On the GEOLOGY and FOSSILS of the NEIGHBOURHOOD of NÁGPUR, CENTRAL INDIA. By the Rev. Messrs. S. HISLOP and R. HUNTER.

[Communicated by J. C. Moore, Esq., F.G.S.]

[Read June 21, 1854*.]

(PLATE X.)

[*Note*.—A full Abstract of this Communication appeared in the Society's Journal, No. 40, p. 470 *et seq.*, in consequence of unavoidable delay in the publication of the Memoir itself.]

PART I.†

(GEOLOGY OF THE DISTRICT.)

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Physical Geography of the District.—The country to which the following paper refers is the western part of the recently acquired kingdom of Nágpur‡, lying, with the southern corner of the Ságur

* For the other Papers read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. x. p. 454 &c.

† Part II., containing the Palæontological Portions of this Communication, with Illustrations, will appear in a subsequent No. of the Journal.

‡ With regard to the spelling and pronunciation of Hindu names of places, the authors have furnished the following remarks in one of their late letters to the Assistant-Secretary:—

“Orthography in India is a very unsettled branch of learning. Those who first stereotyped in English characters the Hindu names of places were most unsuited for the work, and hence most unscientific is the system of spelling practised by the generality of our countrymen. We follow the Jonesian system, as it is adopted by such societies as the Royal Asiatic. By that every Hindu letter has an English representative, though that representative has more a continental than an English sound attached to it. The vowels are *a*, *á*, *i*, *—i*, *—u*, *ú*, *—e*, *ei*, *—o*, *ou*. They are in pairs, short and long; *a* unaccented having the sound of *u* in *but*, *á* accented the sound of *a* in *have*, *u* the sound of itself in *full*, its long being just the same sound more dwelt on, *i* the sound of English *ē* made long or short as it has accent or no accent. There is only one consonant that may occasion difficulty, that is a *d* written in italics. When so written or printed it is intended to have a sound somewhat like *r*. Thus we write *Weirágad*, whereas it is commonly written *Wyraghur*. The *gh* for *g* is just a gross mistake, which destroys the etymology of the language to a person who does not know the original Hindu name. *Silewádá*, as written by us, is usually represented *Sillewarra*.”

and Narbaddá Territories, between $78^{\circ} 15'$ and $80^{\circ} 35'$ east longitude, and $19^{\circ} 35'$ and $22^{\circ} 40'$ north latitude. It is of a triangular shape, each side extending about 180 miles. Its northern side is formed by the table-land stretching from the Mahádewa Hills on the north-west to the northern extremity of the Lánji Hills on the north-east: the south-eastern side is constituted partly by the chain last mentioned, and partly by a line drawn from its southern base to the junction of the Wein Gangá and Wardhá, which latter river marks out nearly the whole of the south-western side. (See Map, Pl. X.) The limits as thus defined enclose an area corresponding with that surveyed by Lieuts. Norris and Weston in 1826, and amounting by their calculation to 24,000 square miles.

The city of Nágpur is situated very near the centre of this area. In the northern division, where the hills are both most numerous and most elevated, the direction of the ranges is east and west. In the southern, which contains a greater extent of level country, the course they take is generally north and south.

Chourágad, the highest summit of the Mahádewa hills, and the loftiest point in our district, rises to an altitude of 4200 feet above the sea: the usual height of the range, which entering the Nágpur territory from Gáwilgad passes by Dewagad towards Siwani, is not above 2000 feet, though in the east of the same chain, where it goes under the name of the Lánji Hills, some of the peaks attain an elevation of 2300 and 2400 feet. At Nágpur the country has fallen to a level of 1000 feet. On the west, however, it immediately rises by 200 or 300 feet in a succession of eminences, which run parallel to the Dewagad range, until they reach the basin of the Wardhá, when they suddenly sink in precipitous descents as at Talegaum Ghat. Towards the east of the capital, the plain extends almost without interruption to the banks of the Wein Gangá, where the general level is about 900 feet above the sea. Still further east, on crossing the river, we find the country preserving its former flatness, except that occasionally it is diversified by ranges of hills running north and south, of which that encircling the Lake of Nawagaum is the most considerable. In the southern division of the territory there are few hills, if any, that rise above 2000 feet; while the champaign tracts, which abound on both sides of the Wein Gangá and Wardhá, fall, ere these rivers have effected the junction of their united streams with the Godávári, to 800 feet above the sea-level.

It will thus be seen that our district presents a watershed from north to south. The most important rivers which flow through it are the Kanhán from the Mahádewa Hills, which at Kámpti receives the Pech from the same upland tract, and the Kolár,—the Wardhá, which is joined by the Wanná from the hills west of Nágpur, and by the Pain Gangá from the Nizam's country,—and the Wein Gangá, the largest of all, which on its left bank is increased by the united streams of the Wág, the Son, and the Dewa, and by the Chulband, and on the right by the Kanhán and Wardhá, after its confluence with the latter of which it takes the name of the Pranhítá, and ere long discharges its waters into the Godávári.

History of the Geological Observations of the District.—The geological structure of the territory, whose extent and natural features have been thus briefly described, has for some time engaged the attention of scientific men in India. Dr. Voysey and Captain, now Colonel, Jenkins were the first who examined it. From the result of their investigations, as published in the Bengal Asiatic Society's Transactions, Part I. for 1829, it would seem that they were unsuccessful in their search for fossils. The lamented Voysey, indeed, who was the first in India to find shells in a stratum enclosed in trap, thought he had discovered, on the journey hence to Calcutta, which terminated his distinguished career, bivalves in a bed of limestone near Ráyepur within the Nágpur State, though on the east of our district*; but I have since ascertained† that the appearances, which he regarded as organic, are the consequence of the rock having been brecciated. The next observer within our field of investigation was Dr. Malcolmson, who in 1833 worthily following up Voysey's discoveries within the Nizam's dominions in 1819 and 1823, pointed out new localities for the formation in the same part of the country, and traced it into this kingdom to Chikni and Hinghanghát. At the former of these places, which is sixty miles south of the city of Nágpur, he met with *Unio Deccanensis*, *Physa Prinsepü*, *Paludina Deccanensis*, and *Melania quadrilineata*: at the latter, which is sixteen miles nearer the capital, he found an abundance of silicified wood. But though he lived in this neighbourhood for some years, he does not appear to have been aware of the existence of similar organic remains here; and, while with Voysey and Jenkins he enlarged on the *mineralogy* of Sitábaldi Hill, like them he failed to advert to the two rocks which are its most interesting features,—his own trap-imbedded stratum with *Physas* and *Melania*s towards the top, and an unfossiliferous member of the sandstone formation resting on gneiss at the bottom. In 1842 Lieut. Munro, of H.M.'s 39th Regt., brought to light in the sandstone quarries near Kámpti, nine miles N.E. of Nágpur, the impressions of ferns, which were forwarded to Malcolmson as having previously discovered the first vegetable remains in the sandstone of the Hyderabad country, by whom they were figured and described as resembling *Glossopteris Danaeoides* of Royle‡. As this species of fern is now understood to be a *Tamiopteris*, it seems likely, that the comparison of the Kámpti specimens with it was incorrect, and that they belonged to a *Glossopteris*, whose species, owing to the fragmentary state of the fronds, cannot be determined.

In 1845 I procured a few fossils of the same kind from the Kámpti sandstone, and two years subsequently my esteemed colleague the Rev. R. Hunter and myself fell in with them in the

* Beng. As. Soc. Journ. vol. xiii. p. 856.

† The first person singular here refers to Mr. Hislop, by whom the memoir is for the most part written, with the exception of the description of the Plants and Insects of the Tertiary deposits, which is from the pen of his fellow-labourer Mr. Hunter. For a previous notice of the "Geology of the Nágpur State," by the Rev. S. Hislop, see Journ. Bombay Asiat. Soc. No. 18, July 1853, p. 58, &c.—Ed.

‡ Bomb. Br. R. As. Soc. Journ. vol. i. p. 249.

contemporaneous strata of Chándá, eighty miles south of Nágpur. None of these specimens, however, were preserved, nor was anything further done by us or by others to understand the paleontology of this part of India, until June 1851, when, walking with my fellow-labourer in the neighbourhood of our residence, two or three Physas in a deposit enclosed in a trap hill about a mile west of Sitábalí, and two miles in the same direction from Nágpur, forced themselves on my notice. They were at once referred to the fossils which Voysey and Malcolmson had discovered in a similar situation, and the deposit in which they occur was identified with the freshwater formation that they had traced in several parts of the Nizam's territory, and at Chikni and Hinghanghát in this state. In a few days after, at the same spot, I found the first bone, and Mr. Hunter the first tooth; and, after a week or two, on Tákli Plain, about $2\frac{1}{2}$ miles N.W. of Nágpur, I met with the first Fruit and Entomostracan. About the same time, from observing the traces of ancient vegetation on the soft clayey sandstone, used in the absence of chalk for whitening the writing-boards in our Mission schools, I was led to make inquiries about the locality from which it was brought, which ended in the discovery of *Glossopteris* and *Phyllothea* and some seeds or seed-vessels at Bokhárá, six miles north of Nágpur. Ere long we were joined by our friend Capt. Wapshare, Judge Advocate of the Nágpur Subsidiary Force, who added many valuable vegetable remains to our collection; and it is to his able and generous efforts that we owe, among other rare acquisitions, the first palm and the first mulberry-like fruits. From the red shale of Korhádi, seven miles north of Nágpur, I procured tracks of Annelids, and more recently, in combination with them, the foot-marks of some Reptile: and towards the end of the year, in company with Lieut. Sankey of the Madras Engineers, I visited Silewádá, twelve miles north of Nágpur, where the sandstone yielded a profusion of rich and most beautiful specimens of *Glossopteris*, and whence have since been obtained a variety of Exogenous stems, several species of *Phyllothea*, and an interesting specimen, contributed by Mr. Hunter, of an allied genus, which by Lindley and Hutton is reckoned an *Equisetum*, and by Bunbury probably an *Asterophyllites**. A Mission tour, undertaken about the same time, conducted my colleague and myself past the freshwater formation at Pahádsingha, forty miles W.N.W. of Nágpur, in which was detected an abundance of fish-scales, dispersed through the stone. On our return, Mr. Hunter, among the seeds and fruits of Tákli, discovered the first specimen and the greater part of our fossil *Coleoptera*; while we received an accession to our collection of shells from Dr. J. Miller, then of the 10th Regt. M. N. I., who, while on an excursion with Dr. Fitzgerald, had found the freshwater formation at Butará near Machhaghodá, eighty miles north of Nágpur, and also from Mr. Sankey, who had fallen in with it at Pilkápahad, twenty-five miles to the north-west. The latter-named officer, after discovering in the Kámpti quarries the first *Vertebraria*, a fine species of *Phyllothea*, a long

* Quart. Journ. Geol. Soc. vol. vii. p. 189.

endogenous leaf, and an abundant kind of seed, all of which he liberally handed over to us, proceeded along with Dr. Jerdon, the Indian ornithologist, in the direction of Butará and the Mahádewa Hills*, whence they returned with several new fossils belonging to our Eastern Coal-formation, and excellent specimens of the shells previously collected by Dr. Miller, agreeing in general with those of this neighbourhood. In a portion of the Butará rock which they kindly gave me, I was struck with the appearance of a diminutive creature, which proved to be a second genus of the *Entomostraca*. Ere the first anniversary of the discovery of our earliest *Physa* had come round, several other localities had been ascertained for both the freshwater and sandstone fossils, and observations had been made on the remains of quadrupeds and shells imbedded in comparatively recent deposits. Since that, on our annual Mission tours we have become acquainted with a productive site for sandstone organisms at Mángali, sixty miles south of Nágpur, which has afforded a few unusual vegetable remains, a species of *Estheria*, scales and jaws of Fish, and the entire head of a Saurian; we have passed through districts abounding in laterite and iron-ore, and have increased our knowledge of the geological structure of the country generally.

General Geology of the District.—From the rapid survey which we have taken in the preceding historical introduction of the fossils that have been brought to light within our area, it is obvious that its palæontology, contrary to the common idea of Indian formations, is both varied and important; but, even in a lithological point of view, there are few tracts of equal extent that are worthy of more attention, and of all the portions of that interesting area, there is none for interest that can be compared with the vicinity of Nágpur,—its centre at once political, historical, and geological. We have only to take a few steps from our house and we reach the summit of Sitábalí Hill,—the scene of as heroic a conflict as ever our countrymen gained in the East. The spot on which we stand consists of nodular trap (fig. 1). At the distance of a few yards from our feet, just under the brow of the hill, is a narrow stripe of green or yellow calcareous indurated clay, which, on close inspection, is found to contain a number of decaying casts of freshwater shells. Under this we perceive a bluish-green friable rock, which hardens first into a tough amygdaloid, and then, a little above the level of the plain, down to which it is scarped by the quarrymen, into a compact greenstone. Cropping out from under the foot of the hill may be seen a bed of soft variegated sandstone, and then, according as we look east or west, the prevailing rock covering the plain beyond is either gneiss or trap.

