MEMOIRS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Description of the Geology of NÁGPÚR *and its neighbourhood, by* WILLIAM T. BLANFORD, F.G.S., *Deputy Superintendent, Geological Survey of India.*

The neighbourhood of Nágpúr has become, through the writings of Voysey, Malcolmson and Hislop, and especially of the latter, one of the best known geological areas in the Indian peninsula. Its position precisely on the edge of the two great series of formations, the trappean and metamorphic, which, between them, occupy by far the larger portion of the Indian peninsula, gives to the locality a peculiar geological interest, which is greatly increased by the existence in its neighbourhood of several groups of sedimentary strata, and the occurrence of fossils in considerable abundance.

Until the season 1866-67, although the Geological Survey had been extended to within a comparatively short distance of Nágpúr, both on the north and the west, it had been impracticable to examine the very interesting formations in the immediate neighbourhood of the city, and to correlate them with the rocks containing similar fossils in other parts of India. It was especially desirable that this should be done in the case of the sandstone of Silewádá and Kámthi, because the fossils found in them by Malcolmson and Hislop were known to be similar to those occurring in the beds associated with coal in Bengal and the Narbadá valley. The practical results of the examination, so far as the probability of finding coal near Nágpúr is concerned, were published in the Records of the

Geological Survey of India for 1868, p. 26. A more detailed account of the rocks is given in the present paper.

It should be premised that, with the exception of the sandstone area, the country was not closely examined, as much important work remained to be done in the working season. No attempt was made at following out the intertrappean beds in detail, nor of mapping the various forms of metamorphic rocks.

Previous Observers.—It is unnecessary to enter into any detail in describing the earlier notices of the Geology of Nágpúr. The first was a paper by Voysey, "On the Geological and Mineralogical Structure of the Hills of Sítábaldí, Nágpúr, and its immediate vicinity," published in the Asiatic Researches, vol. xviii, pt. 1, p. 193; and in Gleanings of Science, 1830, vol. ii, p. 27. In this the basaltic rocks of Sítábaldí are the principal subject treated of, and the sandstones are scarcely mentioned.

Voysey: 1830.

The next contribution was by Captain F. Jenkins, As. Res., xviii, pt. 1, p. 195, in a paper entitled, "An account of some minerals collected at Nágpúr and its vicinity," with remarks on the Geology, &c., of that part of the country. This account which appears to have been drawn up with Voysey's assistance contains many details of the rocks, and is accompanied by a very fair Geological map. Malcolmson's well known article "On the fossils of the eastern portion of the Great Basaltic District of India, Trans. Geol. Soc., Lond., Ser. ii, vol. v, p. 537, added nothing to Captain Jenkins's account of the immediate neighbourhood of Nágpúr, but in a "Note on fossil plants discovered in the sandstone rocks at Kamptee near Nágpúr," published in the Journal of the Bombay Branch of the Royal Asiatic Society, vol. i, p. 249, the same geologist first announced the discovery by Lieutenant Munro of vegetable remains in the Kámthi sandstone. The fossils figured are species of *Glossopteris*.

Jenkins.

Malcolmson.

Hislop : 1853.

Nothing of any importance was added to the published information on the Geology of Nágpúr until the appearance of a description of the "Geology of the Nágpúr State," by the Revd. Mr. Hislop, in the Journal, Bombay Br. Roy. As. Soc. for 1853, vol. v, p. 58,* followed by Messrs. Hislop and Hunter's paper, "On the Geology and Fossils of the neigbourhood of Nágpúr, Central India," in the Quarterly Journal of the Geological Society, London, for 1855, vol. xi, p. 345. This admirable paper, the geological portion of which is entirely Mr. Hislop's work, is one of the most important additions to the Geology of India ever made by an independent observer. Although I am obliged to differ from some of Mr. Hislop's views as to the relations of the different strata, and although some additional instances will be pointed out in the following pages in which I cannot coincide with his results, it is a simple act of justice to acknowledge what a vast amount of aid has been afforded to the Survey by his published observations. The whole country in the neigbbourhood of Nágpúr and for many miles around in every direction, had been searched for fossils, so that, in many instances, in order to decide questions concerning the identifications of beds, it was sufficient to visit and examine a well-defined locality. The Survey in fact, in a similar case, is placed in the same position as Geological Surveys in Europe, and it is no exaggeration to say that the duties of the Indian Survey would be lightened and facilitated to an immense extent if every locality had received from previous observers the same close and careful examination which the neighbourhood of Nágpúr had received from Mr. Hislop, while the collection of fossils is an undertaking which can only be successfully carried out by a local observer, who can avail himself of such opportunities as may be afforded by quarrying, mining, road-making, digging for tanks, &c.

* See also a Postscript to this paper in the same vol., p. 148.

Additional papers were published by Mr. Hislop "On the connexion of the Umret Coal Beds with the plant beds of Nágpúr, and of both with those of Burdwan" in Quart. Jour., Geol. Soc., Lond., 1855, vol. xi, p. 555; "On the ages of the coal strata in Western Bengal and Central India,"—Jour., As. Soc., Bengal, 1855, vol. xxiv, p. 347; On the tertiary deposits associated with trap rock in the East Indies, with descriptions of the fossil shells, &c.,"—Quart. Jour., Geol. Soc., Lond., 1860, vol. xvi, p. 154; "On the age of the fossiliferous thin-bedded sandstone and coal of the province of Nágpúr, India,"—*Ibid*, 1861, vol. xvii, p. 346; Remarks on the Geology of Nágpúr,—Jour., Bombay Br. R. A. S., 1861, vol. vi, p. 194; "Supplemental Note on the plant-bearing Sandstones of Central India,"—Quart. Jour., Geol. Soc., 1862, vol. xviii, p. 36, and finally, "Extracts from letters relating to the further discovery of fossil teeth and bones of Reptiles in Central India,"—*Ibid*, 1864, vol. xx, p. 280. These communications, each of which announced some addition to the previous knowledge of the geology or the fossil remains found in the country, were only interrupted by the writer's untimely death, by drowning, in 1863.

A Labyrinthodont amphibian found at Mángli by Mr. Hislop was described by Prof. Owen as *Brachiops laticeps*. in 1854,—Quart. Jour., Geol. Soc., vol. xi, p. 37; some entomostraca tertiary and mesozoic by Prof. Rupert Jones,—*Ibid*, vol. xvi, p. 186, and vol. xix, p. 149; tertiary insects by Mr. Andrew Murray,—*Ibid*, vol. xvi, p. 182; and, lastly, the plants from Kámthi and Silewádá by Sir C. F. Bunbury,—*Ibid*, vol. xvii, p. 325.

Owen: 1854.

Jones: Murray: Bunbury.

The following is a brief review of the rocks around Nágpúr according to Mr. Hislop's classification as amended in his latest writings:—

I.—Superficial formations:—1, black soil, or regur; 2, red soil.
II.—Brown clay.
III.—Laterite.

IV, V, and VI.—Upper and lower trap and the enclosed sedimentary formation.

VII.—Sandstone formation.

A. Coarse thick-bedded sandstone with iron bands, subsequently considered the equivalent of the sandstone of the Máhádevá hills or Máhádevá group of the Geological Survey classification. To this group Mr. Hislop referred the sandstones of Bokhárá, Silewádá, Kámthi, and other localities northward of Nágpúr, and that of Báráogáon and Chookherí to the west and north-west, also that at the base of Sítábaldí hill. In one of his later papers, Q. J. G. S., vol. xvi, p. 159, Mr. Hislop classed this division with the traps.

B. Laminated sandstone or shale; subsequently considered the equivalent of the Damúda group. In this division, Mr. Hislop placed the laminated fossiliferous sandstones of Silewádá and other localities near Nágpúr, and also the red shale of Mángli. The latter Mr. Hislop subsequently considered newer than the laminated sandstones.

C. Red shale of Korhádí near Nágpúr, afterwards referred (correctly) to the Talchír group, but still later, Q. J. G. S., xx, p. 282, classed with the beds of Mángli and Maledi above the laminated sandstones.

D. White marble of Korhádí, &c.

VIII.—Plutonic and metamorphic rocks. The plutonic rocks Mr. Hislop considered as of later date than the sandstone formation.

It is as well to mention at once that, besides the differences from Mr. Hislop's views on the history of the traps and intertrappean, which, in common with the late Mr. J. G. Medlicott,* I have already expressed in these memoirs†, the result of my examination of the Nágpúr country has led me to conclusions with regard to the relations of the sandstones differing from those of Mr. Hislop in the following points. With regard to Mr. Hislop's division A, I look upon the beds at the base of Sítábaldí hill and

Relations of these groups.

