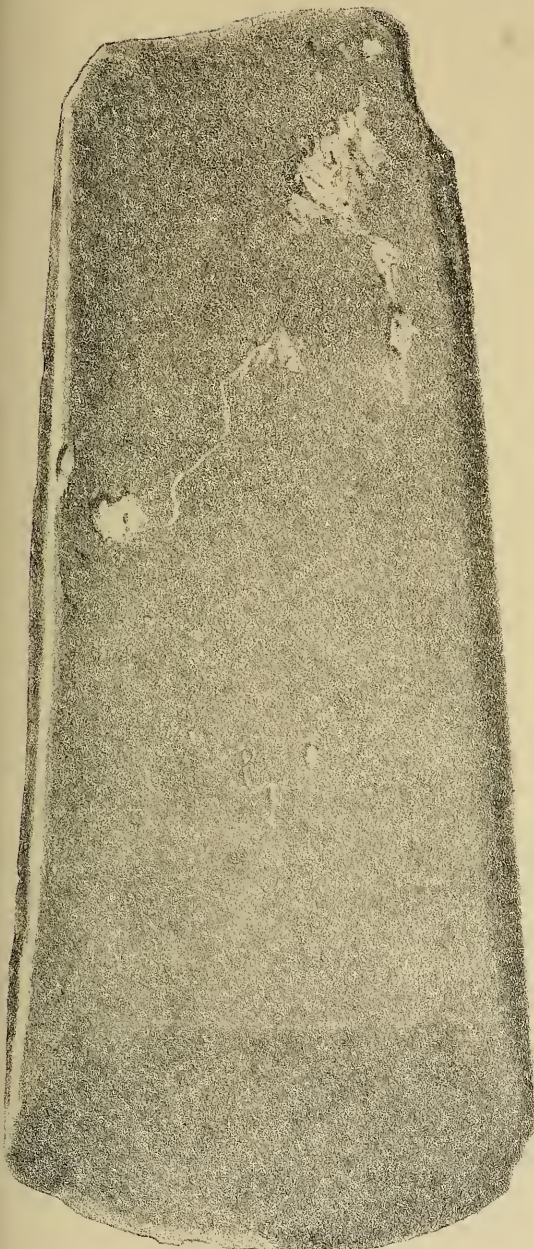

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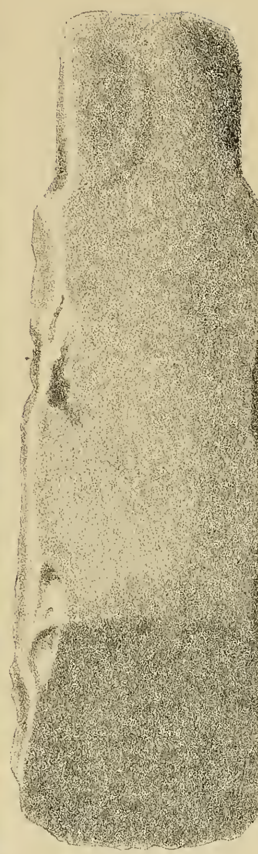
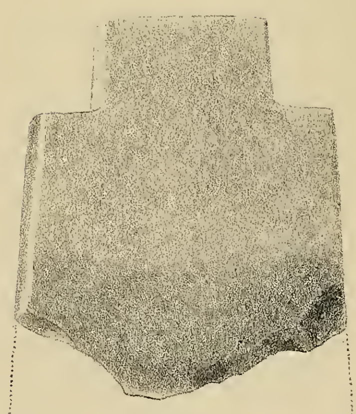


3. a.

3. b.



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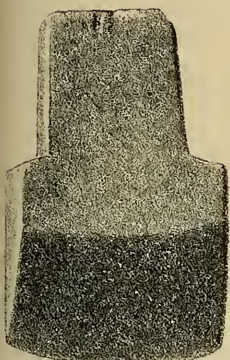

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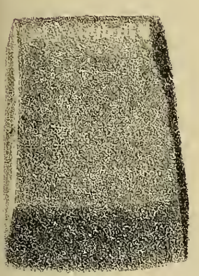