But let us extend the prospect to the horizon. As we stand with our faces to the north, the first glance that we cast on the distant hills shows that there is a marked difference among them. Behind us, on our left, and in front we follow a long sweep of flattened summits, with here and there a valley to break the uniformity; but no sooner do we look towards the right than we descry a series of round-topped hills rising up at intervals in massive strength. These

* Quart. Journ. Geol. Soc. vol. x. p. 55.

Fig. 1.—Section through Sitábádi Hill.

flattened summits are the tops of trap-hills, which stretch, in the form we see, from our present position to the coast of the Arabian Sea; and these massive eminences are granitic hills which rise up in the manner that meets our eye, at various distances from each other, from the place where we stand to the Bay of Bengal. The intermediate hills and plains, which in front fill up the foreground, are formed of the dolomite and shale of Korhádi, and the sandstone of the basins of the Kanhán and Kolár.

From our elevated station we are thus enabled to command a prospect of twenty miles in every direction, and the formations that we can trace within that range make up an exact miniature of the geology of our whole area. Nay, were we to go down the hill and walk around its base, in the descent and circuit, which might all be accomplished in twenty minutes, we should meet with almost every rock that is to be found between Bombay and Katták.

The geology of our area must at one time have been extremely simple. Its principal feature was then sandstone, associated with shale and limestone. But now other two formations are discovered on the arena, and these seem on the surface as if they had been two huge icebergs, which approached each other in frightful collision, crushing the sandstone between them, and allowing the fragments to slide out at either end, and scattering them here and there over their own bulk. Or, to speak in language more precise, the sandstone formation, which once occupied the whole space that we have chosen for description, is now covered up by trap on the west, and broken up by granite on the east, leaving only a small diagonal stripe running through the centre, which, after being interrupted at the north-west and south-east, increases in these directions to a broad expanse, while a few detached portions, formerly continuous with it, appear in the body of the trap and granite. It is the juxtaposition of trap, sandstone,

and granite in this neighbourhood which invests the geology of Nágpur with special importance, and which, when investigated by competent observers, may shed a flood of light some future day upon Indian geology in general.

Trap Rocks of the District.—The greater part of the trap within our area lies in the west in the shape of a parallelogram, one of whose corners has been encroached on by a projecting portion of Berár and the Betul district of the Sagar and Narbaddá territories. Its greatest length is 120 miles, and its breadth is from fifty to sixty. Its south-western side, on which the irregularity of figure is found, and by which it joins on to the great sheet of basalt in the Dakhan, is formed by the Wardhá. Its south-eastern side, commencing from Suit on that river, crosses the road from Nágpur to Chándá on the south of Chikni, and, passing by the north of the Mángali fossiliferous quarry, extends to Sákra and Bhiwákund, after which it coincides very nearly with the political division between the Súbás (provinces) of Nágpur and Chándá, which stretches by Lingá, Jángaum, and A'lasur Hills to the north-west of Bhísi. Here begins its north-east side, which skirts the small patches of sandstone on the west of Umret and Kuhi, and, running close by the city of Nágpur, meets with an eruption of granite, and then touches the sandstone basin of the Kanhán and Kolár, after which it again encounters plutonic rocks on its passage up the right bank of the Kanhán to Dewagad. At this ancient Gond fortress, the upland tract of Multái, which constitutes the north-west side, joins that last described, and completes the parallelogram.

In addition to this, the main body of trap within our area, and connected with it, there is a smaller development of the same formation in the north. Stretching south and east from Dewagad, it fills up the space between the Kanhán and the Pech, and, sweeping westward round the granite at Chindwádá, and eastward by way of the summit of Kurai Ghát to Siwani and Chapará, it merges, along with the Mathur range of hills, in the basaltic district that extends to the Narbaddá at Jabbalpur.

The above is, I believe, all the overlying trap within our area, with the exception of one or two isolated portions south-east from Suit, near Warodá and the confluence of the Páin Gangá with the Wardhá.

Granitic and schistose rocks.—The plutonic and metamorphic formation, the extent of which I shall now briefly indicate, lies chiefly in the eastern portion of our area. It is intersected by the Wein Gangá for the greater part of its course. The tract on the left bank of the river I have had little opportunity of exploring; but, from the cursory examination I have given it, I have reason to believe that granite and its allied rocks are there very largely developed, being only occasionally diversified by patches of sandstone and variegated shales, among which red shales predominate. On the right bank of the Wein Gangá, in the district near its junction with the Wardhá, the extent of the formation is not so great. It is observed principally in the channel of the Wein Gangá, though it may also be traced around the bases of the sandstone chains of hills, which it has been

the means of upheaving. In both the districts under consideration the general strike of the strata is N. & S., corresponding with the direction of the streams and mountain-ranges, and in that last mentioned the dip is for the most part to the west. But it is on the north that the greatest development of granite and crystalline schists occurs. There we may perceive these rocks rising to the surface (though it would be hazardous to conclude that there are not others of a different character in the hollows covered up by the deep soil) from Nágpur north-eastward to the Lánji Hills,—a distance equal to the length of our trappean parallelogram, and with a breadth in proportion. This second parallelogram is applied perpendicularly, but unequally, to that previously described. Near the line of contact, *i. e.* in the district near Nágpur, the gneiss and other metamorphic rocks, like the hills and tributaries of the Wein Gangá, which run through it, had uniformly an east and west direction, with veins of the massive rock penetrating them at right angles to the strike.

This is the case with the crystalline formation north of the Kámpti quarries, which has communicated to the sandstone strata there and at Silewádá a southerly dip. As the granitic eruption, however, is traced up the basin of the Kanhán, it is seen to bend round a little, and to give a westerly inclination to the sandstone at Bábulkheḍa, Tondakheiri, and Adássá. From the last-mentioned place it proceeds northwards past Sánér and Kelod, in a narrow stripe on both sides of the Kanhán up to Dewagaḍ. Beyond this we find it rising up around Chindwádá, and running west into the shaly beds of Jám-wahi and Hardágaḍ. But returning to the neighbourhood of Nágpur, we discover parallel to the great body of the granitic formation on the north of Kámpti a range of quartz hills running in the line of the strata westward from Wáregaum to Gumtára. The plutonic force, which has tilted up these, has greatly disturbed the limestone rocks at Korhádi, and given to the sandstone at Bokhára, on the south of the Kolár, the same dip as we observe at Silewádá and Kámpti on the north of that river.

Sandstone.—But let us now refer to the sandstone formation, which I have said exists in the central parts of our area, though only the wreck of what it once was. Its upper member, reduced in thickness by metamorphic agency, may be observed horizontally entering the trap-hill of Sitábaldí on the east side, and again emerging on the west. It is then wholly displaced by gneiss and granite towards the Nág River, after which it again becomes the surface rock for a short distance to the west, until it is a second time overlaid by trap. It remains thus concealed for sixteen miles, when it is seen on the north-west of Yahár at Nimji, whence it extends to Sátawari on the south-west and Kotwalbaḍi on the north-west. At these villages it is a third time covered up by trap, nor does it in that direction rise again to the surface within our area, or indeed, I believe, anywhere beyond it. The division of this formation which proceeds to the north of Nágpur occupies a part of the basins of the Kanhán and Kolár from Kámpti on the south-west to Kelod on the north-west, being about thirty miles long and twelve broad. Its north-eastern border touches

the great granitic tract, which stretches from Nágpur to the Lánji Hills, while its south-western boundary is constituted by the trap, surrounded by which two of its detached portions are found at Kutkheiri and Chorkheiri, near the source of the Kolár. Were we to follow the direction of these outliers, they would lead us to the sandstone hills beyond our area, that skirt the southern side of the trap chain of Gáwilgaḍ, north of Elichpur. But if we suppose the sandstone continued north-west in the line of the Kanhán's course, we arrive, after crossing some miles of trap and granite, at the beds of carbonaceous and clayey shales, which, running under the trap-range of Mathur, appear on the north side, and form the base of the lofty development of sandstone at the Mahádewas. The largest body of this formation, however, lies to the S. in the basin of the Wardhá and Pranhítá, extending, with only a few slight intrusions of plutonic rocks at Segaum and the north-west of Chándá, and some outliers of trap indicated on the map, from the termination of the basaltic effusion at Jámgau Hill and Suit, south-west into the Nizam's country by Kotá, until within a short distance of Badráchellam.

A very marked feature in the geology of the country between the Iri and the Wein Gangá is the occurrence of ranges of sandstone-hills, running for the most part north and south, corresponding in general direction with ranges of the same formation in the district of Kotá, described by Dr. Bell*. These hills, where they have fallen under my observation, rise from plains of plutonic rocks, by which the strata have been indurated and elevated, though still retaining their horizontal position. Such are the flat-topped chain which stretches on the east of Segaum, and that which terminates in the castle-like bluff of Perzágaḍ. On either side of the Wein Gangá we meet with some isolated remnants of the sandstone formation. One of these, but very limited in its dimensions, lies on the banks of the Selári, a small stream which joins the Wein Gangá near the town of Pawani. Another farther down the river extends for some distance, first on the right bank and then on the left. In the district on the east of the Wein Gangá, a little sandstone proper is met with at Koká to the north-east of Bandará, and on the banks of the Wág River near Ámbgaum, and on the east side of the Nawagaum Lake, from which it extends south as far as Mahágaum; while on the west of the lake there is an abundance of shale, which is also seen to cross the road from Nágpur to Ráyepur at Mundipár Ghát and Jamnápúr near Sákoralí. These argillaceous strata, which are red, green, and as partly at Mundipár even white, seem to be the same as the fossiliferous laminated clays at Korhádi. In addition to the dolomitic strata at Korhádi mentioned above, there are eminences of the same crystalline limestone running eastward among plutonic rocks from the Pech, on the west bank of which river higher up there is a small patch found along with a little outcrop of sandstone at Dudhgaum, surrounded by trap.

Laterite, &c.—In various parts of our area we meet with beds of laterite, covering the rocks already described. I have not found it

* Quart. Journ. Geol. Soc. vol. viii. p. 230.

on the west of Nagpur; but it is seen abundantly within the trap-district at Ságár N. of Dudhgaum, and at Pándarataláw S.W. of Umred. At Karanlá, E. of the same town, it overlies plutonic rocks, and from Pawani on the Wein Gangá it stretches in a broad belt sometimes over sandstone and at other times over gneiss and granite towards Weiragá. South and west of this throughout all the province of Chándá it occurs more or less. I have already mentioned the fact of its resting on dolomite at A'mbágiri. At Máhonda on the Kanhán, straight east from Nagpur,—at Dharmapuri and Karbi in the basin of the Sur River, which flows from Rámtek into the Wein Gangá,—and again in the neighbourhood of Chándpur further up the Wein Gangá, the same formation is presented to view. But it is on the east bank of the river that its most extensive development is witnessed. Crossing the Ráyepur road at several places it unites on the north of it to form extensive tracts in the district of Lánji, and all around Hattá and Kámtá.

The superficial deposits that are superior to laterite are either red or black. The former is found in general where plutonic rocks, sandstone, or laterite prevail, though instances are not rare of the latter being met with in such situations. The “regur,” or black soil, occurs almost universally where trap abounds.

Description of the Strata.—Having thus given some account of the extent of the formations within our area, as they appear on the surface, I shall now endeavour to point out in a descending order their thickness, nature, contents fossil or mineral, as the case may be, and age.

I. Superficial Formations.

1. *Black Soil or Regur.*—The regur is of no great depth in this district, seldom if ever exceeding 20 feet. In some places, as at Tákli village, it is seen to overlie a stratum of brown tenacious clay, which, like itself, is much mixed with “kunker.” I have not succeeded in finding any organic remains in the regur except bones of oxen and sheep, of very doubtful antiquity.