* Memoirs of Geological Survey of India, vol. ii, pp. 206—208.

Dr. Carter was the first to suggest the idea of the trap beneath the intertrappean formation being a subsequent effusion,—Jour., Bombay Br. R. A. S., vol. v, p. 267.

† Vol. vi, pt. 2, pp. 152—155.

its neighbourhood as later in age than the coarse sandstones of Bokhárá, Silewádá, Kámthi, &c. The former I class, as did Mr. Hislop in his later papers, as representatives of the Lameta or infratrappean beds, now clearly ascertained to be much newer than the Máhádevá sandstones proper.* The latter I associate with the 'laminated sandstone' of Mr. Hislop in a group which I call '*Kámthi*,' and which is, I believe, older than the Máhádevá group. To this Kámthi group I refer the rocks of Mángli and the mass of the Chándá sandstones, together with an immense mass of beds in the valley of the Godávari.† The red shale of Korhádí I consider Tálchír, and the white marble of the same locality I refer to the metamorphic rocks. The latter here, and throughout the plains of India, I believe to be of much older age than any of the unaltered sedimentary rocks found in the neighbourhood of Nágpúr.‡

General Features of the Country, Geographical and Geological.—The neighbourhood of Nágpúr has been so often and so well described by previous writers that it is only necessary briefly to point out its leading characteristics. The town stands upon the eastern edge of the undulating trap country, the cantonment and civil station of Sítábaldí being, for the most part, built upon the trap itself. The country to the west does not rise into hills of any great height, though it is interspersed with low ranges, and both these and the valleys between

* Mr. Hislop in 1859, Q. J. G. S., vol. xvi, p. 159, so far modified his views as to class the sandstone at the base of Sítábaldí hill with the overlying intertrappean, but he still considered it as the equivalent of the sandstones of Bokhárá and of the Máhádevá hills.

† See Records, Geological Survey, India, 1871, p. 49.

‡ It is only justice to Mr. Hislop to say that to any one unacquainted with the rocks in other parts of India, as Mr. Hislop was when he commenced his explorations, the Geology around Nágpúr presents unusual difficulties, from the circumstance that the greater part of the country is covered by alluvium, and that the rocks are only seen at all in a few isolated spots. Besides, when Mr. Hislop first wrote, scarcely anything definite was known of the relations of the different sedimentary formations; now, we have the advantage of some 15 years' study of them by the Geological Survey.

are covered with black soil, much mixed with stones. Near Nágpúr the greater portion of the country is cleared, but the amount of jungle increases with the distance from the station, until, at a distance of 12 to 15 miles, it covers a considerable proportion of the surface. Southward the country is similar to that to the west.

To the south-east, east, and north-east the surface is, for the most part, a plain covered with the alluvial deposits of the Kanhán and its tributaries. This plain extends to the north-east for some distance beyond Kámthi, and the sandstones near that station are only exposed in a few places on the left (north-east) bank of the river. To the north and north-west the same plain of alluvium is continued, but from its surface in several places, rise hills of sandstone and metamorphic rocks.

Classification of Rocks.—Excluding the soils and the alluvial deposits of the Kanhán and its tributaries, the following formations are found near Nágpúr:—

3. Trappean series	*b.*—Trap and intertrappeans.
	a.—Infratrappean or Lameta.
2. Sandstone series	*b.*—Kámthi group.
	a.—Tálchír group.
1. Metamorphic series.	

1.—Metamorphic Series.

As already observed, no special attention was paid to these rocks. They must occupy all the country to the east and north-east of Nágpúr for a great distance, but, near the city, they are, in general, completely concealed by alluvium. They are seen at the base of Sítábaldí hill around the railway station. Here the rocks are gneiss, very much decomposed at the surface, and it must be their decomposed appearance, and the resemblance to a soft sandstone thereby produced, which led Mr. Hislop to a belief in their being an altered form of the overlying sedimentary rock. They are also seen, but only for a very short distance,

At Sítábaldí.

in the Nág Nadi, about half a mile west of the spot where the stream crosses the Chándá road, and north of Sítábaldí they were detected in one place just north of the high road to Kámthi. To the east of the city the country was not examined.

Korhádí.

To the north of Nágpúr a low range of metamorphic hills commences about a mile east of Kámthi, and extends to Korhádí. The rock is chiefly a granitoid gneiss. The foliation to the eastward is about north-east—south west, with a dip to the south-east, but north and west of Korhádí village it runs north and south, and is vertical. At this spot a considerable quantity of crystalline limestone occurs, being the rock which Mr. Hislop described as a sub-division (D) of the sedimentary formation altered by the plutonic rocks of the neighbourhood.* The strike, as abovementioned, differs entirely from that of the gneiss a little farther to the east, but to the west towards Máhádúlá it changes again to the same strike as to the eastward. A little limestone, here containing serpentine, is again seen west of the small village of Máhádúlá, and again about a mile still further to the westward, rather more than half a mile south-east of the village of Gúmthulá.

Serpentine.

Kolár river.

Gneiss is seen at intervals in the bed of the Kolár from the neighbourhood of the Korhádí hills to the village of Dáhígáon Rangarí. To the north of the Kolár the country consists of sandstone, mostly, however, concealed beneath alluvium, but near the Kanhán, and in the Pench, metamorphic rocks are exposed at intervals. To the north-west, they are best seen near Khápá and Kelod, where the strike is east and west and the dip south.

* Mr. Hislop was probably chiefly induced to class this limestone with the sandstones from the latter having been considered by Voysey and Malcolmson representative of their 'diamond sandstone" (the Vindhyan or Kadapá series of the Geological Survey Classification), which, in the Krishna and Godávari valleys and in Bandélkand, is associated with limestone.

There can be no reasonable doubt of the metamorphics around Nágpúr being an integral portion of the great series which occupies the greater part of the country thence to the Bay of Bengal. The age of the formations which have been altered into the gneiss, mica schist, hornblend schist, quartzite, limestone, &c., which are its principal constituent rocks, is quite unknown, but that they were all in their present crystalline condition, before the deposition of the Vindhyans, is clear, because the latter rest unconformably upon them, and contain rolled fragments derived from them, and the Vindhyans are of vastly greater age than the very oldest of the sandstone formations found at Nágpúr, for the latter, as will be presently seen, contain rolled pieces of the former. It cannot, therefore, be conceded that the plutonic rocks contemporaneous with the alteration of the gneiss have affected the sandstones found in the Nágpúr area.

2.—Sandstone Series.

a. Tálchír group.—Rocks occur at two places near Nágpúr, one of which there can be very little hesitation in assigning to the Tálchír group, whilst the other probably belongs to it. The only important exposure is that already referred to as the red shale of Korhádí, the type of Mr. Hislop's sub-division C of the sandstone series. This occurs between Korhádí and Bokhárá, about six miles north of Sítábaldí.

Bokhárá.

West of the Chhindwárá road, and north-east of the village of Bokhárá, grey clays and yellow sandstones are exposed in some ravines. They are, however, very ill seen, and all that can be said is that they are probably Tálchírs. Gneiss appears to come in beneath them, but close to the road, yellowish sandstone is again seen at the head of a small stream which runs to the north-east. The recurrence of the sandstone is probably due to a fault. Following the little stream across the road, hard calcareous red

shale is met with in places, dipping south-south-west. This is the spot at which Mr. Hislop obtained worm tracks.

In this stream the beds are somewhat decomposed, and have not the typical character of Tálchírs. But in a very small watercourse which runs from the north into that already mentioned, and which is just south of the little limestone hill immediately east of the Chhindwárá road, the typical fine silty shales are met with, breaking up into minute flakes, and only differing from the Tálchírs of Bengal and Orissa in their dull red colour. Calcareous bands, also of a red tint, and sandy layers are intercalated, as is frequently the case elsewhere. Pebbles and boulders abound, mostly surrounded by a calcareous crust: some are rolled, many angular; and besides metamorphic fragments, rolled and unrolled blocks of quartzite-sandstone and limestone from the Vindhyans* are abundant, and many of them are of large size. Pebbles of slate of unknown origin are also found.

'Boulder bed.'

Some huge blocks of granitoid gneiss, seen east of this, may be from the same boulder bed; but farther to the eastward no rocks are seen, and the whole country is covered with alluvium; so it is also possible that they may be masses *in situ*. To the north near Korhádí the metamorphics with limestone, as already described, come in beneath the Tálchírs.