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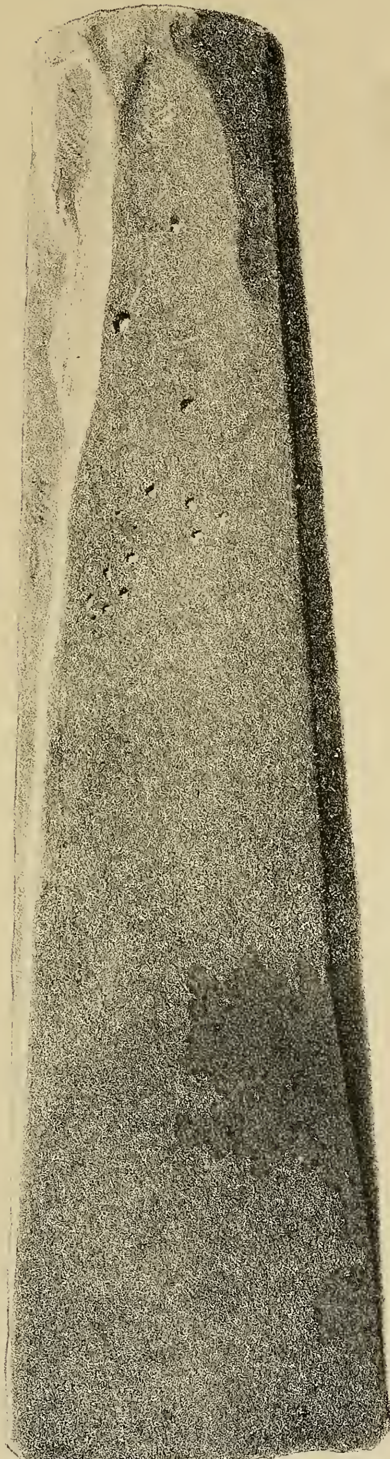

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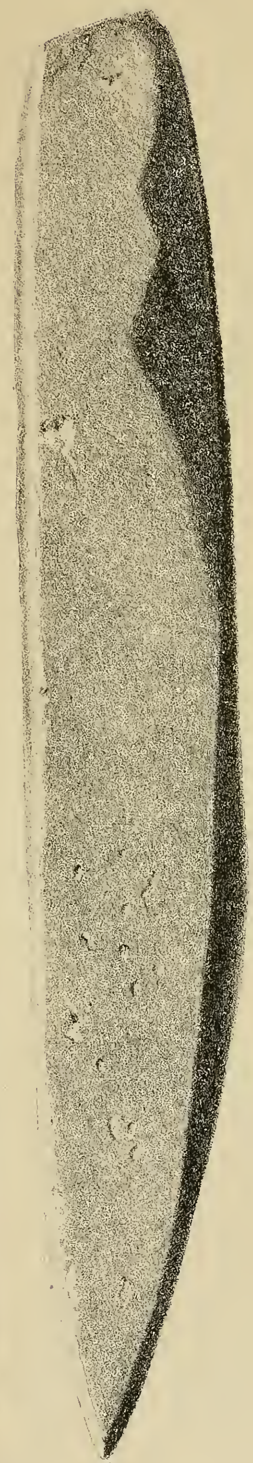

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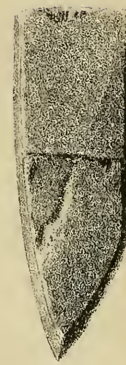

2. b.

3. b.