2. *Red Soil.*—The red soil in our area is of greater depth than the black, frequently displaying a section of 50 feet. Like it, it seems to rest on a brown calcareous clay, at the bottom of which there is in general a layer of conglomerate. In river-basins it alternates with layers of loose sand and gravel, often imbedding existing fluvial shells of the genera *Melania*, *Cyrena*, and *Unio*. In the district west of Nágpur, the rivers often expose a bed of sand and gravel cemented by a small quantity of lime, and in its consolidated state furnishing blocks of sandstone or conglomerate two or three feet thick. This stratum for the most part is unfossiliferous, but near the Kolár, about ten miles north of Nágpur, there occurs in it an abundance of *Paludina*, *Melania*, and *Cyrena*, which, though belonging to existing species, from the nature of the matrix have been much altered since the period of their deposition. Of some the cavities are simply filled with siliceous and calcareous matter, but in

the greater number of instances the shell has been completely absorbed, and employed as a cement in aggregating the particles of the rock. A similar deposit is seen at Nágálwada near Elichpur, to the west of our area ; but there, in addition to the fossils just mentioned, it includes *Limnæus*, *Planorbis*, and *Unio*. On the banks of the Sarpan River, near Tondakheiri, 14 miles N.W. of Nágpur, there is an accumulation of the freshwater shells previously enumerated, with a considerable intermixture of a species of *Bithinia* and a few specimens of land shells—*Helix* and *Bulimus*. Mingled with these remains of *Mollusca*, there was a quantity of jaws, vertebræ, and other portions of *Mammalia*, which were not much petrified ; but, I regret to say, they were accidentally destroyed before they could be examined*. In the bank of the Kanhán at Kámpti about 45 feet under the general surface I found the shoulder-bone of some mammifer, much increased in weight from the process of petrification. Bones in the same state have been discovered lying above ground, between Nágpur and Kámpti, which must have been washed out of the kankaraceous red soil.

Judging from the relation of the regur and red soil to the brown clay, I am inclined to regard these two formations as contemporaneous ; and, from the evidence of the fossils contained in the latter, I would class both as Post Pliocene.

II. The *Brown Clay*, on which I have said both the red and black superficial deposits rest, averages, together with its underlying *Conglomerate*, a depth of 20 feet. The clay is not known to be fossiliferous, but in Tákli Plain there were found in the conglomerate apparently the tusks of a large mammal, which had been completely converted into stone, but they were so much affected by the weather as to fall to pieces on being removed. The formation containing them, I suppose, should be assigned to the Newer Pliocene, and will rank with similar deposits at Jabbalpur and elsewhere.

III. *Laterite*.—This formation seldom exceeds 10 feet in depth anywhere in our area. No fossils have yet been discovered in it here, but diamond-mines have been opened in it east of Nágpur. Malcolmson †, and after him Newbold, inferred the identity of the sandstone of Central with that of Southern India, from the existence of diamonds at Weirágad, a town about 80 miles S.E. of the capital. The inference, however, is drawn from erroneous premises, which would have been corrected, had these authors personally visited the spot. At Weirágad there is no sandstone near the diamond-mines ; the only rock in the vicinity is quartzose and metamorphic. It has been too much taken for granted, in my opinion, that the diamond-conglomerate of Southern India is connected with the sandstone, within tracts of which it is sometimes found ; and hence the arenaceous strata of the Peninsula have actually come to be

* Some fragmentary bones, from the banks of the Sarpan, imbedded in a sandy earth and associated with numbers of *Melania*, *Paludina*, and *Unio*, form part of the series of organic remains forwarded by Messrs. Hislop and Hunter. The bones, having been kindly examined by Prof. Owen, prove to have belonged to Ruminants of two sizes,—such as a Buffalo and a small Antelope.—ED.

† Bomb. Br. R. As. Soc. Jour. vol. i. p. 250.

designated by the name of diamond-sandstone. Now, although the diamond-conglomerate has been found reposing on sandstone beds, yet there is no instance, that I am aware of, of the diamond having been extracted from any one of them; nor are there any data to prove that the conglomerate derived most of its materials from that source. On the contrary, Heyne * has shown that the pebbles at Kondápetta and Ovalampalli, near Kaddápá, are chiefly of chert and jasper-basalt, quartz, hornblende, and felspar. The first two have evidently been derived from the limestone of the neighbourhood, and the rest from igneous rocks. And these pebbles are not contained in a paste of sand, but, according to Heyne, of clay †. It is true the diamond-conglomerate may in one place overlie sandstone; but in another place, as at Kondápettá, it may rest upon limestone, while in a third, as at Bejwádá, near Másulipatam, according to the statement of Captain Newbold, it may be found immediately above gneiss ‡. In short, I am inclined to concur in the verdict long ago pronounced by that experienced Indian observer, Dr. Heyne, when he remarked, "All the diamond-mines which I have seen can be considered as nothing else than alluvial soil" (superficial deposit). But if the matrix of the diamond be a surface-deposit overlying several rocks, I can perceive no propriety in attaching its name to one of these more than another. The matrix at Weirágad is a lateritic grit, and it is worthy of notice, that wherever the precious gem is sought for, whether in India or Brazil, there for the most part oxide of iron is diffused.

Having myself met with no fossil in this formation, I have nothing to offer by way of determining its precise age, but would content myself with remarking, that it must be posterior to the overlying trap, on which it is found occasionally, though in our district very rarely, to rest.

IV. V. and VI. *Trap and its enclosed sedimentary Formation.*—The next rock to Laterite in order of downward succession is the overlying trap, with which, however, for the sake of perspicuity it will be necessary to combine the freshwater formation previously alluded to and the underlying trap.

Trap, it was before stated, is the prevailing formation in the west of our area; but when that assertion was made, it was understood that this volcanic rock is of two kinds,—one overlying, and the other underlying,—and that between these two, and therefore seldom exposed to view, there is for the most part found an aqueous deposit. All three generally occur together. The exceptions are met with in the plains, on the outskirts of the trap-formation, where we not unfrequently observe the usually enclosed stratum resting immediately on sandstone without the presence of either the upper or lower basalt. In some of these instances it is probable that the overlying rock has been removed, and cases occur of its remaining where no underlying trap has ever existed. On the other hand, there are examples in similar border-localities of a single sheet

* Tracts on India, p. 97.

† *Ibid.* pp. 96 and 105.

‡ R. As. Soc. Jour. vol. viii. p. 245.

of trap extending over sandstone without being associated with a second sedimentary formation or volcanic effusion.

Though the three formations are generally connected with each other, yet it is chiefly the upper one, viz. the overlying trap, that meets the eye over the face of the country. Leaving out of consideration the very few examples of denudation which have uncovered the freshwater deposit in the plains, and the equally rare instances of eruption which have there upheaved it on its edge, it is on the escarpments of the table-lands that we may be said to gain our whole knowledge of this department of Nágpur geology. In commencing our ascent of these steep hills, our attention is attracted by a number of blocks near the foot, which are easily distinguished from the masses of basalt among which they have fallen from above. As we make our way up over the hard, dark, vesicular rock, the blocks increase in number until we come to a friable greyish or bluish-green zone. We must now move slowly and look narrowly, for a few yards of upward progress may conduct us from the soft amygdaloid, where fragments are thickly strewed, to a nodular basalt, where not a trace of them is to be seen. Occasionally the freshwater formation is so thin that a very little earth or herbage may suffice to hide it from our sight. But generally the water from the brow of the hill in the monsoon collects into little rills just at the place where it leaves the nodular trap, and having now gathered enough of strength to make an impression on intervening barriers, it proceeds to plough up the soft deposit, and the still softer subjacent amygdaloid, leaving an interval between each streamlet, like a talus resting on the harder vesicular rock below (see fig. 2). The thickness of the overlying trap on Sítábalí Hill and the tabulated summits in its immediate vicinity is from 15 to 20 feet, which agrees very exactly with the

Fig. 2.—*Sectional View of one of the Trap Hills near Nágpur.*

thickness assigned to it by Dr. Voysey at Jillan. On the Western Ghats, however, according to Colonel Sykes, a stratum of earthy jasper, which is just our freshwater deposit, was found near Junar under a thickness of from 300 to 600 feet of basalt*. But it not unfrequently happens, that in leaving the plain and climbing up a

* Trans. Geol. Soc. 2 ser. vol. iv. p. 419.

trappean hill we may come upon the freshwater deposit at three distinct elevations. There is first the stratum which underlies the nodular trap generally throughout the plain, and which may be seen sometimes laid bare at the commencement of the ascent ;—then, after passing over hard and soft amygdaloid, we come to another bed, overlaid by nodular trap ; on gaining the top of this we reach a terrace, which conducts us to another ascent, where we find ere mounting to the summit a repetition of amygdaloid, sedimentary rock, and globular basalt. An example of this occurs at the hill of *Gidad*, 40 miles S. from *Nágpur*, the top of which has been

Fig. 3.—Section of *Gidad Hill*.

- a.* Freshwater deposit, as seen in the plain, of a white colour.
- b.* Freshwater deposit, of red colour, under the terrace.
- c.* Freshwater deposit higher up, brownish green in colour.

appropriated by the disciples of a Musalman saint, named Shek Farid, to a mendicant establishment, which is supported by the donations of Hindus and Muhámmadans alike, from all parts of the *Nágpur* territory. See the accompanying section of the hill from east to west (fig. 3), where *a* is the deposit in the plain, white ; *b* the same stratum of a red colour under the terrace ; and *c* a repetition of it higher up, brownish green. Whether there was a fourth stratum above *c*, the quantity of brushwood and want of time prevented me from observing. That all these strata are one and the same, though they differ in hue, I have no doubt. When we become acquainted with the changeableness of this deposit within a space of a few yards, its different phases on the eastern declivity of *Gidad Hill* occasion no difficulty. Near *Kátol*, 40 miles N.W. from *Nágpur*, a similar appearance is presented. There a thick stratum of red clay lies at the foot of the hill, and we see its tendency to slope upwards and lean against the ascent ; but we leave it behind, and come upon the amygdaloid, which emerges from under it. The amygdaloid is overlaid by a bed of red clay, which is surmounted by nodular trap constituting a terrace. Above this, before we reach the summit, we meet with a succession of amygdaloid, red clay, and nodular trap again. In ascending the ghat to *Gawilgad Fort*, which however is beyond the limits of our map, the same thing may be observed. The slope is so steep, that the road is carried in a winding direction up its face, and, although there are no terraces, yet, if I remember

right, the traveller comes upon one deposit, which is there of a deep red clay as at Kátol, three or four times successively.

From the remarks now made it will be inferred, that the stratum in question is extremely varied. Not only is it of all colours and all mixtures of tints, but it is of all kinds of substance, and all forms of structure. At one place it is calcareous, at another siliceous, at a third clayey, and at a fourth a compound of all three. Here it is soft, and there indurated; frequently the upper layer, which is next the overlying trap, is hardened, while the lower part remains unchanged. Here it is crystalline, there cherty, and elsewhere scoriaceous. In one spot it is full of fossils, in another and neighbouring locality it is utterly devoid of all traces of ancient life. In one part of a hill we see it six feet thick, but as we follow its line along the face of the escarpment we may witness its reduction to little more than an inch. I know not one constant feature that is characteristic of it. In judging of its identity a very useful guide to follow is its position between the nodular trap above and the vesicular trap below; but even this, as we have seen, fails us on the outskirts of the formation. Extensive experience, that enables us to combine several criterions that would singly be insufficient, is here, as in so many other cases, the only sure help towards arriving at a correct decision.

The greatest depth of the underlying trap, from its lower part being generally concealed, it is impossible to ascertain. It is obvious that according to its greater or less development the plain rises into a gentle swell or increases to the dimensions of a hill. Near Tákli, at the spot where almost all the fruits have been discovered, it is only a few inches thick, and a few yards from that locality it thins out altogether; whereas at Sítábalði Hill, where it is observed to rest on sandstone, it attains a thickness of 100 feet; and in hills where its superposition on the sedimentary rock cannot be seen it must be a great deal thicker.

I have been thus minute on the appearances exhibited by the overlying and underlying trap and the deposit enclosed by them, in order that we may have a clear idea of their relation to each other. The conclusions to be derived from my description I need scarcely indicate. It is quite evident, that before either of the volcanic rocks was poured out in our area there had been deposited on the sandstone a stratum which must have been at least six feet thick. Over this there was spread a molten mass of lava, which hardened the surface of the stratum, and itself cooled into a flat sheet of globular basalt about 20 feet thick. After a period of repose the internal fires again become active, and discharge another effusion, which insinuates itself between the sandstone and the superior deposit; and accumulating in some parts more than in others, through force of tension ruptures the superincumbent mass, tilting up the stratum and scattering the overlying trap, or raising both stratum and trap above the level of the plain, either leaves it a flat-topped hill, or with boiling surge pushes up its summit gradually or by fitful effort. In these convulsions, the more recent trap, where it has not tilted up

the deposit altogether, has generally encroached upon it, entangling some of its fragments, converting the greater portion of it into a crumbling vesicular rock, or producing miniature outliers of amygdaloid from materials susceptible of the change.

[*Fossils*.—As the detailed description of the fossils of this Tertiary formation and of the older Sandstone series will form the subject of Part II. of this Memoir, and be published hereafter, the fossils of the fresh-water deposit are here merely referred to in short.