The only other place near Nágpúr where beds have been observed, which appear to belong to the Tálchírs, is north of Pátan Sáongí, 14 miles north of Nágpúr. All around the village is alluvial, but, about two miles north of it, a

Pátan Sáongí.

* No Vindhyans are known to occur in the neighbourhood of Nágpúr. The nearest now existing are probably some hills lying east of Umred (Oomrair). But there can be little doubt of these Tálchír boulders having been derived from a distance as is so frequently the case amongst these rocks.

small isolated hill called Koda Dongrí, consists of pale buff argillaceous sandstone, very hard and compact, and containing pebbles of purple and white quartzite, and of very compact fine sandstone, all probably derived from the Vindhyans. It is far from clear to what formation this rock should be assigned, but similar beds are sometimes found in the Tálchír group. The stratification is vertical, striking east and west, and the rock is much cut up by quartz veins. Another small hill, rather more than a mile north-north-east of Koda Dongrí, consists of brecciated quartz rock similar to that found on lines of fault, and still farther to the north, near the Kanhán river, metamorphics are exposed.

b. Kámthi group.—No rocks which from their *mineral* character can be identified as belonging to the true Damúda formations (Barákar and Rániganj groups) of Bengal and the Narbadá valley, have as yet been found near Nágpúr. The beds containing coal to the south near Chándá, on the other hand, are similar in character to the Barákar group. The Kámthi beds, the relations of which to the Damúdas proper will be discussed in a subsequent page, occupy a considerable tract of country north and north-west of Nágpúr, a great part of the area being, however, concealed by alluvial deposits. They also appear in some inliers within the trap country.

Kelod.

The north-western extremity of the sandstone tract is at Kelod, where coarse felspathic grits are seen dipping to the north, in which direction they are faulted against the metamorphics. Very little is seen here, all the rocks being covered to the east and south-east by alluvium, while, to the west, both sandstones and metamorphics disappear beneath the trap.

Sáoner.

From Kelod to Sáoner, about six miles south-south-east, no sandstones are exposed. South of the latter place, brown grits and lilac clays or decomposed argillaceous sandstones crop out from beneath the traps with an undulating dip.

Thence to the eastward a long rise of sandstone extends, the beds being apparently horizontal. South of this, close to the village of Adúsa, there is a small hill, composed of rather soft grit, with a few thin beds of very fine compact red argillaceous sandstone,* or compact shale. The general dip of these beds is to the north. All the intermediate country between these few outcrops is occupied by alluvium.

Adúsa.

About five miles farther to the south-east, hills again appear, south and south-east of Pátan Sáongí, in a ridge stretching for about three miles from west to east, from the village of Chándá to Chicholí, close to Pádrí Kháp á. The rocks consist of whitish argillaceous sandstone with lilac streaks, intercalations of red and yellow compact shale, and coarse gritty beds with conglomerate and bands of deep brown ferruginous grit. *Glossopteris* leaves are met with here and there in fine white argillaceous sandstone, the plant impressions being destitute of carbon and coloured red. Altogether a considerable thickness of rocks is exposed. The dip is irregular, the beds rolling about very much; but they have a general inclination to the south.

Plant remains.

West of the hill, near Pátan Sáongí and south of that at Adúsa, sandstones are exposed close to Sáilorí, and may be traced to the trap boundary near Walní and thence along the south edge of the igneous formations as far as Bokhárá six miles north of Nágpúr. The rocks here seen may be described before the remaining isolated exposures in the plain to the north.

Sáilorí.

* It is difficult to say what is the correct name for this rock. It is compact, and under the lens has the appearance of an amorphous limestone, which it also resembles in hardness and in its somewhat conchoidal fracture, but it is not calcareous. It appears to consist of very fine sand and clay. It has no shaley structure. Its original colour is sometimes buff, sometimes red; at the surface it is usually of the latter colour. It is a very well marked and characteristic rock.

The little hill south-east of Sáilorí is of sandstone; just south-west of the hill in the Chandarbhága stream, a small fault is seen apparently running north-west—south-east. North-east of this fault the beds dip to the north, while on the other side conglomerates containing quartzite pebbles and lilac shales, impregnated with carbonate of lime, have a high south-west dip.

Tondakherí.

The rocks of the rise near Tondakherí, about two miles farther south, are coarse felspathic grits, conglomeritic in places, with sandstones and fine red compact shale, which is more conspicuous here than it usually is. The beds are quarried to some extent, and are traversed by joints striking west-15°-north and north-20°-west and nearly vertical.

Khandálá.

West and south of Tondakherí, the junction of the Kámthi beds and the trap is concealed by alluvium. To the south-east, the village of Walní is on trap, a very thin cap of which covers the little rise north-west of the village, and the sandstone crops out all round, except to the south. The uppermost beds of the Kámthi group here seen are purplish felspathic grits. At Khandálá, half a mile farther to the south-east, coarse grit, somewhat hardened, is seen, only a little appearing above the alluvial clay, and here, as at Tondakherí and Walní, the sandstone rocks have no definite dip, but roll about, for the most part, at low angles. They can only be traced here and there close to the trap.

Bharatwádá.

Beds similar to those of Walní and Tondakherí are exposed at Bharatwádá and Gotaikhápá, or Chakikhápá, as the village is also called. No good sections are seen, but a few small quarries exist here and there; they are very small excavations, from which a few cubic yards of stone are removed for local purposes, and the excavations are then abandoned and allowed to fill with rubbish. South of Gotaikhápá a few poor sections of felspathic

sandstone are seen in a stream. These have a steadier south or south-south-west dip, which continues hence to the eastward as far as Bokhárá.

Bokhárá.

The rocks may be traced here and there along the base of the trap hill south-east of Gotaikhápá, and one or two ridges formed of them are seen just west of Bokhárá. This locality is of especial interest, from being one of those most frequently mentioned in Mr. Hislop's papers, and although no large exposure of the rocks takes place, those seen demand a somewhat closer description.

The Kámthis form a small ridge, stretching along the trap boundary, which here runs nearly east and west. Trap is seen resting upon them in the little isolated hill close to the village of Bokhárá, again a short distance south-west of the hill, and also at the base of the trap hill about a mile west of the village. In all these cases, except the first, where a few inches of silicious beds representing the infratrappean group intervene, the trap rests directly upon the Kámthi sandstone. West of the village, the uppermost beds of the latter are felspathic sandstones or coarse grits, often stained with iron. They are not calcareous, nor do they contain chert, as is usually the case with the infratrappean group.

The quarried beds which succeed in descending order have been well described by Mr. Hislop.* I did not, however, observe the angular fragments of fine sandstone which he notices as contained in them. The principal rock is a hard compact grit, with a peculiar vitreous character, and breaking with a conchoidal fracture. In the quarries to the westward, hardened shales, pale bluish grey in colour, rest upon this grit, and contain imperfect plant remains; and near the village, at the side of the road which passes south-west of the little trap hill already mentioned, *Phyllotheca* is found in some shaley beds. Mr. Hislop mentions a car-

* Quar. Jour. Geol. Soc., Lond., xi, p. 369.

bonaceous* bed at Bokhárá. This I could not find; here, as elsewhere, I was struck by the absence of carbonaceous matter even in the impressions of fossil plants.

Lonhárá. Gúmthula.

Of beds below the hard band of grits, very little can be seen. On the road from Bokhárá to Lonhárá, coarse felspathic sandstones are exposed; thence to Gúmthula, where metamorphics occur, all the surface is covered by alluvium. East and south-east of Bokhárá, also, no rocks are seen, the last place where Kámthi beds are exposed being nearly due south of the village. From this spot the trap boundary sweeps round to the south, and when sandstones again appear below it near Táklí and Nágpúr, they belong apparently to a different series of beds, which will be described presently.

Chicholí.

Silewádá.