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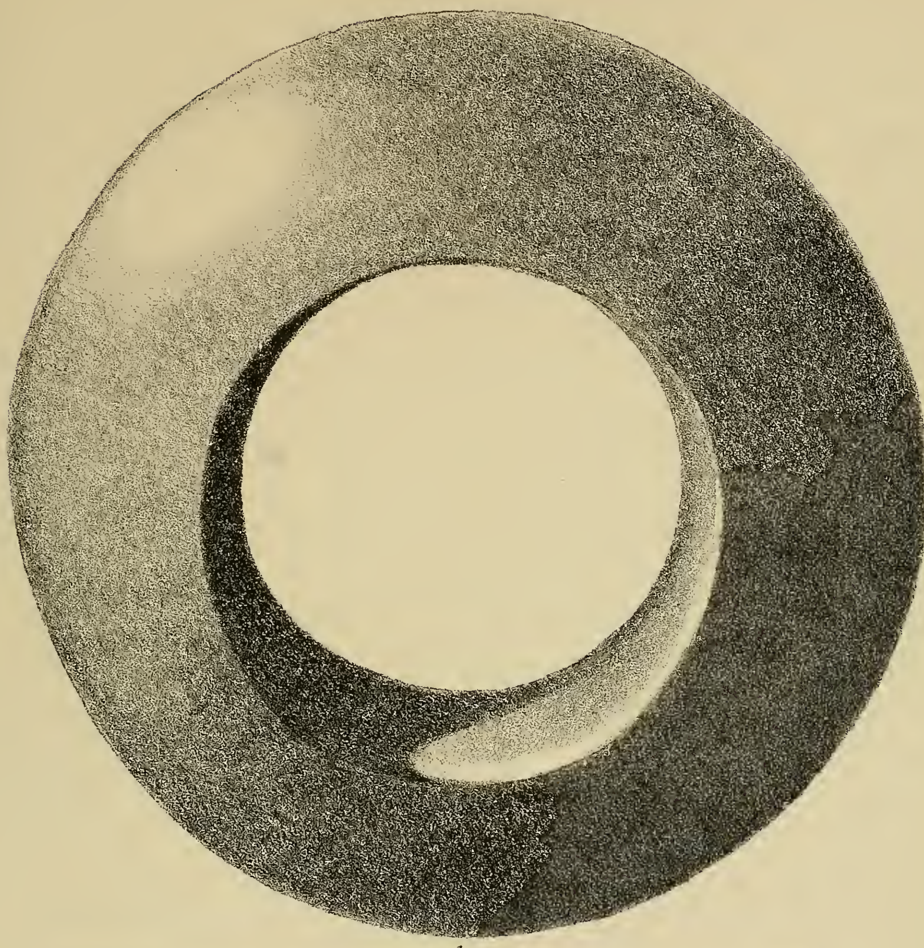

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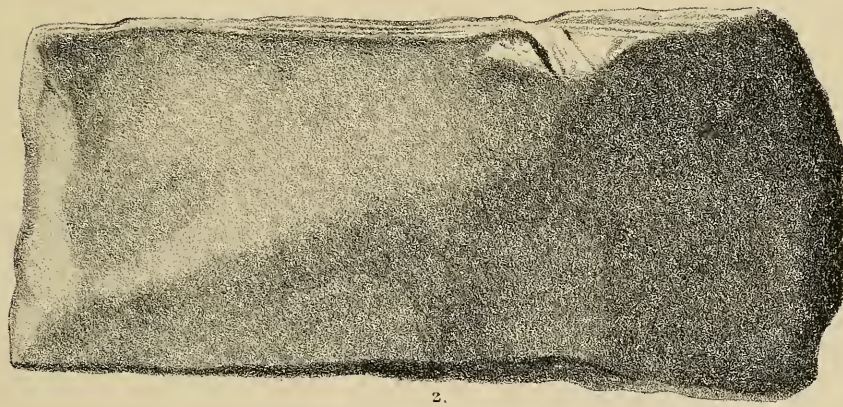