From the collections made by Messrs. Hislop and Hunter and their friends from this deposit*, the authors mention the following organic remains :—

Small bones, probably reptilian.

Remains of a freshwater tortoise.

Fish-scales, both Cycloid and Ganoid, in great numbers.

Insects, found at Tákli : Mr. Hunter enumerates about ten species of *Coleoptera*.

Entomostracans ; five or six species of *Cypris*.

Mollusca, land and freshwater, in great numbers. The following genera are enumerated :—

Bulimus.

Melania.

Limnæus.

Succinea.

Paludina.

Unio.

Physa.

Valvata.

Plant-remains : Mr. Hunter enumerates—

Fruits and seeds, about fifty species.

Leaves, exogenous, six forms.

—, endogenous, three or four.

Stems, exogenous, few species ; some specimens 6 feet in girth.

—, endogenous.

Roots, six or seven kinds.

Chara, seed-vessels.

In concluding his notice of the Tertiary insects and plants, Mr. Hunter observes :—

Before quitting this part of the subject, it may be observed, that it would not be difficult to conceive with some degree of accuracy the nature of the locality in which the fruits grew. Going back to the tertiary epoch, we find Tákli part of a lake, extensive enough to be bounded at least on the west and south, and probably on all sides, by the horizon. We assume rather than can demonstrate the existence of islands, which break the uniformity of the sea-like expanse of waters. On the higher land of these are forests, mainly of exogenous trees, some approaching 6 feet in girth. More scattered, but yet sufficiently numerous to attract notice, are palms, exhibiting

* An extensive series of organic remains and of rock-specimens from the superficial deposits, the tertiary beds, the fossiliferous sandstone and shales, and from the crystalline rocks, has been presented to the Society by the Authors of this memoir. The fossils, however, have not yet been fully worked out.—Ed.

on their stems, when closely examined, protuberances of aerial roots, similar to those so frequently observed on the Wild Date of India. In the more shady valleys are leguminous and other plants, in great variety and profusion; and there may be seen occasionally climbing by numerous tendrils over the bushes, a cucurbitaceous plant allied to the *Luffa*, its tender stalk weighed down by a ponderous and probably 10-angled fruit. The *Nipadites* here and there fringes the marshy shores; and wherever the water is shallow there rise above it the reedy peduncles of Aroid plants, terminated at one season of the year by spikes of flowers, and at another either by long succulent purple fruit, resembling mulberries, or by large pericarps, that without minute examination might be mistaken for cones.]

Age of the Freshwater Deposit.—It has already been shown by my esteemed colleague, in his concluding observations on the tertiary plants (see above), that the body of water in which the strata containing the above-enumerated fossils were deposited must have been a lake. I shall now inquire at what period that lake existed. The determination of this question is attended with peculiar difficulties. In a temperate climate like Britain, the discovery of a large number of organisms fitted for a tropical abode at once demonstrates that the rock in which they occur cannot have been deposited subsequently to a remote tertiary period. Here, however, where we have a tropical heat at the present day, the evidence derived from such a source is much more equivocal.

Still I think there are sufficient dissimilarities between our recent and fossil floras to prove the great antiquity of the latter. While there is a general resemblance between the two, inasmuch as *Hedy-sarææ*, *Cassia*, *Luffa*, and *Nipa* are comprehended in both, there may be remarked on the other hand the total extinction of two genera, if not an order of endogenous plants, that once flourished luxuriantly here,—I refer to the mulberry-like and strobiliform fruits, which, though formerly so abundant, have at present no representative either in India, or so far as I know, throughout the world. We must therefore direct our thoughts to some period comparatively remote, when there was a greater uniformity of temperature over all parts of the earth. Of the more ancient tertiary floras, none corresponds with ours so well as that of the London Clay of Sheppey and Belgium. In both of these localities we find *Nipadites*, and in the former also the *Xylinosprionites* and *Tricarpellites* of Bowerbank, fruits apparently allied to those found at Nagpur.

Of all the animal remains we have collected, scarcely one seems to be identical with forms now existing on the surface of the globe. The nearest approximation to specific identity is in one of the *Cyprides*, and in the minute discoid *Valvata*; but whether the identity is complete, I am not competent to say. Supposing, however, that it were proved to be so, this fact would merely show that of all the living tribes inhabiting the waters, or the margin of our old-world lake, not one has survived in India, except a single species of *Cypris*, for the *Valvata minuta* is not now found here, nor indeed does any species of that genus appear to occur throughout Asia. But with these most

diminutive exceptions, if exceptions they are to be called, the statement holds good that between our ancient and our modern fauna the agreement is not closer than generic. In the class of fishes, the resemblance even to that extent is true only of one order,—the Cycloidans; while the other order, the Ganoidans, which have left their horny and bony scales so abundantly in our rocks, have entirely disappeared from our rivers and tanks. Of the class Mollusca, while the genera *Planorbis* and *Ampullaria*, now so common in our pools, are altogether absent from this deposit, *Valvata* and *Physa*, so extensively represented in it, both in species and individuals, have disappeared from the plains of Central and Southern India. Of the six genera *Melania*, *Paludina*, *Limnæus*, *Bulinus*, *Succinea*, and *Unio*, which are common to both ancient and modern India, the differences between the recent and fossil species, especially in the *Paludina* and *Limnæus*, are very great. Of the former, we have nothing at all so large as the *P. Bengalensis* of the East, or even the *P. vivipara* of Britain. In the latter genus, none of our species appear to have belonged to the inflated type, but they are generally more on the model of the *L. glaber*, than that of the *L. stagnalis* of our native country.

Combining then these facts, on the one hand we have the total dissimilarity between every species of our ancient and modern plants,—the disappearance from our flora of several genera, if not of something higher—the difference in prevailing type between some of our fossil and existing genera of molluscs, and the removal of others entirely from our continents to regions most remote,—and lastly, a still more decided transference among the orders of our fishes,—data, which all point to the negative conclusion, that it is no newer tertiary that can be compared with our freshwater deposit. On the other hand we find generically, specifically, and individually an equality, to say the least, between our Ganoid and Cycloid fishes, and a resemblance between our flora and that of the London Clay,—proofs which, in my opinion, lead us on to the positive inference that among older tertiaries the eocene formation is that with which our freshwater deposit must be classed. Bronn, I perceive, assigned it to the era of the continental molasse. Whether or not the statements above made will be sufficient to show that this view is incorrect, it is not for me to say; at all events, the fossils, which we have contributed, will enable others to decide.

Extent of the Freshwater Formation.—The extent of this tertiary freshwater formation throughout India is very great. In Capt. Sherwill's recently published Geological Map we find it laid down on the west of Rajmahal on the Ganges. Following the same parallel of latitude, we come to Rae near Narwar, about forty miles south of Gwalior, whence specimens of *Physa* were obtained by Mr. Fraser, formerly Agent to the Governor General in the Sagar and Narbaddá territories. At Sagar itself organic remains were first discovered by Col. Sleeman, afterwards described by Dr. Spry, and more recently investigated by Capt. W. T. Nicholls of 24th Regt. M.N.I. East of Jabbalpur, in the same territories, occur the sites Suleya, where Dr. Spilsbury

procured *Physa* in 1833, Dhunra in the same vicinity, Narayanpur near Sohajpur, Mandla, and Phulságar, on the north bank of the Narbaddá, and as far up the river as Mohtura and Domadadar, in the Ramgad Raja's country,—at all of which localities the same indefatigable and successful geologist found shells, including an abundance of *Physa*, several specimens of *Unio*, and, if I may judge from the figures, of *Limnæus* and *Valvata*. None of them, however, are named*. North of the Narbaddá, near Mandla, univalve and bivalve shells abound in the marls and earthy limestone, as we learn from Capt. Dangerfield; who styles them "Buccinum and a species of Mussel" (*Physa* and *Unio*?)†. Leaving the Narbaddá, and coming to the Tapti, near its source, we find that Voysey, as has been mentioned by Malcolmson, in his memoir on this deposit, discovered shells, which he named "Conus and Voluta" (two forms of *Physa*?), at Jirpa and Jillan, which lie apparently on the north of the Gawilgad range‡. On the S. of the same chain of hills near Elichpur, are Muktagiri and Bairam, whence Dr. Bradley procured the excellent specimens of *Physa* and *Unio*, which I had the pleasure of sending to the Geological Society. Returning to Jirpa, we enter the district of Betúl, about 100 miles N.W. of Nágpur, which was explored by Capt. Ousley, who found shells at Chichundra and Murkha on the E. of the town, at Bharkáwadá, Bheiwada and Jawará on the S., and at Badori, Kolgau, Gaikhám and Bakur, on the S.W. Passing over the localities within the State of Nágpur, to which sufficient reference has been made in the previous part of this paper, we arrive at the district north of Hyderabad, where, I am informed by a friend, *Physæ* have been extracted from one of the banks of the Godáveri at Náundur, and where also fossils were discovered near Hatnúr and Manúr by Malcolmson, and at Medkondá, Shiwalingapá, and Deglur by Voysey, who as early as 1819, when organic remains were almost unknown in India, met at these localities with shells, including, as he thought, "Turbo, Cyclostoma, Buccinum, Helix, and Turritella," some of which may be identified as *Physa* and *Valvata*. Not far from Deglur, on the S. side of the Manjará, Capt. Newbold obtained specimens of *Physa* at Munapilli§, and again from between Kulkonda and Digái, on the banks of the Bhima, he was presented with specimens of *Paludina deccanensis* by Capt. Windham. These are all the fossiliferous localities for our tertiary formation with which I have become acquainted, with the exception of Bombay, and Padpangali near Rajamundry, afterwards to be more particularly noticed. But besides these, there are many places where the same deposit occurs destitute of organic remains. For example, my friend Mr. Hunter and myself, on a mission tour, traced it almost without interruption from the vicinity of Nágpur, where the fossils cease, westward to Elichpur, a distance of 100 miles and upwards; and, while the material of the rock was sometimes a whitish lime, and at others

* Bengal As. Soc. Journ. vol. viii. p. 708.

† Malcolmson's Central India, vol. ii. p. 329.

‡ Trans. Geol. Soc. 2nd ser. vol. v. pp. 570-1.

§ Bengal As. Soc. Journ. vol. xiii. p. 987.

a green or a red clay, we were uniformly unsuccessful in finding in it any kind of fossils. Similar differences are exhibited in the unfossiliferous stratum around Shiwani. At Garhákotá near Ságár, thence to Tendukhedá on the Narbaddá, wherever Major Franklin met with trap, he "always found it in association with earthy limestone*." The experience of Capt. Dangerfield regarding its position was somewhat different, he having met with it in certain parts of Malwa, as "a thin bed of loose marl, or coarse earthy limestone," "near the bottom of the small hills and banks of the rivulets†." The country between the Wardhá and the trap region described by Col. Sykes has not been examined by any geologist, so that no site can be named in it for lacustrine formation except Jálná; but I remember noticing it on my first arrival in India, nine years ago, at many localities, though I have now forgotten their names. But when we come to the scene of Col. Sykes's efficient labours‡, we can trace it almost everywhere under the name either of "ferruginous clay," or "pulverulent limestone." The stratum of "red ochreous rock," varying in thickness from an inch to many feet, and in texture from friable to compact earthy jasper, occurs at Nandur and Jihur near Ahmednagar; at Kothul; in the scarps of the hill part of Harichandargad, and a mountain near Junir; and at Sirur, Wángi, and Barloni, between which two last-mentioned places the bed is believed to be continuous. Finally it occurs abundantly on the Ghats, frequently discolouring the rivulets, and giving a ferruginous character to the soil, over a considerable area§. Pulverulent limestone is generally found in layers, varying from an inch to three feet in thickness, and covered by a few feet of black earth. Examples of it are met with at Jib and Islampur near Ahmednagar; at Karkamb and at Salseh, ten miles S. of the fortress of Karmali||. Crystalline limestone, which occurs as an imbedded mineral in amygdaloid¶, and "great masses of mesotype**," which are found in a similar position, seem to me, if I may judge from the analogy of the district of Nágpur, to be instances of our formation somewhat transformed. The ochreous rock or ferruginous clay above mentioned was discovered by Newbold at Sindaghi, in the Southern Marátha country, which lies south of Col. Sykes's district, and it was described by him as "finely laminated bright red bole," from 3 to 6 feet thick††. And this is most probably the origin of the "red clay," which Newbold on analysis found to be the basis of the amygdaloid in which zeolitic crystals abound‡‡.

The strata of Bombay have been described in an able and luminous manner by H. J. Carter, Esq., of the Bombay Medical Service§§. In thickness they greatly surpass anything we meet with in Central India, reaching to between 40 and 50 feet, and they are peculiar in

* As. Researches, vol. xviii. pl. 1. p. 33.