But if, instead of following the trap boundary from south of Pátan Sáongí to Bokhárá, the strike of the isolated hilis already described as extending from Chándá to Chicholí be followed, after passing over a considerable tract of alluvium on the banks of the Kolár river, a very interesting low ridge of rocks is met with, on the same strike as those of Chicholí, exposed south of the village of Silewádá, and again, on the same strike, after another intervening tract of alluvium, a second exposure of similar beds occurs just north of the river Kanhán at Kámthi. Between the belt of Kámthi rocks thus exposed in these two localities, and the area occupied by beds of the same group near Bokhárá, the metamorphic rocks and Tálchírs of Korhádí intervene, apparently brought up by a fault. The two localities near Silewádá and Kámthi are those from which the bulk of Mr. Hislop's fossils were

* Mr. Hislop's words are, "the higher laminæ .. exhibit .. an approximation to the "carbonaceous colour, being quite brown through the amount of comminuted vegetable "matter which they contain"—Quar. Jour. Geol. Soc., vol. xi, p. 557. The bed is again mentioned in the same Journal, vol. xvii, p. 347. I cannot help suggesting the possibility of the brown colour being due to iron or manganese.

derived, and from the latter the name of this group of rocks has been taken.

Silewádá.

As already mentioned, the exposure near Silewádá consists of a low ridge striking about east-30°-south, about three miles in length, and not more than 200 yards broad; the village of Silewádá lying north of the centre, and on the alluvium, with which all the country to the north and south is covered. The beds dip south-30°-west at an average angle of 15°; neither their top nor their base is seen, nor can their relations to the metamorphics, which appear at a considerable distance in both directions, be ascertained. It is most probable that the sandstones are faulted on both sides, the fault to the north continuing to Kelod in one direction, and to Kámthi in the other; but this is not certain, and can only be inferred from the apparent straightness of the line of outcrop.

Quarries.

Numerous quarries have been opened in the neighbourhood of Silewádá, upon at least four different beds, and these afford opportunities for examining the section to some extent, although the surface between the quarries is much concealed by the débris taken from them. The following is a combined section, made out partly from the rocks seen in the quarries, partly from surface measurements, aided by information obtained from the quarrymen, and, although only an approximation, it is probably nearly correct as regards the succession of the rocks and their average thickness :—

		Thickness in feet.
1.	Compact coarse gritty felspathic sandstone, light brown or grey in colour, containing one or more thin bands of fine purplish argillaceous sandstone, which is quarried in one place. This is the highest bed seen, the thickness cannot be correctly determined.	?
2.	Soft felspathic grit, very loose in texture, red, speckled with white, the top is not seen; in one quarry there is exposed a thickness of	15 0
3.	Yellow and red gritty sandstone, slightly micaceous, with gritty ferruginous bands.	2 0

4. Greyish white sandstone, purplish in places, slightly argillaceous, varying somewhat in texture, being coarse in patches, though generally fine. 4 0

This is a good building stone used by the natives for temples, and large slabs are cut for gravestones. In another quarry, this rock is softer, much coarser, and more felspathic, but still quarried for building purposes.

5. Grit with hard ferruginous bands; no section seen, minimum thickness. 10 0

This bed is probably thicker and may include other bands.

6. Fine yellow (or deep buff) compact shale, becoming red near the surface. 3 0

A fine building stone used for ornamental purposes.

7. Grit and conglomerate, no section seen; it probably resembles the next. 50 0

8. Coarse ferruginous grit and conglomerate with irregular ferruginous bands as in 3 and 5; these bands are very hard,* and are evidently not due to original deposition, as they cross the bedding, and in one case a band was seen in the form of an oval. Conglomerate beds are dispersed throughout the rock. In one quarry there is seen a thickness of 25 0

9. Fine brown argillaceous sandstone, peculiarly laminated in places, with curved joints, nearly in the direction of the stratification, which contain a black mineral† (sesquioxide of manganese?). This bed is probably local. 0 6

10. Fine buff-coloured compact shale, much resembling 6, very similar to the bed containing *Estheria* at Mángli between Nágpúr and Chándá. The rock becomes red near the surface. It has been largely quarried. 4 0

11. Fine compact variegated lilac and grey sandstone, slightly felspathic, containing *Glossopteris*, &c., used for the floors of bungalows. 0 6

From this bed all the Silewádá fossils have been obtained.

12. Compact grey and purplish sandstone used for building, base not seen. ?

Bed 8 appears to be Mr. Hislop's bed A, and the underlying beds, his division B. It is difficult to account for his considering No. 8 the highest bed seen, unless he looked upon the fine-textured beds, 4 and 5, as repetitions of 10 and 11. But it is clear that all form one continuous series, one bed after another crops out with the greatest regularity. It is true that at the base of No. 8 there is slight irregularity of

* These are the "iron bands" of Mr. Hislop.

† This is perhaps similar to the brown bed observed by Mr. Hislop at Bokhárá.

deposition, as frequently happens where a coarse-textured bed rests upon a fine one, but there is no good reason for believing that any break in the sequence takes place, far less for assigning the rocks above this line to the Máhádevás and those below it to the Damúdas.

In a quarry nearly a mile farther to the west than the spot where the above section was measured, the coarse grit, No. 8, appears to rest directly on the *Glossopteris* bed 11, 9 and 10 being wanting or represented by a layer of argillaceous sandstone a few inches thick. The ferruginous bands in 8 are here strongly developed, and above it there is thick felspathic sandstone. To the east, the outcrop runs along the right bank of the Kanhán river for some distance, and one of the bands of argillaceous sandstone, apparently No. 10, is well exposed.

The above section is, on the whole, the best met with in the neighbourhood of Nágpúr; the rocks opposite Kámthi, though well exposed, being, on the whole, more concealed by alluvial clay. The details given afford a fair conception of the typical kinds of rock in the Kámthi group with one exception, the semivitreous grit quarried for millstones at Bokhárá.*

Absence of carbon.

At Silewádá, as elsewhere, there is a remarkable absence of carbon. All the plant remains are mere impressions, the substance of the leaves being replaced apparently by red ochre. It is difficult to say how far this replacement of carbon by iron peroxide may have taken place. The yellow and red compact shales may be an altered form of the compact blue and carbonaceous shales elsewhere associated with the Damúda rocks, which contain the same plants as those of Silewádá. This subject, however, will be discussed in the sequel.

* The hardness and peculiar semi-vitreous character of this rock might be ascribed to the neighbourhood of the overlying trap (not to hardening by heat, an effect which rarely extends more than a few inches, but to infiltration of silica); but a similar semi-vitreous rock is found elsewhere in the Kámthi beds far from the trap boundary.

The rocks in the quarries at Kámthi have the same dip as near Silewádá, and appear to be on a continuation of the same beds. It is therefore unnecessary to describe them in any detail.

The quarry whence Mr. Hislop obtained most of his fossils is a little to the east of the high road from Nágpúr to Jabalpúr. The fossiliferous blocks which he looked upon as boulders derived from a lower bed appeared to me to be the remnants of a band of sandstone very similar in character to that (No. 11) containing *Glossopteris* at Silewádá, but, as is frequently the case close to the surface, a large portion of the bed has decomposed, and the remainder appears in the form of irregular rounded blocks loose in the soil. That these are in their original position, and that they form parts of one bed, is evident from their arrangement along one line, and from the planes of bedding in all being parallel. The forms of fossil plants are more numerous than at Silewádá. *Pecopteris* and other forms occur besides *Glossopteris*.

Large blocks or separate portions of bed.

No other exposure of Kámthi rocks has been detected in this neighbourhood to the south or south-east within the limits of the Nágpúr district, but within the trap area west and north-west from Nágpúr there are three inliers* of the same beds. Two of these, one being very small, are near the villages of Chorkherí and Kútkheri, 12 miles west of Kelod, the third is near the town of Bázárgáon, 20 miles west of Nágpúr.

Chorkherí: Kútkheri.

The Chorkherí inlier is about four miles in diameter from north-west to south-east, and nearly three miles broad at right angles to the above. Except at the north-west corner, where some infratrappean limestone occurs, the only beds met with are Kámthi, the most common being the usual coarse

Chorkherí.

* These are all mentioned and briefly described by Mr. Hislop—Q. J. G. S., vol. xi, pp. 352-353.

gritty felspathic sandstone, conglomeritic in places, and often intersected by hard ferruginous bands with red compact shale here and there. No good sections are seen, and the country is covered with thick jungle. The coarser grits are quarried for millstones, &c. The rocks have, throughout the inlier, a tolerably steady dip to the north, which seldom, if ever, exceeds 5° to 10° at the extreme north of the field; and, consequently, amongst the highest beds exposed, a few plant fossils, principally *Glossopteris*, were found in a fine compact reddish sandstone. These impressions are red in colour, and devoid of any carbon as near Nágpúr.

Kútkheri.