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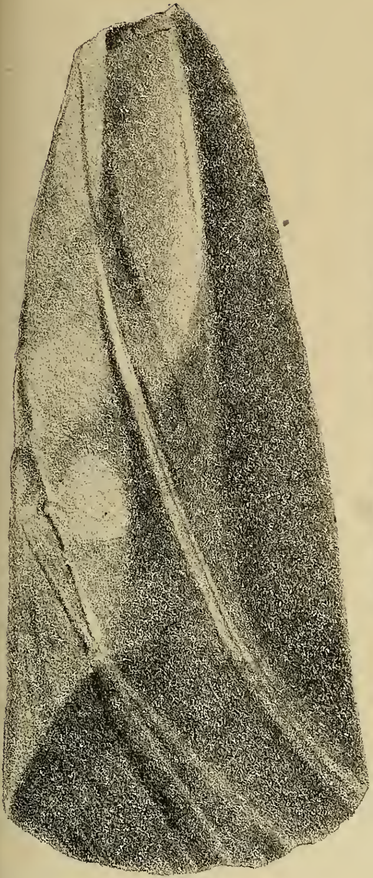
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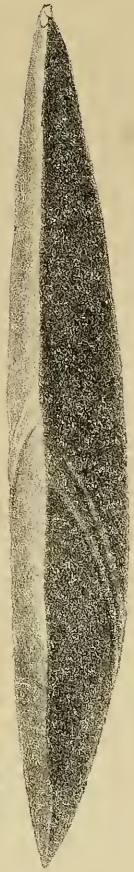
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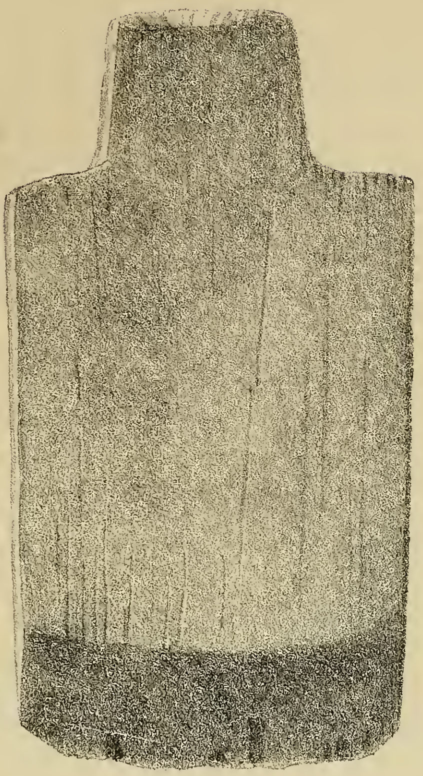
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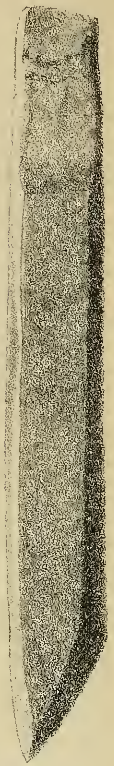
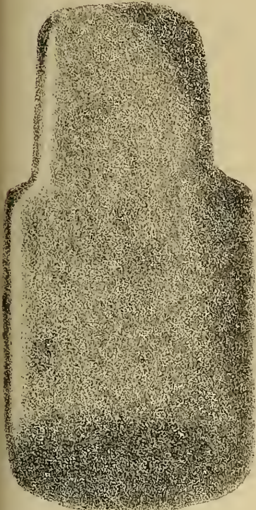

2. b


3. a.


3. b.

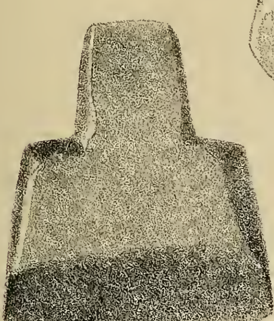

4. a.


4. b.



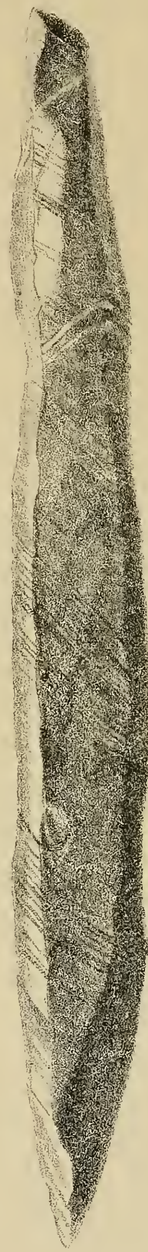
2. a

3. a.



4. a.

1. a.



1 b

2. b

3. b.