† Geol. Trans. 2nd ser. vol. iv.

‡ Ibid. p. 420.

¶ Ibid. p. 421.

†† Royal As. Soc. Journ. vol. ix. p. 33.

§§ Bomb. Br. R. As. Soc. Journ. vol. iv.

† Malcolmson, vol. ii. p. 328.

§ Ibid. p. 419.

** Ibid. p. 425.

‡‡ Ibid. p. 35.

having a little carbonaceous matter covering some of the vegetable remains. The fossils themselves, however, whether animal or vegetable, bear a remarkable resemblance to those which have been brought to light at Nágpur. Thus we find among them a freshwater tortoise,—the elytra of insects,—an abundance of *Cyprides*, one species of which appears to correspond with the *C. cylindrica* (Sow.), first found by Malcolmson,—a few indistinct impressions of shells like *Melania*,—fruits and seeds, though not of the same genera as ours,—ensiform endogenous leaves, like the Nágpur specimens,—cormiform roots, which differ from ours only in being larger,—and an abundance of dicotyledonous wood.

At Pádpangali or Pangádi near Rajamundry, not far from the mouth of the Godávári, there are found some outlying trap hills, which Gen. Cullen pointed out to Dr. Benza as fossiliferous. That gentleman visited the place, and described one of the eminences as consisting at its base of sandstone, which is overlaid by amygdaloid veined with jasper, then a limestone deposit with fossils, and finally a sheet of basalt. The fossils were stated by Dr. Benza to be partly marine, and partly freshwater; but, as his statement was made at a time when not much attention was paid to the distinction between these two classes of shells, it was supposed that it might be incorrect. I confess that I myself was guilty of this wrong to the memory of an able geologist. However, I took steps to discover the truth, and through my friend Lieut. Stoddart, employed in connection with the Godávári public works, I have ascertained, I am happy to say, that Dr. Benza is substantially right. His Oysters were real oysters, though his “*Ampullariæ*” most probably belonged to some species of *Physa*. “On only one of these hills,” says my intelligent informant, “could I find any Oysters; but there, I must say, they were as plentiful as stones.” At the foot of a hill opposite to this, Mr. Stoddart found several kinds of shells, and among them a *Physa* identical with a species common around Nágpur, which was in the same block with a *Chemnitzia*. There seems to be a great variety of molluscous remains at this locality, and it would well deserve a longer investigation than my kind friend was able to give it*.

Here then we have the best proof which similarity of position and specific identity of contained fossils can afford, that the deposit enclosed in trap at Pádpangali is properly contemporaneous with our freshwater deposit in Central India, although a majority of its organisms are truly marine. It is evident that it was here our great collection of fresh water, stretching either in one continuous sheet or interruptedly a distance of 1050 miles, in a direct line from Rajmahal to Bombay, and of 660 miles from N. to the neighbourhood of Pádpangali, discharged itself by an estuary into the sea. Whether this great expanse of freshwater was one or many lakes, cannot now be determined, in consequence of the disappearance of trap from many situations where once it must have existed, but I am persuaded that the more careful the exploration made in the great basaltic region

* A small series of fossils from Pádpangali sent by the authors comprises *Ostrea*, *Cardium*, *Venus*, *Chemnitzia*, and *Nerinea*?—Ed.

of Western India, the more evident it will become that the intervals between the lakes, if any there were, must have been exceedingly small. This was the conviction left on my mind by travelling from Nágpur to Elichpur, and this I think will be the feeling produced in the mind of any one, by taking a glance on a map at any district, like Col. Sykes's, that has been surveyed, even without a reference to a lacustrine deposit.

Minerals in the Trap.—I ought now to describe the minerals contained in our overlying and underlying trap; but this has been so well done by Voysey, in his remarks on the structure of Sitábalí Hill*, that it is unnecessary. One of the most common in the locality just named, though elsewhere rare, is a pitchy black substance, with a sloe-like bloom upon it, lining the amygdaloidal cavities. This Voysey appears to have called "Conchoidal augite:" my friend Dr. Carter supposes it obsidian. It occurs in bands lying one above another, which may be followed to a great distance in a horizontal direction. The intermediate spaces seem as if they had been successive effluxes of volcanic matter, running along beneath the freshwater deposit, and then under one another, each efflux being united or welded to the preceding one by a vesicular belt. Many of the minerals that are met with in the amygdaloid are derived from the tertiary strata. This is particularly the case with jasper, the veins of which, as may be learned from Benza's description of Pád-pangali Hill, and as we perceive in numerous places in this vicinity, are situated just at the zone of the vesicular trap's intrusion on the superior deposit. Sometimes instead of being jaspified, the entangled parts of the strata are converted into chert, at other times they are crystallized into ponderous masses of mesotype. In one locality the calcareous matter is diffused as strings all through the amygdaloid, forming seams of kankar, like those represented by Newbold†; in another they are scarcely enclosed within its substance, but remain in blocks at the lower part of the deposit, which are compact externally, but in the interior, where the heat has continued longest, are found to be an aggregation of crystals.

On the plain south of Gídad Hill there is lying about a great abundance of spherical nodules, which on being broken up exhibit a structure radiating from a central point, so that they have been mistaken for *Alcyonites*‡. The fakirs, who have located themselves on the top of the eminence, have adroitly taken advantage of this natural phenomenon to exalt the name of the saint whose disciples they profess to be. These nodules, according to them, are so many fruits and spices of different sorts, which Shek Farid converted into stone, the largest having once been cocoa-nuts, the middle-sized betel-nuts (*Areca*), and the smallest nutmegs. There is a resemblance of the nodules to the last two natural productions; but, as all alike display an acicular crystallization, it is difficult to trace the similarity of the largest to the fruit of the cocoa. Much light must be intro-

* As. Res. vol. xviii. p. 123.

† R. As. Soc. Journ. vol. ix. p. 33.

‡ Journ. Beng. Asiat. Soc. vol. ix. p. 625.

duced into this land before the inhabitants shall be convinced of the falsehood of the alleged miracle, and shall be able to understand that the seeming organisms are simple zeolitic concretions that have issued from the soft subjacent rock. Nodules of the same shape are found in the same formation at Sonegaum, near Kalmeshwar, fifteen miles N.W. of Nágpur, but, being purely calcareous, their interior consists of a confused mass of rhombic crystals.

The Age of the Trap.—Beginning with the more recent, as we have done in regard to the stratified rocks, we find that the amygdaloid or underlying trap has not only invaded the tertiary formation, but broken it up, and along with it the nodular basalt, by which it is capped. The amygdaloid eruption, then, is incontestably subsequent to the basaltic. But what age is to be assigned to the latter? It is evidently posterior to the freshwater beds on which it rests. We have thus an overlying effusion of nodular basalt, which has taken place after the tertiary strata, and an underlying intrusion of amygdaloidal trap, which has occurred after the basaltic effusion. Besides these two formations of trap, I know of no others in Central India, either more modern or more ancient. Capt. now Col. Grant, in his paper on the Geology of Cutch*, and Dr. Carter, in his memoir on the Geology of Bombay before quoted, have adduced ample proofs to show that in the districts which they have examined, there have been eruptions of volcanic matter subsequent to the amygdaloid; but in all the district through which my colleague and myself have been called to travel, no trap formation so modern has fallen under our observation. Nor has any more ancient than the overlying trap been discovered. It might be thought from the occurrence of isolated pieces of trap in the lower part of our freshwater strata, that while these were being deposited, there were sheets of volcanic rock already on the surface of Central India. But it appears to me that there are no such fragments whose existence may not be accounted for on the principle explained by Lyell in his 'Manual,' 4th edition, p. 446, and stated in a preceding page of this paper. Besides at Bokára, and some parts of Tákli plain, where the amygdaloid has not been intercalated under our tertiary formation at all, but where the latter, with its characteristic fossils, rests immediately and conformably on the sandstone, there is not a trace of volcanic matter to be seen. I am inclined therefore to doubt the occurrence of any trap in Central India older than our lacustrine deposit. In the southern portion of the Rajmahal Hills, M'Clelland† informs us that amygdaloid is found underlying the coal-strata of that district. The coal there is manifestly the usual so-called oolitic coal of India, and therefore we have amygdaloid disturbing the jurassic formation. But, if a stranger to the locality may be allowed to express an opinion, I would respectfully submit that the position of the amygdaloid is not conclusive against its comparatively modern origin. It is obvious that the most recent age attributable to an intruded rock, such as it is, cannot be exactly determined by ob-

* Trans. Geol. Soc. 2nd Ser. vol. v.

† Report Geol. Survey of India, Season 1848-9. Calcutta 1850.

serving what strata it has disturbed in one district; for it may have invaded an older formation in one locality, and yet, rising higher, it may have broken in upon a newer formation in another place; or, applying the principle to the case in hand, the very same amygdaloid which M'Clelland calls secondary trap, because it has been erupted among the oolitic strata of Rajmahal, may be tertiary trap here, if it is, as I believe, the identical effusion which has been intercalated between the oolitic and tertiary formations of Nágpur. But for the conclusive determination of this question, the district of Rajmahal with a tertiary formation found in connection with trap in its northern part, and jurassic strata associated with trap in its southern part, presents the most befitting arena.

Mode of its Eruption.—Before leaving the volcanic rocks, it is desirable to indicate the lessons which Central India teaches as to the manner in which they were formed. Now the first thing which strikes any observer of the great basaltic field of this country is the comparative absence of all cones or craters throughout. I cannot name a spot in all the tract with which I am acquainted, where I could say either the nodular basalt or the amygdaloid came up from below. The nodular basalt seems to have flowed along for immense distances, filling up the tertiary lake, and leaving an arid plain in its rear. Then the amygdaloid inserting itself between the sandstone and the freshwater bed seems to have flowed generally underground on the same scale of grandeur. Sítábalí Hill, which is almost an outlier of the great basaltic region of Western India, being connected with it by a very narrow neck, would be a favourable place for ascertaining whether the underlying trap, which has there accumulated under the tertiary deposit to a considerable thickness, has been forced up vertically through the gneiss and sandstone, which appear around the base of the hill to be inferior to it, or whether it has been horizontally intercalated, as in the generality of places, between the sandstone and the tertiary. I am disposed to take the latter view; but, if the government quarry were only excavated a few feet lower, as Voysey long ago suggested, it would put an end to all doubt.

From the statements previously advanced regarding the trappean rocks of Nágpur, taken in connection with the same formation in other parts of the country, it is obvious there is no foundation whatever for the supposition that the great outpouring of basalt in India took place in the ocean. And, although I believe that the freshwater in which it really was effused must have stretched over great areas without much interruption, yet the discovery in the tertiary strata of abundance of pulmoniferous molluscs, such as *Limnæus* and *Physa*,—of plants, such as marsh- or shallow-loving *Endogens*, buried with their roots and fruits almost entire and therefore not far from the spot where they originally grew,—not to mention the occurrence of an amphibious univalve like *Succinea*, and of land-shells like *Bulimus*, together with great quantities of seeds and fruit and timber, the spoils of the neighbouring dry land,—plainly shows that the water in that part of the lake was of no great depth. Indeed it seems

obvious that in places not a few the water of the lake must have been so shallow as to allow the igneous rock which was poured out over its bottom to rise above its surface into the atmosphere. We must resort then to some other hypothesis than aqueous pressure to explain the horizontalness of our trappean-hill tops, and a cause adequate to the effect is the well-known law by which the surface of liquid bodies is reduced to the same uniform level. To this law volcanic matter is subject in spreading over an area either of land or water. If to this it be objected, that then we should expect the surface of the effusion to appear scoriaceous like modern lavas, it may be replied that naturally all such light materials in the lapse of ages would be worn away.

VII. *The Sandstone Formation.*

Under the amygdaloid, or, where it has not been intercalated, immediately under the tertiary freshwater strata, is found an extensive series of rocks consisting chiefly of arenaceous beds.