The Kútkheri inlier is only 1½ miles south-east of that of Chorkherí. It consists of a mere ridge of rocks nearly a mile long, striking east-20°-south and projecting above the traps, the dip is to the northward. The beds are identical with those of Chorkherí.

Bázárgáon.

The Bázárgáon inlier is much larger; it extends 10 miles from east to west, and 5 from north to south. The western part, which is covered with jungle, is hilly, consisting of flat-topped rises of no great height, and between them valleys filled with sandy soil, in which no rocks are seen in general, even in the streams which traverse them. The hills are composed of horizontal or nearly horizontal beds of coarse white, grey and brownish grits, sometimes blotched and streaked with purple. These are more or less felspathic, and contain pebbles of quartz or quartzite scattered through them, occasionally in sufficient numbers to make the rock a conglomerate, and the ground in places is covered by the pebbles. Mica frequently abounds.

Ghorpúr.

Fine red and mottled compact shale similar to that of Silewádá is seen below the grits on the hill south of Ghorpúr. No rocks are exposed immediately beneath this, but grits, undoubtedly, underlie it, and appear on the lower ground not

far off. On the whole, the rocks of the western portion of the Bázárgáon inlier much resemble some of those seen at Sálbaldi east of Ellichpúr.

Lárái.

The rocks near Lárái about the centre of the sandstone patch are exactly similar to those seen further west, but instead of being horizontal, they dip to the south-west. From beneath them, south of Lonhárá, grits and red and yellow compact shales crop out, similar to those of Silewádá and Kámthi. These grits are not conglomeritic; they contain the usual hard ferruginous bands, fragments of which are scattered over the country.

Dhámná.

To the south near Dhámná scarcely any sandstone can be seen in place, but north of the village plenty is visible. The trap is well exposed outside the north-east boundary near the village of Ashtí, but thence towards Lonhárá all the rocks are concealed by alluvium, and it is impossible to say what are the limits of the sedimentary formations in this direction. They may extend towards Kalmeswar, but it is more probable that trap exists beneath the alluvium in that direction.

3.—Trappean Series.

At Kelod.

a. Infratrappean or Lameta Group.—Throughout the greater portion of the trap boundary between Nágpúr and Kelod, wherever the contact of the two series is exposed, the igneous rocks rest immediately upon the sandstones of the Kámthi group. At Kelod a thin infratrappean bed is met with. It is well seen about half a mile west of the town, resting upon Kámthi sandstones, and again to the north near Jáithgarh tank, where it overlies metamorphic rocks. The bed in each place is nodular calcareous grit or gritty limestone, and the thickness apparently does not exceed 10 feet, but perhaps it is more than this, and it probably varies. Down the stream which flows past Kelod, about 200 yards east of the small quarry, itself at the east end of the town, the Kámthi rocks are seen

faulted against the intertrappeans, but the junction is ill seen, and throughout the surrounding ground the rocks are concealed by alluvium. From this point to the immediate neighbourhood of Nágpúr, the only spot where any sedimentary rock was found intervening between the traps and the subjacent formation, was at the little trap hill close to Bokhárá.

Infratrappeans are seen on the edge of an inlier near Rámpúra, south-west of Kelod. Below the earthy trap at the base of the igneous rocks there is a foot of green marl and then 1½ to 2 feet of red marl, both containing much nodular carbonate of lime; beneath these again apparently (the section is obscure) there is calcareous grit. Kámthis probably occur here, but they are not seen at the surface.

Rámpúra.

Along the edge of the Chorkherí inlier, as already mentioned, infratrappean calcareous grit is seen at one spot only on the north-west corner.* In the large Bázárgáon inlier, it occurs along the north-east boundary near the village of Ashtí, and thence for some distance towards Lonhárá. In both the above instances, the rock is the usual limestone with irregular nodules of chert.

There can be no doubt but that the sandstone seen below the trap at the eastern base of Sítábaldí hill also belongs to the infratrappean or Lameta group; it is a gritty tufaceous sandstone of a white colour mottled with red, and somewhat decomposed; the total thickness is not seen, but it is apparently less than

Sítábaldí infratrappean.

* About four miles north of Chorkherí, on the road from Nágpúr to Betúl, close to the village of Chicholí, there is a small inlier about a mile in diameter entirely composed of limestone, resembling the infratrappean bed. The rock is scarcely exposed, except in the small stream which runs west and north-west of the village. In places it is finer in texture and purer than usual, being free from grit and chert nodules, but in general it presents the usual character. The bed is mostly horizontal, but it must be much thicker than at other places. It is possible that this inlier is an intertrappean bed, the base not being seen, and the intertrappeans occasionally, though rarely, assuming the same mineral character as the bed at the base of the trap. But probably it is infratrappean.

20 feet. The upper portion does not appear to have been altered to any perceptible extent by the overlying trap.

Mr. Hislop, as already mentioned, considered that this sandstone passed into gneiss. The surface of the latter rock is so much decomposed that an appearance is produced of a change from the hard crystalline gneiss into the soft decomposed sandstone, but this is merely an appearance, and one not unfrequently met with. It is undoubtedly deceptive, and, for reasons previously mentioned, the gneiss rock must be considered as of long prior date to the sandstone.

The sandstone is well seen along the eastern base of the hill, but it is almost impossible to trace it round the southern end or amongst the houses and gardens west of the hill. There is, however, every reason to believe that it occurs there, and, as was pointed out by Mr. Hislop, it is exposed a little farther west in the Nág stream close to the bridge on the road from Nágpúr to Bisnúr and Umráwatí, and in some ditches near the stream. The thickness here appears greater than it is beneath Sítábaldí hill. The lower portion of the bed is again white tufaceous gritty sandstone, conglomeritic in places and mixed with chert, which does not occur east of Sítábaldí hill. Above the sandstone is a bed of very compact hard grit having a cherty or jaspery texture, and breaking with a conchoidal fracture, which does not appear to be calcareous.

The same jaspery bed is seen north of Sítábaldí in the fields lying to the north of the north-western branch of the road to Kámthi. Beneath it there is white gritty sandstone. A similar sandstone is seen in places beneath the trap of the rise on which the Táklí artillery barracks stand. The bed could be traced no farther north.

The occurrence of a few inches of cherty vesicular rock beneath the trap of the little hill close to the village of Bokhárá has already been twice mentioned. In neighbouring hills the same bed appears to be intercalated between trap flows.

b. TRAPS AND INTERTRAPPEAN BEDS.—It is unnecessary to enter into any details concerning the traps; as usual, they consist of various kinds of dolerite, varieties of basalt, melaphyr, and anamesite prevailing. The distinctions between amygdaloidal and nodular beds are more or less local; each in turn is found resting upon the other. Anything like a detailed description of the different forms assumed by the rocks of this series locally would be useless, and their general features have been discussed in a previous paper. Memoirs, Geological Survey, Vol. VI, pt. 2.

The intertrappean beds abound to the west of Nágpúr, but no attempt has been made to map them except near the boundary of the igneous rocks in the neighbourhood of the city. To have searched over all the country represented in the accompanying map for these little beds, which frequently do not exceed a few inches in thickness, would have taken far more time than could be devoted to the district, and would have led to no important result. The beds marked on the map may be briefly described, commencing on the north-west.

The first outcrop to be noticed in this direction is about three miles north of Kalmeswar on the little isolated flat-topped hill south of Dhápawádá. The trap flow forming the top of the hill is nodular and of no great thickness, perhaps 30 or 40 feet in the centre of the hill, and 10 to 15 at the sides, the upper surface being of course denuded. Beneath this flow is a bed of argillaceous rock, distinctly altered, and with a nodular structure above, unaltered below; it is 4 or 5 feet thick where best seen on the north side of the hill, and abounds in casts of shells (*Paludina, Lymnea, Valvata, Physa,* &c.), mostly broken.

Dhápawádá.

No intertrappeans are seen south-east of this hill until the neighbourhood of Bokhárá is reached. On all the low trap rises between that village and Mahurjharí, a thin band of vesicular cherty rock can be

traced, precisely similar to that at the base of the little outlying trap hill at Bokhárá. In the next hill to the west this bed is 15 feet below the top of the hill, and 60 feet above the base of the trap, the lowest flow of which is here distinctly nodular, and only slightly amygdaloidal. The intertrappean band is seen as far as north of Pitaisúr, but near Mahurjharí, and to the west of it, it appears to have died out.

Táklí.