4. b

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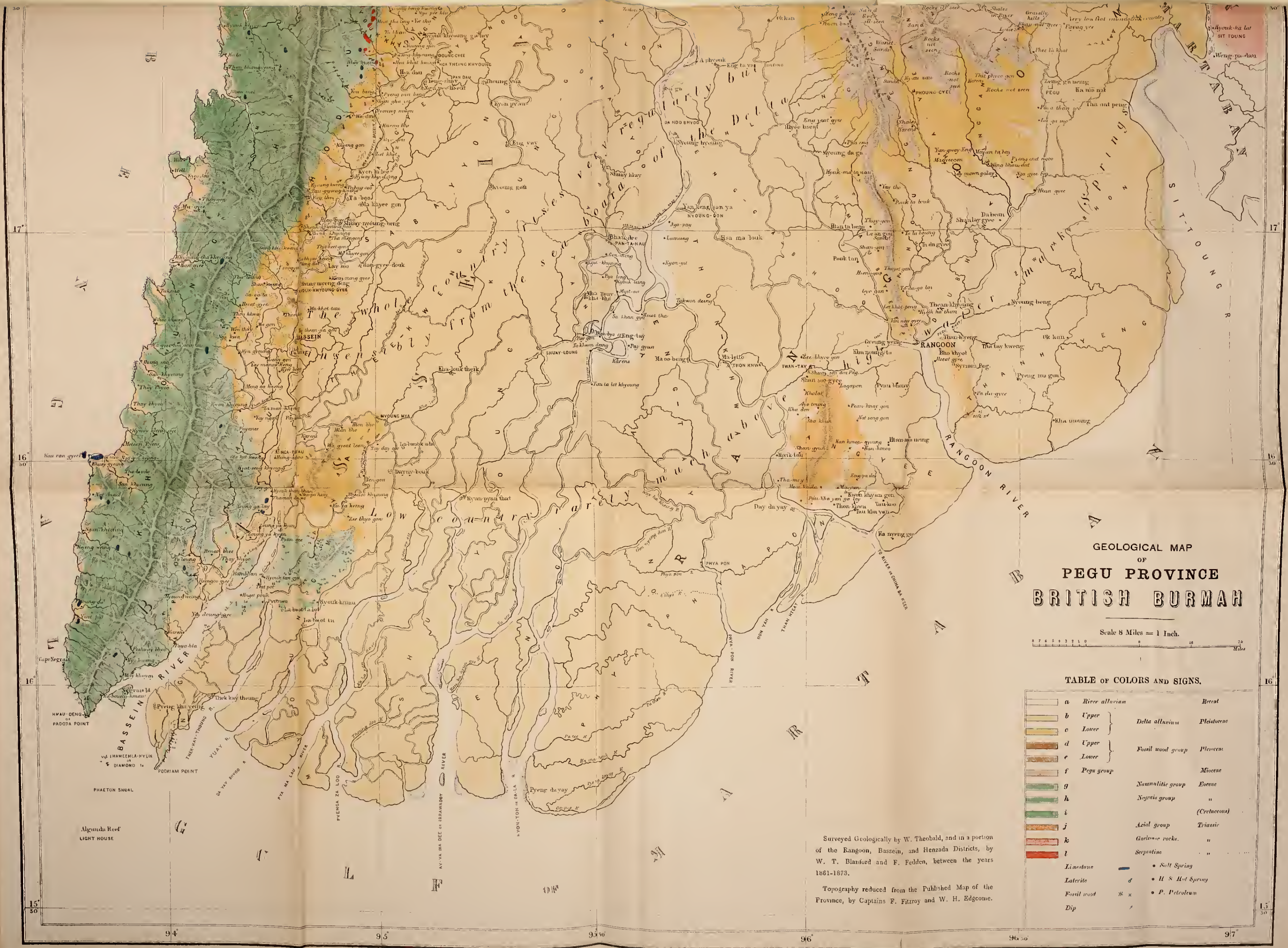
X [illegible]


PROME
TOUNG NGOO


GEOLOGICAL MAP
OF
PEGU PROVINCE
BRITISH BURMAH
Scale 8 Miles = 1 Inch.
Miles
TABLE OF COLORS AND SIGNS.
a River alluvium Recent
b Upper
c Lower
Delta alluvium Pleistocene
d Upper
e Lower
Fossil wood group Pliocene
f Pegu group Miocene
g Nummulitic group Eocene
h Negrais group "
i (Cretaceous)
j Axial group Triassic
k Gneissose rocks. "
l Serpentine "
Limestone
Laterite
Fossil wood
Dip
• Salt Spring
• H. S. Hot Spring
• P. Petroleum
Surveyed Geologically by W. Theobald, and in a portion of the Rangoon, Bassein, and Henzada Districts, by W. T. Blanford and F. Fedden, between the years 1861-1873.
Topography reduced from the Published Map of the Province, by Captains F. Fitzroy and W. H. Edgcome.
The whole country from the sea board to the Delta but very regularly above high water mark.
Low country rarely much above high water mark.
RANGOON
BASSEIN
PEGU
RANGOON RIVER
BASSEIN RIVER
SIT-TOUNG R.
AY-YA-WA-DEE or IRRAWADDY RIVER
HMAU-DENG or PAGODA POINT
Cape Negrais
Algunda Reef LIGHT HOUSE
PHAETON SHOAL
PEGU YOMA
MARTABAN
GULF OF MARTABAN
BAY OF BENGAL
17°
16°
16° 30'
15° 30'
94°
95°
95° 30'
96°
96° 30'
97°