A. The upper member of this series is seen at the foot of Sitábaladi Hill, passing into gneiss, into which much of it, as well as most probably all the lower members, have been converted. Without enumerating all its localities, I may mention that a good section of it is presented by a rivulet skirting the Lal Bág, where the layer under the nodular trap has itself been rendered distinctly nodular. It may be observed in the western division of the city of Nágpur; and it stretches in some places under the amygdaloid, in others under the tertiary bed, but for the most part as the surface-rock, through Tákli plain to Bokhára. At Nágpur and in Tákli plain the strata are of friable sand intermixed with kankar, and variegated with a deep irony-red and occasionally a purple colour. But it is at Bokhára where we can understand it best. In one of the quarries there we find it as at Nágpur, only with less of the colouring matter. Going northward to another quarry, we see it on the way overlaid by the lacustrine formation before described, which is capped by a small rise of nodular trap. Arrived at the quarry, which is only about 100 yards from the first, we find the same upper member of the sandstone, now however no longer soft and crumbling, but so hard that the hand-millstones of the country, which resemble Scottish *querns*, are derived from it; and the ferruginous matter, instead of being diffused as blotches, is gathered into waving iron-bands more indurated still. At this place these upper beds, which are about 25 feet thick and very coarse, contain angular fragments of a finer sandstone which lies below. Near Bazargau the strata where exposed are pierced with irregular holes, which seem to have been caused by the action of rain and the atmosphere. At Kámpti, situated towards their top, and rising even to the surface through the soil, are imbedded huge blocks, some of them angular, but most of them rounded and waterworn, which contain almost all the fossils that have been procured from that interesting locality. At Silewáda, towards their lower part there occur a considerable number of com-

pressed stems of trees *in situ*, one of which, presenting its thin edge in the side of a quarry, may be traced for about 20 feet. A few inches farther down we come to the largest of the iron-bands, which consists of a conglomerate, about 6 inches thick, enclosing fragments of dicotyledonous wood converted into a kind of jet and impregnated with iron. Ferruginous bands are common not only at Silewádá, but also at Bábulkhedá and Tondakheiri. It is only, however, in the neighbourhood of Chándá that any one of them has been found to contain wood in a silicified state.

B. Underlying the iron-band we come to layers of a much finer kind, consisting of argillaceous sandstone, varying from white to yellow and pink, and generally containing specks of mica. These strata, which are used for pavement and carved work, extend downwards for about 15 feet, when they gradually become coarser until they are suitable for millstones. The entire depth of these layers after their change from fine to coarse has not been ascertained. Dispersed through them, as we saw was the case with the upper member, are occasional angular fragments, so that it is difficult to distinguish lithologically between the two, except that the inferior beds always contain less oxide of iron than the superior.

It is in the argillo-arenaceous strata that we have met with nearly all the fossils which the sandstone of Silewádá, Bokhára, Bábulkhedá, Bharatwádá, Tondakheiri, Bazargau, Chorkheiri, and Chándá has yielded; and there is every reason to believe that the imbedded blocks of Kámpti also, which have furnished so many vegetable remains, were originally derived from them.

Chorkheiri and Chándá are the furthest limits north and south from which I have procured fossils of the inferior member of the sandstone; and the fact, that the fossils are exactly the same, in addition to a resemblance in lithological characters, demonstrates that the strata are so also.

Between these two extreme points, however, under an outcrop of coarse sandstone of much the same character as the generality of our upper beds, except that it is not coloured by iron or pervaded by iron-bands, there are found at Mángali and its neighbourhood fossiliferous strata applied to the same architectural purposes as our ordinary lower strata, though they differ from them in being of a deep-red colour, finer and more sectile, and with a larger admixture of clay and mica. As the Mángali red slaty sandstone contains scarcely any organic remains common to the inferior layers about Nágpur, it is not without hesitation that I include it under the present head, and arrange its fossils along with those of the more typical strata.

[*Fossils of B.*—For the same reasons as stated above, p. 360, in the case of the palæontology of the tertiary deposits, the numerous fossils of this division of the sandstone series are here merely mentioned in short, their detailed description being deferred until the publication of Part II. of this Memoir.

These fine and coarse argillaceous sandstones, rich with plant-remains, have afforded,—

Labyrinthodont Reptile* (from Mángali).

Fishes ; Small jaws and ganoid scales.

Crustaceans ; *Éstheria*.

Plant-remains.

Fruit and seeds ; numerous and undescribed.

Leaves ; Conifer, Zamites, Poacites, and Ferns (*Pecopteris*, *Glossopteris*, *Tæniopteris*, *Cyclopteris*, *Sphenopteris*).

Stems ; exogenous and endogenous.

Acrogens ; *Aphyllum*, *Equisetites*, *Phyllothea*, *Vertebraria*.]

c. Between the sandstone quarries at Bokhárá and Korhádi, granitic rocks have lifted to the surface, with a dip of 30° to S.W., a series of red shaly beds ; and between these and Bokhárá another species of green argillaceous strata, lying somewhat more horizontal. The relation of these two to the sandstone beds, from the absence of any good exposure, I have not been able to ascertain ; but they would appear to underlie it. Besides the locality now named, these rocks are developed in the district north of Chándá ; and, as I have been told by Mr. Sankey, the green shale covers an extensive tract of country near Hardagaḍ, south of the Mahádewa Hills. It is probably the same strata that are found to lie on the west and north of the Nawagaum Lake, and to cross the Ráyepur road at Mundipár Ghát and at Jamnápur, near Sákorali. The red shale at Korhádi has yielded the following organic remains :—

Fossils of c.—A reptilian footmark of one-third of an inch long, and as much broad. Three or four specimens have been obtained, each exhibiting only one print, owing to the brittleness of the matrix. I am not sure that all the impressions are of the same kind.

On the same specimens that bear these footmarks are seen the tracks of wormlike animals. That the animals forming these tracks have been Annelids resembling Earth-worms will be evident to any one who considers the appearance of the furrows ; the way in which the head has occasionally been pushed forward, and then withdrawn ; the tubular holes by which the ground has been pierced, and the intestine-shaped evacuations which have been left on the surface. Fossil worm-borings have been found in the green shale of Tadáḍi, N.W. of Chándá, seventy miles S. of Nágpur.

The only vegetable organism which has been discovered in the shale is a sulcated plant, which most probably belongs to the genus *Phyllothea* ; but as a sufficient length of the stem has not been obtained to display the articulation, its precise character cannot be fixed.

d. Immediately below the red shale there are found beds of white marble at Korhádi, which have been greatly disturbed and dolomitized by the plutonic rocks above referred to. Similar strata, but pink and blue, occur in the channel of the Pech at Gokala, a little above Parshiwani ; and still higher up at Nawagaum it rises into a chain of eminences, which runs thence westward to Kumári. Following up the river still further, on its right bank we come to a patch of

* The *Brachyops laticeps*, Owen ; see Quart. Journ. Geol. Soc. vol. x. p. 474 ; and xi. p. 37, pl. 2.

the same crystalline limestone at Dudhgaum, where it is in the vicinity of trap. To the east of this, at A'mbájiri in Chándpur, it occurs again: but there, as in most of its other localities, the granite rises to the surface in the neighbourhood. Limestone is found also on the Lánji Hills at Kunde and near Bhánpur to the east of Hattá; but whether it is the limestone associated with sandstone, or just a calcareous phase of our freshwater tertiary formation, from not having visited the spot, I am unable to decide. It seems to be comparatively free from magnesia, in which it differs from the generality of the strata of which we are now treating. From the heat to which these have everywhere in our area been subjected in the process of dolomitization, we need not expect to discover in them any organic remains. Newbold thought that he had found in certain cherty veins of limestone near Karnúl myriads of spherical Foraminifera. We have also veins of chert in the Korhádi limestone, which exhibit appearances that might be mistaken for the same objects, but they do not seem to be really organic. The minerals most abundant in the dolomite are tremolite and red and yellow steatite, which last, when the surface of the rock is weathered, stands out in little prominences, as if it were a species of lichen.

The whole series of strata which we have designated by A, B, C, D we conceive to be only subdivisions of the same formation. They have been disturbed by the same granitic eruptions, and, where fossiliferous, bear a general resemblance to each other in their organic remains. But this mutual connection is more apparent when we compare the series within our area with strata beyond it. From Mr. Sankey we learn that the sandstone represented in the north-west corner of our map is succeeded in a descending order at Chotá Barkoi by bituminous shale with fossils and sandstone, and at Bhuwan, at the foot of the ascent to one of the Mahádewa or Pachmađi Hills, by indurated green clay-stone and green shale, and bituminous shale with fossils. Again below the sandstone in the south-east corner of the map, as we are informed by Dr. Bell, there occur argillaceous limestone, bituminous shale with fossils, and a few alternating layers of impure limestone and bituminous shale, until we come to a bed, eight feet thick, of laminated sandstone, &c. Situated, as our sandstone is, between these two extreme points, and appearing to be a bond of connection between them, we might *à priori* expect that the intermediate beds would be of the same age as those at the localities on either side; and this opinion is confirmed by the appearance of the sandstone near Nágpur, which shares with the sandstones of the Mahádewa and Kotá hills, the distinguishing feature, first noticed in this neighbourhood, of being pervaded by ferruginous septa. These dark-brown stripes, which in all their hardness protrude from the weathered surface of the enclosing rock, will be found, wherever they occur, a very good criterion for judging of the age of the sandstone. But besides identity in the arenaceous beds of our whole district, we can trace the same identity between the subjacent strata at Nágpur, Pachmađi, and in the Hyderabad country. On

the south of the Mahádewa Hills there is the same green shale as here and at Tadádi; and at Kotá, according to a private letter with which I was favoured by (the late) Dr. Bell, red clay, of greater thickness than any stratum that was passed through, underlies the other shales which he has enumerated in his sections*: and in localities farther south, Malcolmson states† that the shales on which the sandstone rests are blue, red, green, or pure white; by which last-mentioned rather rare colour we are brought in mind of some of the strata at Mundipár. And as we are told by Newbold‡, the sandstone of the Eastern Ghats frequently “passes into red and green argillaceous and siliceous slates and laminated marls.” I think then, that, though inferring the identity of Nágpur sandstone with that of Southern India from the occurrence of diamonds at Weiragad, Malcolmson’s statement was wrong as to its grounds, yet it was perfectly correct as to its matter. The position of the shale in reference to the limestone seems to vary. At Korhádi it is the superior rock. Such also is its position at Bágnápilli according to Malcolmson§, and generally according to Newbold. In a section, however, of the Pass at Mudalaity, given by the latter writer, we have the following order: “compact light-coloured sandstone, 120 feet; limestone, 310 feet; shales, 50 feet; laminar and massive sandstone;—whereas by the section obtained by Dr. Bell|| we find sandstone, from 50 to 500 feet,—argillaceous limestone, 9 feet,—and, after various unimportant argillaceous, bituminous, and calcareous strata, in all 4 feet, limestone, 1 ft. 9 in., laminated sandstone and shale, 8 feet, and argillaceous &c. strata as before, 11 feet 8 inches, we come to limestone, 23 feet, then argillaceous and calcareous beds, 25 feet, red clay, 27 feet, and limestone.” Here it would appear that shale, sandstone, and limestone are interstratified.

Though there is no great development of carbonaceous beds in the district which is the more immediate subject of this paper, yet I should regard the communication as incomplete without some notice of the position of the Indian coal in reference to our sandstone strata. Bhuwan, in the north-west of our area, at the foot of the Mahádewa Hills, furnishes us with a common term of comparison.

[In the foregoing observations on the so-called Jurassic (or plant-bearing) formation of the Nágpur territory the authors recognize four members in the following descending order:—A. Thick-bedded, coarse, ferruginous sandstone, with a few stems of trees. B. Laminated sandstone, exceedingly rich in vegetable remains. C. Clay shales of various colours, and bearing worm-tracks and foot-marks. D. Limestone, generally altered and crystalline. At the time when this memoir was written, the authors thought it probable that the Bengal coal-deposits might be referable to the shales (c) of this series; but, having since had further opportunities of personal in-

* Quart. Journ. Geol. Soc. vol. viii. p. 232.

† Trans. Geol. Soc. 2nd ser. vol. v. p. 543.

‡ Journ. As. Society, vol. viii. p. 167.