The localities near Táklí close to Nágpúr from which Mr. Hislop obtained so large a number of fossils are the next to the south;* one of these is just west of the artillery barracks: the bed is a greenish grey clay, or hardened mud, breaking into small polygonal fragments, and occasionally containing rounded pieces of a rock precisely similar to itself, probably decomposed trap. The whole bed appears to consist of trap detritus; it can only be traced a few yards in any direction, and Mr. Hislop's idea,† that it is a portion of a bed caught up in a lava flow, may very possibly be correct.

The other locality is farther west, south of the Rassala lines. The bed here is a fine muddy clay, and has also the appearance of being formed of trappean débris. It contains fossil shells in abundance. It cannot be traced to any distance, but this may be due to its position in a small ravine, as it is a well marked bed.

There is nothing to be added to Mr. Hislop's description of the freshwater bed on Sítábaldí hill.‡ It is another inconspicuous band. In the quarry at the base of the hill, there is an appearance of more than one flow of trap being included in the thick bed which forms the mass of

* I doubt if I could have found either of these but for their being shown to me by Mr. Hislop's old servant Virápá. Both exposures are extremely small, and the rock so much like decomposed trap that it is most difficult to recognise it; probably many similar obscure beds of very small extent occur in this neighbourhood.

† Quar. Jour., Geol. Soc., Lond., Vol. XVI, p. 158. Of course I do not admit that the whole intertrappean formation has been similarly transposed, as was maintained by Mr. Hislop. See Mem. Geol. Surv., Vol. VI, pp. 152—155.

‡ Quar. Jour., Geol. Soc., Lond., Vol. XI, p. 349.

the hill. There are vesicular bands which may be the surfaces of flows, but they are not very distinct.

Telingkhedí.

West of Sítábaldí, a thin argillaceous intertrappean band may be traced for some distance along the scarp which runs parallel to the road from Sítábaldí to Telingkhedí, and bounds the valley of the Nág to the north. This bed disappears, apparently by thinning out, at both ends, to the east near the station of Sítábaldí and to the west near Phultálá or Telingkhedí tank. It is probable that the thin band on Sítábaldí hill is on the same horizon, and that the two were formerly continuous between the traps now removed by denudation in the Nág valley. North of Telingkhedí the bed is a foot in thickness; it abounds in shells and remains of plants, and in one place a trap pebble was found imbedded in it; this pebble was much decomposed, and it is impossible to say whether it had been rolled or not.

This is the locality to which Mr. Hislop's description at pp. 156-157, and his figure 2 in his paper "on the tertiary deposits associated with trap-rock in the East Indies," Quar. Journ., Geol. Soc., Lond., Vol. XVI, refer. Calcareous bands traverse the trap in an irregular manner, and are considered by Mr. Hislop to be formed of the intertrappean bed dispersed and scattered by the injection of the igneous rock. Newbold* in a similar case spoke of the irregular bands as "kunkur," and evidently considered them to be due to the deposition of carbonate of lime derived from surface water in cracks. This is my own opinion also; similar bands are often found near the surface, not only in trap, but in sandstone, gneiss, and other rocks, and that they can scarcely be dispersed portions of the intertrappean bed is, I think, clear from the circumstance that the latter in this locality is not calcareous.

At the side of one of the small ravines north of the Telingkhedí road, a band of greenish jaspery porcelain rock, resembling a greatly

* Jour. Roy. As. Soc., Vol. IX, p. 33.

hardened clay, is seen in the middle of amygdaloidal trap; it is about a foot thick, and extends for about 20 yards, terminating abruptly at one end. Whether this is part of a sedimentary intertrappean deposit, or a concretionary mass, such as occurs frequently in the infra-trappean sandstones and limestones, it is difficult to say: it may either be part of a sedimentary bed caught up by a flow of lava or simply the result of segregation, like the irregular nodules of jasper and chert which are found both in the amygdaloidal traps and in the underlying beds. The latter appears the more probable view, because bands of jasper frequently occur too thin to have been carried forward by a lava flow without breaking into fragments, yet extending for several feet; but the band near Telingkhedí is an unusually large mass.

No intertrappean rock was seen around Ambághari tank, but there is a considerable quantity exposed about 3 or 4 miles west of Telingkhedí. Time, however, did not suffice for the close examination of the country in this direction.

General Character of the Sedimentary Rocks near Nágpúr, and their relations to those occurring in other parts of India.

Tálchír Group.—It was perhaps rather a lucky guess than anything else which led Mr. Theobald, my brother, and myself in the report on the Tálchír coal-field in 1856 (Mem. Geol. Surv., Ind., vol. i, p. 76), to point out that the clays of Korhádí, near Nágpúr, were probably the representatives of the Tálchír of Orissa. The view, however, was adopted by Mr. Hislop, though in some of his latest papers he appeared more inclined to consider the Korhádí bed as representing those of Máledi (Q. J. G. S., vol. xx, p. 282). The first view proves to be correct, and the same beds are much more extensively developed near Chándá.

It is astonishing that, over so large an area, beds of such trifling thickness as the Tálchírs should everywhere maintain their mineral

character with such remarkable precision. The description of them in Nágpúr is the description of them in Bengal, in Orissa, and in the Narbadá valley. In every case the grey "mudstones," the fine pale brown or greenish sandstones with their peculiar tesselated weathering, and the presence of huge transported blocks, generally rounded, are characteristic of the group.

Origin of boulder bed.

I doubt if we can yet clearly understand the origin of the 'boulder bed.' I suggested in 1856 that the boulders had been transported by ground ice, simply because that was the only way in which I could conceive the occurrence of huge rounded boulders in such very fine silt as forms the principal portion of the bed. The hypothesis is, I grant, improbable, and I should be delighted to abandon it if a better one can be suggested. But I cannot subscribe to my colleague Mr. Hughes's comparison of the boulder bed to the accumulations formed on the coasts of Penang.* In the first place there is no evidence whatever that the Tálchírs are a marine formation. Not a single marine fossil has been found throughout the great plant-bearing series from the Tálchírs to the Rájmaháls, and I cannot help thinking it most probable that all were river deposits; the Tálchírs might be lacustrine; but that their being supposed to be so would involve the hypothesis of so enormous a lake or series of lakes with similar deposits throughout. Still reading lake for sea, the difficulty appears to me just as great as ever. My friend, Mr. Hughes, suggests that the Tálchír boulders may be weathered round, not rolled. This possibly might account for their rounding in some cases, but certainly not in all. At Korhádí the boulders are not only rounded, but they have been brought from

* Mem. Geol. Surv., India, vol. v, p. 236. It is only proper to add that Mr. Hughes, when making this comparison, had only seen Tálchír rocks in places where they appeared to have been truly littoral deposits. He abandoned the idea, when subsequently he found Tálchír boulder beds where they could not have been littoral deposits.

a distance; they are of limestone and hard calcareous shale from the Vindhyans, often of considerable size, distinctly and unmistakably rolled, and all the rocks in the neighbourhood, including those on which the Tálchírs rest, are metamorphic. The difficulty remains. Any current or wave action which could move the boulders to the spot, would sweep away the fine mud in which they are imbedded.

General Portlock, President of the Geological Society in 1857,* while mentioning my view, expressed his preference for Mr. Mallet's theory of mud slips on a coast. This theory, which was proposed in order to explain the phenomena of the glacial drift and the grooves and scratches so prevalent on some of the rocks of Great Britain and Ireland, Northern Europe, and parts of America, was, that both the transport of blocks to great distances, together with gravel, sand, and mud, and the grooving of rock surfaces, may be effected by the slow movement of masses of detritus under water, and their "slippage" on the inclined rock surfaces of the sea bottom.† Mr. Mallet considered that the mere weight of loosely aggregated materials would suffice to carry them seaward even on a very low slope. Of course this view, if Mr. Mallet's premises be granted, would be applicable to deposits formed in lakes, and perhaps under peculiar circumstances in river valleys.

I cannot give in my adherence to the principle, notwithstanding its ingenuity. That slipping to some extent takes place, that fine materials at all events are moved seaward to a depth equal to the influence of tidal currents, is highly probable, if not certain; but that anything like the extensive and general movements of loose detritus suggested by Mr. Mallet is of common occurrence, has certainly not yet been proved, so far as I am aware. The evidence obtained by the

* Q. J. G. S., vol. xiii, p. cxxiii.

† Journal of the Geol. Soc. of Dublin, 1852, vol. v, pp. 121—129.

recent explorations of the deep seas, as to the presence of sand and small pebbles carried by the slow currents of the ocean, is a totally different matter, but so far as it has gone, it has only shown how sand and small pebbles can become mixed with oceanic mud. The phenomena which Mr. Mallet endeavoured to explain by his hypothesis of mud glaciers are, to this day, after far more investigation and long discussion, referred by most of the best living geologists to glacial action; and there appears to me one insuperable objection to the explanation of such rocks as the Tálchírs by 'mud glaciers' or 'slippage' in the fact that such an action of slipping in the manner insisted upon by Mr. Mallet, must necessarily destroy all trace of stratification. The boulder clay of North-Western Europe is certainly remarkable for the absence of stratification, but in the Tálchírs the bedding is well marked, and the form it assumes around the boulders is such as to show the effect of the pressure excited by such heavy bodies on the soft bed on which they were deposited, and their gradual envelopement by subsequent layers of the same fine silt.

[NOTE.—Since the preceding paragraphs were written, the Geological Survey have been fortunate enough to discover what had previously been sought for in vain-large masses of foreign or transported rocks imbedded in this fine Tálchír silt, the surface of which was polished as perfectly as marble by a lapidary; this polished surface being beautifully scored and furrowed in parallel and straight lines, precisely similar to the scoring, furrowing, and polishing which rocks carried down by glaciers, and ground ice, are so well known to exhibit. And further, the hard Vindhyan limestone, on which this Tálchír boulder-bed was laid, was also found to be scored in long parallel lines, wherever the upper surface was freshly exposed by the recent removal of the overlying rocks. After a little exposure, these scorings became obliterated by wearing off of the surface, or were covered and concealed by a thin deposit of re-crystallized calcareous matter on the surface, from water trickling over it, holding this calcareous matter in solution. This wonderful confirmation of Mr. W. Blanford's original supposition as to the mode in which this boulder-bed was, in places at least, accumulated, was not observed, I regret to say, until after Mr. Blanford had gone to the important work on which he is at present engaged with the boundary survey between Beluchistan and Persia, or I should have preferred that he should himself have had the opportunity of announcing the interesting discovery and modifying his statements.—T. OLDHAM, 1872.]

I cannot conclude without pointing out the remarkable coincidence of a boulder bed, which from the description* must somewhat resemble that of the Tálchír group, at the base of the Karoo beds of South Africa, in which beds several fossils are found, which are also found in different groups of the Indian plant-bearing series, especially *Glossopteris*, *Dicynodon* and *Palæozamia;* and suggesting that when the geology of Natal is better known, other members of them, besides the cretaceous formations, may be found to correspond to the rocks of India. The connexion was pointed out by Dr. Oldham many years ago, but appears to have escaped the attention of the geologists who have recently added so much to our knowledge of South African geology.

Damúdas, Kámthi Beds, and Panchets.—The beds which, in treating of the rocks of Nágpúr, I have called Kámthi beds, have, for some years past, been generally classed as Damúdas. This name was adopted by Mr. Hislop, and the question of the connexion of the beds with the typical Damúdas of Bengal was fully argued out by Mr. Hislop and by Sir Charles Bunbury, in the Quarterly Journal of the Geological Society for 1861, vol. xvii, pp. 341, 345, &c.

I certainly went to Nágpúr with the impression that not only the rocks were Damúdas, but that their identity with the Bengal beds had been established, on the best authority, by a comparison of the fossils. And even now I am not sure to what extent they should be removed from the series.

Mineral character of Kámthis.

In mineral character, however, all the Nágpúr, and the greater part of the Chándá, rocks, differ widely from the typical Damúdas of Bengal and the Narbadá valley. The latter consist of coarse soft felspathic sandstones, rarely conglomeritic, except towards the base, with brown, blue, and black shales,—the latter frequently highly carbonaceous and with beds of coal. Clay iron ore is rarely absent amongst them over any large area. The Kámthi

* Q. J. G. S., 1871, vol. xxvii, p. 58.

beds, on the other hand, are composed of grits, sometimes so hard as to be largely quarried for millstones, at other times soft and frequently ferruginous. These are often intersected by bands, in which the quartz, &c., are cemented together by peroxide of iron. The group also contains sandstones of various kinds, amongst which fine grained slightly micaceous beds, white in colour, with blotches and irregular streaks of red, are abundant; and the fine homogeneous argillaceous rock, which, for want of a better name, I have called a compact shale, yellow below the surface, but becoming deep red when exposed. The last bed is very characteristic. So far as my examination extended, not a trace of carbon could be found; blue and black shales, coal, and clay ironstone are all wanting.

No carbon.

Such are the rocks around Nágpúr, where, however, only a few poor sections are exposed. At Bázárgáon there is a considerable thickness of conglomerate, the pebbles being mostly of white quartz, and the matrix a grit more or less compact, resting upon beds similar to those of Nágpúr. With this conglomerate fine red argillaceous sandstone is sparingly interstratified. There appears good reason to believe that these beds are a higher portion of the Kámthi group.

The beds of Mángli, which Mr. Hislop, for a long time, considered as identical with those of Kámthi, were by myself* classed as Panchets, chiefly on the evidence of the fossil *Estheria* found in them. This view was subsequently accepted by Mr. Hislop. After examining the rocks, however, I am compelled to return to Mr. Hislop's original opinion, as I can see no sound reason for separating the Mángli beds from those of Kámthi. The argillaceous sandstone, yellow and red, in which the fossils of Mángli occur, is precisely similar to that of Silewádá and other places near Nágpúr, and the associated sandstones present no difference of the smallest importance. They are very conglomeritic, and resemble closely the beds of Bázárgáon, which, as I have just shown, appear to

* M. G. S. I., vol. iii, p. 134.

be a little higher in position than the rocks of Kámthi, but still are an integral part of the same group.

We have thus the Kámthi beds hitherto looked upon as Damúdas, and the Mángli beds hitherto classed as Panchets, both belonging to the same group. To which of the two above-named formations are they to be referred, or do they belong to neither?

First as regards the Damúdas. The mineral character has been shown to be totally different. North-west of Nágpúr, in the Táwá valley, north of Bétúl,—north, in the Pench valley, near Chhindwárá,—north-east and east, in various localities from the neighbourhood of Jabalpúr to the Tributary Mehals of Katák,—and south, close to Chándá, Damúdas occur, always with precisely the same character. At Chándá moreover, these Damúda beds distinctly underlie rocks precisely similar to those of Kámthi, and the numerous borings which have been made for the purpose of proving the extent of the coal seam, as well as the survey of the country by Mr. Hughes, have shown that unconformity to some extent exists between the two groups. It is true that the Damúdas in Chándá very possibly represent only the lower sub-division or Barákar group of Bengal, and the Kámthi beds may replace the higher sub-divisions, the ironstone shales and Rániganj beds, but the Kámthis differ from the two last named in mineral character to even a greater extent than they do from the Barákar beds. So far as *mineral* character is concerned, therefore, it is impossible to assign the Kámthi beds to the Damúda formations.

Next as regards the Panchets.* I have very little hesitation in classing the red clays of Máledí,† south of the Chándá, containing *Cerato-*

* By Panchets I mean throughout this paper, except where upper Panchets are expressly mentioned, the beds called lower Panchets in my report on the Rániganj coal-field. I am now convinced of the fact, which I suggested in that report (Memoirs Geological Survey, vol. iii, p. 30, note), that the name should be restricted to the lower division, the upper division being a well distinguished group.

† Memoirs, Geological Survey of India, Vol. I, p. 295. Quarterly Journal, Geological Society, Vol. XVII, p. 349; Vol. XX, pp. 117, 280.

dus and *Hyperodapedon*, with these beds; and I am inclined also to refer to them some other red clays found in the Pench valley, north of Chhindwárá, and in the Táwá valley, near Kesla, north of Bétúl.* The Máledí beds are also found in the Wardha river, near Porsa, between Chándá and Máledí, and in South-east Berar, west of Chándá. In all these instances, the clays are interstratified with soft white felspathic sandstone, and are remarkably similar to those found in the typical locality near Rániganj, where, however, they are associated with very micaceous sandstone. In the Pench valley nodular limestone also occurs, but it is wanting to the south. There is certainly no resemblance in mineral character between the Kámthi beds and the Panchets in all these localities, which encircle the Nágpúr beds at a distance much as the Damúda localities do. There may be some slight resemblance between some of the beds in the "Upper Panchets" of Bengal and the Kámthi beds. But in cases where mineral character is called in as evidence of the identity of rocks in widely separated localities, something more than a slight resemblance is necessary. There may be a slight resemblance between the red clays of the Panchets or the red shales of the Panchet hill rocks and the red compact shales of Kámthi, and some of the sandstones are similar, but so are some of the Damúda sandstones; but still the Panchets are very unlike the Kámthis. On the whole, I consider that, judging from mineral character, the Kámthi beds must be distinguished from the Panchets.