§ Malcolmson *ut supra*, p. 541.

|| See also Quart. Journ. Geol. Soc. vol. x. p. 374, and *note*.

vestigation, they find that the carboniferous beds of Umret and the Mahádewa Hills are true representatives of the Burdwan coal of Bengal, and are referable, not to the Nágpur shales (c), but to the Nágpur sandstone with plants (b). About six months since the authors were enabled to visit* the coal-bearing deposits at Umret and the plant-beds of Bhuwan at the foot of the Pachmađi or Mahádewa Hills, 120 miles north of Nágpur, some notice of which was given to the Society by Lieut. Sankey†. A few miles north of Umret there occurs a descending series of sandstone, coal, argillaceous, bituminous, and sandy shales, and sandstone. The shales here represent the plant-bearing sandstone of Nágpur. At the Mahádewa Hills the overlying sandstone (which, like that of Umret and of Nágpur, is characterized by iron-bands) is of much greater thickness than to the south. Under this sandstone of the Mahádewas come green shales and bituminous shales, equivalent to those of Umret. From the examination also of the fossil plants (*Vertebraria*, *Trizygia*, *Phyllothea*, *Cyclopteris*, *Glossopteris*, *Pecopteris*, and *Sphenopteris*) plentifully occurring in all these localities, the same conclusion is arrived at, namely, that the shales of Umret and the Mahádewas are truly equivalent to the plant-bearing sandstone of Nágpur, which last, indeed, in some places has argillaceous modifications. The bituminous shales of Kotá, on the Pranhítá, appear to belong to the same series, and underlie the iron-banded sandstone, as in other localities. The Kotá shales have afforded fish-remains of a Jurassic type (*Lepidotus* and *Echmodus*); and at one place, Mángali, between Kotá and Nágpur, the equivalent of the Nágpur plant-bearing sandstone has yielded the Labyrinthodont Reptilian skull, lately described in the Society's Journal by Prof. Owen. The extension of the bituminous and anthracitic shales in other localities, namely, Duntimnapilly, Singra, on the Bágin River, Umla Ghat, &c., is alluded to by the authors in their recent communication; and they remark, that, on the south, north, and east of the Nágpur territory, the carboniferous shales are thus seen to hold the same relation with the overlying iron-banded sandstone; and that, though it is difficult to comprehend the Burdwan coal-field in the comparison, as it lies in a basin and has no overlying formation, yet the fossils are very similar to those of the Mahádewas, Umret, and Nágpur, and bear evident proof of the contemporaneity of the whole.—July 1855.—En.]

Thickness of the Strata.—A. The highest beds as exposed in the quarries of Silewádá and Bokhárá average about 25 feet of coarse sandstone with iron-bands; below which there are 15 feet of argillaceous sandstone, B, with an abundance of fossils, and an undetermined depth of coarse sandstone beneath. These constitute what Dr. Carter, in an able 'Summary of Indian Geology,' which I have just received, calls the Panná sandstone. From outcrops of this subdivision of the sandstone series in other localities near Nágpur,

[* A notice of the results of this visit was read at the Meeting of the Society, June 13, 1855.]

[† Quart. Journ. Geol. Soc. vol. x. p. 55.]

the whole thickness of the highest beds may be reckoned at about 200 or 300 feet. At Kotá, as we have seen, it ranges from 50 to 500 feet, at Mudalaity 120 feet, and at the Mahádewa hills, according to Mr. Sankey, 2700 feet, which must be its greatest development. c. The depth of the shales at Korhádi and Tadádi seems to be—green about 30 feet, red 50 feet. At Kotá, omitting interstratified argillaceous limestone and sandstone, all the argillaceous thin strata united amount to 29 feet, red clay 27; while at Newbold's section of Mudalaity, where the shales, usually reddish, underlie the limestone, they attain a thickness of 50 feet. d. The limestone which underlies the shale has been much disturbed by granite at Korhádi, so that we cannot fix its thickness precisely; but I should think it cannot be less than 100 feet—at Mudalaity it is 360 feet. Under this limestone, which is included in Dr. Carter's excellent paper, along with shales and coal under the name of Kattrá shales, there occurs, as Newbold has shown in Southern India, and Frankiin in Bundelkhand, another series of sandstone rocks, for which Dr. Carter proposes the name of Tará sandstone; but, as most probably, owing to the intrusion of the granite, this member of the formation does not occur in our neighbourhood, I have nothing to say regarding it.

Character of the Formation.—There can be little doubt that the upper strata are lacustrine. The occurrence in them of such an immense collection of terrestrial vegetation, intermingled with *Poacites*, taken in connection with the total absence of Fucoids and other marine plants, shows very plainly that they must have been deposited in fresh water. And, as no river could have covered the extent of surface which these beds occupy, we are bound to conclude that, like the tertiary rock previously described, they must have been formed in a lake, a conclusion which the discovery of *Estheria* (or *Limnadia*), with their two valves entire, and congregated together as they are found in their usual haunts, fully justifies. Again the abundance of worm-tracks and borings in the red shale of Korhádi and the green shale of Tadádi renders it more than probable that the strata at these localities constituted the margin of an ancient lake and not of a sea or even of a river. Of the origin of the dolomitic beds it is impossible to give any certain account, owing to the transformation which they have undergone, though we may suppose they follow the analogy of the other members of the formation. The character of the upper strata at Elichpur, as would appear from the fossils discovered by Dr. Bradley, is exactly the same as at Nágpur. The *Lepidotus* which has been found at Kotá, from its association with terrestrial vegetable remains, has been pronounced to have been probably an estuary or inshore fish; but, as the genus also occurs abundantly in the freshwater strata of the Wealden, it may be perceived that the strata at Kotá are not of a different origin from those in our neighbourhood. This supposition is rendered more likely by the fact, that, while no marine vegetation is said to have been detected there, a piece of the shale which Dr. Bell kindly sent me bears the impression of a bivalve exceedingly like a *Cyrena* or *Cyclas*. Dr.

M'Clelland seems to suppose that the Burdwan coal-measures were deposited in a sea, for in the last plate of his Survey already referred to he has figured a fossil which he has called *Fucoides venosus*; but any person who compares the plant there represented with the *Glossopteris* figured in his plate XV. under the name of *G. reticulata* will, I believe, agree with me in considering both plants generically, if not specifically, the same. I infer, therefore, that there is no evidence whatever to prove that our sandstone, or the shale at Kotá, or the Bengal coal-measures, were deposited in the sea; but on the contrary every reason to believe that they were all formed in a large body of fresh water.

Age of these Strata.—The coarse iron-banded sandstone above, and the more fissile strata lying conformably below, which are undoubtedly of one and the same era, require first to be considered. For the sake of clearness, however, I shall refer to the latter member alone, as it has afforded most of the fossils, and furnishes the best data for comparison with the rocks of other localities. Some of the seed-vessels which it has yielded bear no very distant resemblance to those of the Stonesfield slate; *Asterophyllites? lateralis*, to use the provisional name proposed by Bunbury, and the forms of *Pecopteris*, show its near connection with the carbonaceous shales and sandstones of Scarborough; *Phyllothea*, *Glossopteris*, and the narrow fronds of *Cyclopteris*, if M'Coy's figure* be truly of that genus, mark out the relation to the coal-beds of New South Wales, while *Tæniopteris magnifolia*, and sulcated stems in all respects corresponding with *Phyllothea*, testify to the agreement with the Virginian carboniferous strata. These coincidences, some of which, as in the so-called *Asterophyllites?* and *Tæniopteris magnifolia*, seem to amount even to specific identity, along with the remarkable relations which the distant localities exhibit among themselves, form a network of proof, which in my opinion binds down all the various series of rocks to about the same epoch,—an epoch which the known position of the Stonesfield and Scarborough strata show to be Lower Oolitic.

Whether the Mángali sandstone is to be reckoned contemporaneous with these,—whether the two different kinds of strata there—the coarse thick-bedded upper and the fine fissile lower—are to be reckoned the equivalents of our A and B, is a question which observation in the field and a comparison of the respective fossils do not enable me to answer. The massive sandstone at Mángali, as has been said, is destitute of iron-bands, and the inferior argillo-arenaceous strata are much redder than ours; and especially the organisms of the lower strata at the two places are very dissimilar. Here they are all vegetable, while there they are almost exclusively animal. Only one of the fossil plants at Mángali appears to us to bear a resemblance to anything found in this vicinity. At the same time, if any inference is to be derived from the succession of the rocks there, it is in favour of the idea that they are the counterparts of our A and B. And that they cannot in age be far removed from them, is proved by a comparison, not of the Mángali fossils with others in this

* An. Mag. Nat. Hist. vol. xx. pl. ix. fig. 3.

territory, but of both these with those across the Atlantic. Our investigations in the resemblances of the sandstone fossils show that the Nágpur fossiliferous strata are connected with the Richmond carboniferous formation by *Tæniopteris magnifolia*, while the Mángali fossiliferous strata are still more closely linked to it by the discovery of what appear to be *Aspidiaria*, *Knorria*, and the interesting groups of large and small *Limnadiadæ*. Here, then, we perceive that the lower beds at both of these Indian localities bear a relation to the Virginian coal-measures, characterized by an apparent specific identity of fossils; and, though the genera of which the species seem to be identical are not the same in both cases, yet it is obvious from the sort of *ex æquali* argument which we may be permitted to use, that these lower beds must stand pretty closely connected with each other. But I do not wish to push to an extreme reasoning on a point which the progress of investigation here may soon elucidate by finding the strata under consideration in juxtaposition. Meanwhile I consider myself warranted in asserting, that our Mángali rocks cannot at all events be older than the Jurassic, if under that term the Lias is also included. Indeed the head of the Labyrinthodont tends to communicate to them a Triassic aspect; but, if the Jurassic character of their abundant flora be taken as the real indication of the age of these rocks, we arrive at a conclusion which brings out the interesting fact, that the family of Labyrinthodonts, instead of being confined to the Coal and Trias, survived (in the East) until the period of the Lower Oolite.

Regarding the age of our shale c, which there is every reason to believe underlies the coarse and fine sandstones A and B, I have little to say more than that it cannot be much older than these. The occurrence of worm-tracks, as well as of faint traces of *Phyllothea*, will not allow me to consider it anything but part of the same Jurassic formation. But as I have endeavoured to show that the coal-measures of Burdwan are equivalents of our plant-bearing beds, and therefore belong to the Lower Oolitic group, it will be necessary to make a few remarks to establish the correctness of this view.

On the age of the coal-measures of Bengal two opinions have been submitted to the public within the last four years:—one in 1850 by Dr. McClelland in his “Geological Survey,” and the other in the course of the present year by Dr. J. Hooker in his interesting “Himalayan Journals*.”

Dr. McClelland’s sentiments, which in 1846 were very decided as to the true Palæozoic character of our Eastern coal†, seem to have remained the same at the period of his more recent publication on the subject; for we find him in his “Survey,” while admitting the

[* This portion of the paragraph on the “Age of the Sandstone” has been remodelled since the reading of the Paper, so as to introduce the necessary references to the opinions published by Dr. J. D. Hooker in his most interesting work on the Himalayas.—June 14 and Sept. 6, 1854.]

† “There cannot, however, be a doubt as to its belonging to the true coal-formation, from the nature of the coal itself, as well as of the beds with which it is associated.”—Secretary of the Calcutta Coal Committee on the Coal of the Great Tenasserim River, in Committee’s Report, p. 138. Calcutta, 1846.

Oolitic age of some bluish-white indurated clays at Dubrajpore in the Rajmahal Hills, nevertheless placing the shales, sandstones, and seams of coal of Burdwan, and of Mussinia and Kottaycon in the Rajmahal Hills, as an intermediate formation, which he styles the "Coal-measure," between the Inferior Oolite mentioned above and what he supposes to be the "Old Red Sandstone." After deducting specimens of *Fucoides*, which I cannot, with the aid of his figures, distinguish from those of *Glossopteris*, there are seven genera, to which he refers as "Indian coal-measure fossils." Of these, four, viz. *Sphænoptyllum*, *Poacites*, *Calamites*, and *Pecopteris*, he says, are "common to the coal-measures of Europe." In the conclusion which would naturally be drawn from this statement I cannot concur; and hence it is necessary to review the grounds on which it is made. The three genera not mentioned are *Zamites*, *Tæniopteris*, and *Glossopteris*. Of these, the first two are held to be well nigh characteristic of the Jurassic period, while the remaining genus, though unknown in Europe, must, from the circumstances in which it is shown to occur, now be acknowledged to be equally a Mesozoic plant. And with regard to the four genera specified, I do not suppose that Dr. Royle will assent to the identification of his *Trizygia* with *Sphænoptyllum*; and, if any specimens of the genus *Calamites* had been preserved for description, I have little doubt they would have proved to belong to our "non-tuberculated class of opposite sulcated jointed stems," which abound in formations above the true coal-measures. The genera *Poacites* and *Pecopteris* I have found in our "Jurassic" strata, and a specimen of the latter here is so like one figured by M'Clelland that it is difficult to resist the conviction that they do belong to the same species. If to the evidence now adduced there be added that afforded by the occurrence of the peculiar plants *Vertebraria indica*, *Trizygia speciosa*, &c. at Burdwan and Bhuwan, I think little probability will remain of the Bengal coal-formation being Palæozoic.

Dr. Hooker, in commenting on the opinion of Dr. M'Clelland, which he supposed to be in favour of the Oolitic age of the Burdwan coal-field, at the commencement of his first volume endeavours to prove that no inference can be deduced from the plants discovered in those strata. In his second volume, however, he puts forth an opinion of his own, which, though not formally enunciated in regard to the Burdwan series of rocks, may be gathered from his remarks on the carbonaceous shales near Punkabarree. On these shales there were "obscure impressions of Fern-leaves, of *Trizygia* and *Vertebraria*, both fossils characteristic of the Burdwan coal-field, but too imperfect to justify any conclusion as to the relation between these formations*." And then, in a foot-note, it is added, "these traces of fossils" (including a fragment of bone as well as vegetables) "are not sufficient to identify the formation with that of the Siwalik Hills of North-West India; but its contents, together with its strike, dip, and position relatively to the mountains, and its mineralogical character, incline me to suppose it may be similar."