The fossil evidence is more satisfactory. Sir C. Bunbury has identified the *Glossopteris Browniana*, Brogn., of Nágpúr, with that of the Damúda beds. Several other figures of Nágpúr fossil plants† are unmistakably of those species found also in the Rániganj coal-field, and whether fig. 3, Pl. XI, of Sir C. Bunbury's paper, be that of *Vertebraria* according to McCoy and DeZigno or not, I do not think there can be a moment's doubt

* These were only seen during hurried visits for the purpose of examining the coal seams.

† Quarterly Journal, Geological Society, Vol. XVII, Plates VIII, IX, X, XI, and XII.

of its representing *Vertebraria indica* of Royle.* Now *Vertebraria indica* and *Glossopteris Browniana* are the typical plants of the Bengal Damúdas, and vastly more abundant than any other species except a *Phyllotheca*, which is probably also identical with the Nágpúr species. There is thus a very marked resemblance, if not absolute identity, between the Kámthi plants and those of typical Damúda beds.

On the other hand, the *Estheria* of Mángli has been, by Mr. Hislop (Jour. Bom. Br. R. A. S., vol. vi, p. 201,) and for a time by myself, considered identical with that of the Panchets. But the Panchet *Estheria* is not in a condition to allow of its microscopical structure being investigated an important point. Labyrinthodont reptiles have been found both at Mángli and in the Panchet beds of Bengal, but the genera are not the same. The known plants of the Panchet beds are apparently without exception distinct from those found near Nágpúr.

To sum up. There being an element of doubt about the *Estheria*, the only trustworthy connection of the Kámthi beds with any other known Indian group is with the Damúdas, and consists in both containing the same fossil plants. But although the species are, in some instances, the same, several are different, many of the most conspicuous forms of the Damúda beds appear to be wanting at Nágpúr† and others are rare. Until the vast mass of plant-bearing sandstones in Rewa and Sirgúja are better known, it is difficult to say what the ultimate classification of the different groups may be; but meantime it appears best to keep the Kámthis separate, both on economical and geological grounds, from both the Damúda and Panchet beds. It is far from improbable that they represent, in part at least, the Rániganj group of

* I have perhaps had as many specimens of *Vertebraria* from the Indian coal-fields through my hands as any one living, and I cannot reconcile myself to the idea of its being a *Sphenophyllum* or any other fern. I have always looked upon *V. radiata* of Royle as merely a cross section of *V. indica*, and the plant itself as a hollow stem with radiating septa. Dr. Oldham and Sir C. Bunbury are probably correct in considering it a root.

† For instance, *Trizygia* and *Zeugophyllites*.

the Damúdas, or they may be intermediate in age between the Damúdas and Panchets.

Lameta or infratrappean.—This formation, as developed near Jabalpúr, is fairly represented in the Nágpúr country. The two sub-divisions, *a* and *b*, of Mr. J. G. Medlicott's memoir,* are represented respectively, *a* by the sandstone under Sítábaldí hill, and *b* by the limestone of Kelod, Chicholí, &c. The latter is, in both districts, the characteristic bed of the formation.

The re-examination of the Máhádevá rocks by Mr. H. B. Medlicott has led him to the conclusion that they are much older than the Lametas. To this I am quite disposed to agree, but I still think that there may be a connexion between the Lametas and the Bágh beds as explained in my description of the latter.† It should, however, be remembered that the marked local unconformity between the traps and Bágh beds does not appear, near Nágpúr at least, to exist between the former and the Lametas.

I have, in the preceding pages, used the term infratrappean in preference to Lameta, because it better expresses the close connexion between these beds and the traps. Some of the intertrappeans seen on the Seoni table-land and in the trap country west of Nágpúr, consist of precisely the same grey limestone with cherty masses which form the most persistent and characteristic rock of the underlying group. As a rule, the infratrappeans, or Lametas, are gritty, while the intertrappean beds are not, but there are exceptions, and Mr. Hislop's‡ view of the two being parts of the same group appears to be correct.

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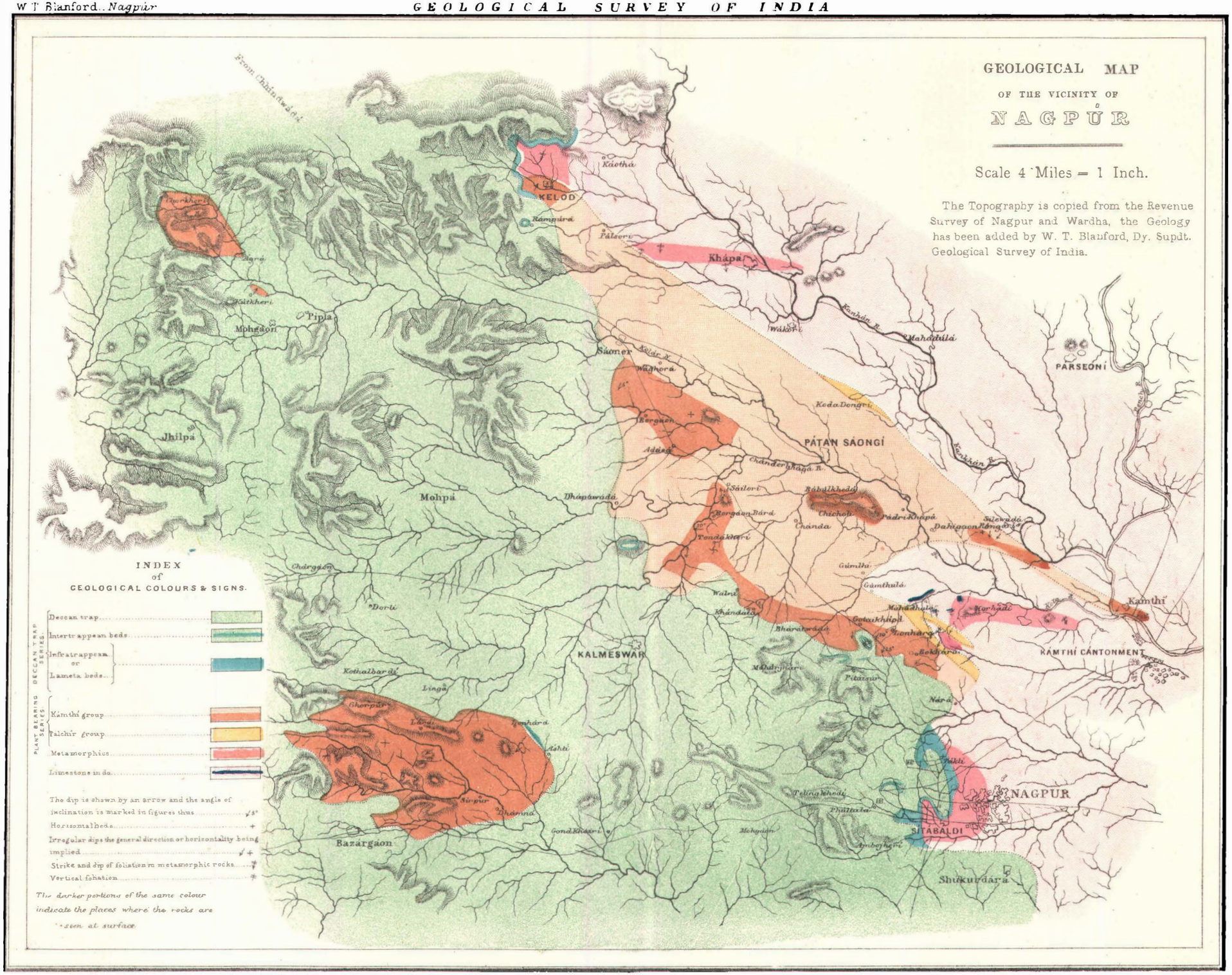
* Memoirs of Geological Survey of India, Vol. II, p. 197.

† Memoirs of Geological Survey of India, Vol. VI, p. 54.

‡ Quarterly Journal, Geological Society, Vol. XVI, p. 159.



LITHOGRAPHED IN COLORS AT THE SURVEYOR GENERAL'S OFFICE,
Calcutta, August 1879.