* Himalayan Journals, vol. ii. p. 403.

It may appear presumptuous in me to impugn the view of one who, from personal as no less than hereditary claims, is entitled to the utmost respect on the subject of vegetable remains. I feel, however, that the learned author has been led away by his distrust of the evidence afforded by fragments of plants to rely on the more uncertain indications of mere lithological phenomena. Do strike, dip, &c. furnish us with such strong testimony on the question of age, that for their sake the Punkabarree shales are to be denied a place with the Burdwan beds which have Ferns, *Trizygia*, and *Vertebraria*, and to be ranked with the Siwálik rocks, which, I believe, have none of the three? Or, if the carbonaceous strata at both places are allowed to be contemporaneous, are both to be classed as Miocene or Pliocene, when the Bhuwan shales, which like them exhibit "impressions of Fern-leaves, of *Trizygia*, and *Vertebraria*," immediately underlie sandstones whose numerous fossils, not to mention those of Burdwan itself, are decidedly not more recent than Jurassic?

It only remains to add, that the age of the dolomitized limestone cannot be expected to be determined by the evidence of fossils; but, as in other localities, it is not unfrequently found to alternate with the shale c, it may be set down as nearly coeval with it;—thus making the whole series of rocks from A to D to correspond with the lower members of the great Jurassic formation,—reaching perhaps from about the position of the Scarborough strata downwards into the Lias.

VIII. *Plutonic and Metamorphic Rocks*.—At the end of a paper which has already extended to such a length, it would be unbecoming to say much on this part of our subject. We have in the city of Nágpur, and many localities to the east of it, the usual combinations of gneiss and quartz-rock, mica and hornblende schist, with massive granite. The peculiarity of the last-mentioned rock in the streets of the capital is, that it is generally a pegmatite, consisting of flesh-coloured crystals of felspar with quartz, disposed so as often to take the appearance of graphic granite. But very frequently it occurs with the felspar compact, in large white masses, which then have much the appearance of a pure dull porcelain. In Nágpur the most common rock is gneiss, passing into mica-schists. The former rock, when fresh, is quarried, though not extensively, for building; and when disintegrated, for the repairing of the roads. But for both of these purposes respectively trap, in the two conditions mentioned, is preferred. Masses of white quartz appear here and there in the city, some with crystals of black schorl, and others with scales of gold-coloured mica. The range of plutonic hills on the west of Kámpti, which is indeed only a narrow prolongation of the great granitic district in the Wein Gangá basin to the east, has been thrown up by an eruption of granite corresponding nearly with the course of the Kólar. The massive rock which lies in the channel of the river, unlike that of Nágpur, is generally grey and very micaceous. Above it, forming the N. base of the range, lies mica-schist, passing into granular schistose quartz, which is overlaid by a stratum of dark-

grey, glistening, resinous quartz, and then by a considerable thickness of white quartz with scales of mica. This constitutes the ridge of the range for about its entire length from Waregaum to Gumtara, and with its snowy-whiteness attracts attention from a great distance. At the northern base of the range, between the quartz and the dolomite of Korhádi, there are interposed some beds of granular quartzose rock, which has very much the appearance of being an altered sandstone; in which case it might be the representative in this part of the country of the "Tará sandstone." But throughout the field of crystalline limestone at Korhádi there are many eruptions of granite, which just rise to the surface without any intermediate metamorphic rocks at all. In some of those instances the granite is garnetiferous, and at its junction with the dolomite the latter, besides its usual ingredients of steatite and tremolite, is intermingled with mica. At Halyadoba, N.E. of Umred, chlorite-schist with garnets is quarried for pavements; it abounds along the course of the Amb River. At Shegaum various plutonic rocks rise from under the sandstone, and extend northwards to Karsingi. The first which appears in the north street of Segaum is syenite, in which the felspar and hornblende greatly preponderate over the quartz. About 300 yards to the north this is succeeded by another kind of syenite, in which red felspar is combined with a small proportion of quartz, and a large quantity of a green mineral (epidote or diallage?). This rock (euphotite?) seems to be massive, and, if we may judge from the fragments of it lying on the surface, is the prevailing rock for some miles. In an adjoining plutonic area, a little to the north, there is an extensive development of pot-stone at Jámbul Ghát. The rich dark kind that possesses a small metallic lustre has hitherto been reserved by Marátha authority for the manufacture of idols; but the lighter-coloured varieties, which are more common, occurring also at Dini near Rampaili, and at Biroli on the Wein Gangá, near Tharora, have been long used for fashioning into vessels. Steatitic schists of a pure white tint, with a few imbedded garnet crystals, occur at Kaneri, on the Chulband river, and at various other localities east of the Wein Gangá. In many parts of this river's course, and in the Lánji Hills, hornblende rocks, both schistose and massive, abound. A coarse kind of corundum occurs at Dali Ghat, on the road from Nágpur to Ragepur.

Metals.—Small quantities of gold are found near Lánji in the sands of the Son river, a tributary of the Wein Gangá. In some fragments of quartz-rock on Nimá Hill, west of the Pech river, Col. Jenkins found galena. Where this rock is associated with dolomite, as at Kumári, it contains manganese. But the principal ore which it yields is iron; this may be obtained in immense quantities in the province of Chándá, both on the east and west of the Wein Gangá. Near Dewalgaum, only three miles from the east bank of this navigable stream, which communicates by the Godávari with the Bay of Bengal, at Masulipatam, in the midst of a level country covered with jungle, there is a hill named Khandeshwar, consisting of strata tilted up at an angle of 60° or 70° , the dip being to the north. The

summit of the hill is about 250 feet above the level of the plain, 100 feet being gradual ascent through jungle, and the remainder an abrupt wall of naked rock. The iron-ore is for the most part specular, though many specimens possess polarity, and seem to be magnetic. It is on the surface of the slope that it is most valuable; but the whole mass, from an unknown depth under ground to the highest peak above it, is richly laden with metal. This single hill might furnish iron for the construction of all the railroads that shall ever be made in India, and with its abundance of fuel and cheapness of labour, and convenience of situation, it is admirably adapted for an export trade to every part of the country. But besides this locality, there are others in the neighbourhood which could each contribute an unlimited supply of the same indispensable metal. Among these may be mentioned Lohara, Ogalpet, and Metápár, Bhánápur, Mendá, and Gunjáwahi, which are all on the W. of the Wein Gangá; and at all of which places the ore seems to occur in quartz, and is sometimes granular, but for the most part compact. Unimportant crystals of it are scattered through the pegmatite of the capital. Notwithstanding that the specular ore is so abundant, there are many districts on the north of those already named where the hydrous oxide, in the shape of the heavier lumps of laterite, are selected for smelting by the poor natives, whose tools are anything but adapted for contending with the hard masses of the metamorphic matrix or gangue.

Age of the Plutonic and Metamorphic Rocks.—These evidently do not all belong to one and the same epoch. Col. Jenkins observes that at Nayakund on the Pech, to the north of Nágpur, he met with “a grey granite, composed chiefly of whitish felspar in very large crystals,” a mass of which “was distinctly traversed three or four times by granite-veins, accompanied by as many heaves.” The granite of the veins was smaller-grained and redder the more recent it was, and, to the best of that officer’s recollection, was destitute of mica. Without, however, more extensive artificial sections of the rocks in this neighbourhood than have ever been executed, I fear it will be difficult to fix the respective ages of the different eruptions. A cursory view of the question would lead to the supposition that the micaceous granite is more ancient than the pegmatite; but, in areas where both are presented in the vicinity of each other, the soundness of this view may be questioned, or at all events it appears to be impossible in the present state of the country to have it confirmed. The pegmatite of Nágpur city, which we have said is associated with gneiss, mica-schist, and quartz with mica and with schorl, is evidently a very recent eruption, for it has not only converted much of the very highest member of the jurassic sandstone into gneiss, but it has completely upheaved it. That the eruption, therefore, was posterior to that formation, there cannot be the slightest doubt. But it has sometimes occurred to me, though the observations of the most eminent Indian geologists are opposed to the thought, that this pegmatitic outburst may be subsequent even to our trap.

The section (fig. 1) at page 350 may throw some light on this

doubtful point. In this section we have the overlying trap (a) occupying the two summits of Sitabaldi Hill, under it the tertiary freshwater formation (b) and the intruded amygdaloidal trap (c) which has encroached on it. At the foot of the hill is the upper sandstone (d), which has been metamorphosed to a great extent by the gneiss (e), or rather by the pegmatite (f) beneath. On the north part of the hill the gneiss comes to the surface; but a little further north it is, together with the sandstone, overlaid by trap. This trap, which agrees with that overlying the tertiary beds in being nodular and poor in minerals, resembles in the very same respects the amygdaloid where it constitutes the superficial rock on the ascent. Proceeding in the same line, we find the trap cease and the sandstone upheaved. After this interruption the trap is again seen to be on the surface. Now the question arises: what is the reason that the trap is not found where the granite has thrown up the sandstone? The most obvious reply is, that once it was there, as it is seen on either side, but that by this eruption it was removed; in which case the plutonic rock would be of more recent origin than the volcanic. But, as there is the alternative of the latter never having been spread over the position of the former, and as this alternative is favoured by the examination of other localities, I content myself with merely submitting the case for determination, merely stating that my latest observations lead me to believe that the trap is of later age than the granite. At all events the section undoubtedly shows that the pegmatite and some of its accompanying gneiss are of an age subsequent to the upper sandstone. And yet in a layer of conglomerate contained in the red shale of Korhádi we meet with pebbles of undulated mica-schist very like that which occurs in the present day between Surádi and Korhádi. Rocks of this character, then, whether we are right or wrong in suggesting their connection with any still existing, did exist before the deposition of the red shales.

Conclusion.—In tracing the geological history of this district from the facts that have been brought forward, we are made to feel that the early epochs are involved in the utmost obscurity. While in many other countries the records of what took place in Palæozoic times have been preserved in successive strata of the earth's crust, in the Dakhan they have been wholly obliterated. It is not until we come down to the Jurassic era that we meet with archives whose characters can be read. Then we find that Central India was covered by a large body of fresh water, which stretched southward into the Peninsula, and eastward into Bengal, while on the north and west it communicated by some narrow channel with the sea. On the shores of this lake earth-worms crawled, and small reptiles (frogs) crept over the soft mud. In its pools sported flocks of little Entomostracans resembling the modern *Estheria*, mingled with which were Ganoid fishes and Labyrinthodonts. The streams which fed it brought down into its bed the debris of the plutonic and metamorphic rocks which then constituted the greater part of the dry land, and which were covered with an abundant vegetation of Ferns, most of them distin-

guished by the entireness of their fronds. Low-growing plants with grooved and jointed stems inhabited the marshes; and Conifers and other Dicotyledonous trees, with Palms, raised their heads aloft. Meanwhile plutonic action was going on, and strata, as they were formed, were shattered and reconstructed into a breccia; and finally an extensive outburst of granite elevated the bed of the lake and left it dry land. The sea now flowed at Pondicherry and Trichinopoly, depositing the cretaceous strata which are found there.

At the end of this epoch Central India suffered a depression and was again covered by a vast lake, communicating with the sea, not towards Cutch as before, but in the neighbourhood of Rájámandri, to which the salt water had now advanced. When the lake had during its appointed time furnished an abode to its peculiar living creatures and plants, it was invaded by an immense outpouring of trap, which filled up its bed, and left Western and a great part of Central India a dreary waste of lava. But these basaltic steppes were ere long broken up. A second eruption of trap, not now coming to the surface, but forcing a passage for itself under the newer lacustrine strata, lifted up the superincumbent mass in ranges of flat-topped hills. Since then, to the east, water has swept over the plutonic and sandstone rocks, and laid down quantities of transported materials impregnated with iron, and some time after there were deposited in the west a conglomerate, imbedding bones of huge mammals, and above it a stratum of brown clay, which immediately preceded the superficial deposits of the black and red soils.

I have to acknowledge my great obligations to Lieut.-Col. Alcock, of the Madras Artillery, and Drs. Leith and Carter, of Bombay, for assisting me in obtaining access to books (or extracts from them), of which I should otherwise have been deprived.

The map (Pl. X.) of the district described is coloured geologically from an excellent political map given in Rushton's Bengal and Agra Gazetteer for 1842. The formations between Chindwádá and the Mahádewa Hills are laid down from a sketch obligingly furnished to me by Mr. Sankey.