LXXII. Notice of the geological features of a route from Madras to Bellary, in April and May 1822

W. Cullen

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it. There is no spheroidal triangle; there is no geodetical line. The data consist of the latitudes, nearly equal, and the azimuths, of two distant stations, yet sufficiently near for one to be seen from the other. Now in the case of such distant stations, the observed azimuths are not the same with the azimuths in an imaginary geodetical line passing through the stations. In this, and in other respects, there is great want of precision and geometrical rigour in Dr. Tiarks' argumentation. He has, in fact, brought forward nothing new either in proof, or in elucidation of the problem of which he treats; he has merely added the name of Dr. Tiarks to the other authorities that have upheld the correctness of the method of calculation in the Survey, which it is, nevertheless, just to characterize as the greatest delusion that has ever prevailed in practical mathematics. I can add nothing more on this subject at present; but on another occasion I will give another solution of the same problem, more nearly allied in point of form to the speculations of Dr. Tiarks, which will enable us better to appreciate their merits. When the principles of the problem are fully unfolded, we may then discuss the question, Whether the calculations in the Survey are correct or not?

Nov. 1828.

J. IVORY.

LXXII. *Notice of the Geological Features of a Route from Madras to Bellary, in April and May 1822. By Captain W. CULLEN, of the East India Company's Artillery service.*

[Concluded from p. 363.]

THERE are two instances of the occurrence of a rather remarkable variety of quartzose rock in the course of the preceding route, which have not been yet noticed, because it differed very sensibly from any of the others, both in its colour and composition, and appeared likewise to be altogether independent of them. The first occurred on the west side of the pass between Baukrappett and Cuddapah, occupying about one mile of the route, and appearing to constitute the hills on both sides. The lower end of the line of hills, crossed three or four miles before reaching Nundialpett, were composed of rock precisely similar, and were, I imagine, merely a continuation of those forming the pass. I do not recollect any appearances of stratification in either case, although the course of the range was conformable to the general direction. Perhaps this rock rested on clay-slate, and may be considered as merely one of those transitions, formerly alluded to, from sand-

stone to quartz*. All the hills on the right of the road from Chinoor towards Nundialpett exhibited parallel lines on their slope, similar to those of clay-slate formerly adverted to.

The second variety occurred four or five miles north of Poornamila, distinctly interstratified with clay-slate. Immediately on leaving that village, a low but very extensive and sharp ridge is observed to issue from the eastern boundary of the Poornamila plains, and crossing the road obliquely, to enter the clay-slate range forming the western boundary of the valley, which extends by Alinuggur towards Cummum.

This low range is very conspicuous, being at least six or eight miles in length, and running directly across the north-east portion of the plain. The high road lies immediately over it, near its western extremity. The rocks, in this instance, were distinctly stratified, and formed the crest on the centre of the ridge, bounded on both sides by clay-slate of a brownish gray colour and silky lustre.

I do not observe that I have any specimens of the quartz rock forming the west side of the pass to Cuddapah, but externally it resembles the specimens from Nundialpett. This latter was internally of a dark bluish gray colour, with rather a granular appearance, and having small earthy specks of a rusty brown, sparingly dispersed through it. The second variety in the ridge north of Poornamila appeared to be composed of similar ingredients, but the earthy specks in much greater quantity, and giving a decided colour to the rock. It contains also a few distinct crystals of a black or deep red colour, which appear to be garnets, and which may explain the nature of the rusty specks.

No limestone of any consequence was observed before reaching Wuntimettah, although calcareous depositions are to be met with; such as a white tufa in wells between Codoor and Pollumpettah, occasional traces of marl, and a singular reddish coloured limestone, or marl conglomerate, near Rajampett, between Pollumpettah and Nundaloor.

From the similarity of colour in the clay-slate, flinty-slate, and calcareous schistus, it is not improbable, however, that I may have occasionally been mistaken in my judgement as to their nature in the early part of my march, and even when

* I have since visited the inner range of hills near Cuddapah, running north-west from the pass. They consist of sandstone; towards their base rather coarse grained and dark coloured, but on the summit extremely compact and of a light colour, and giving the hills much of the appearance of quartz. This upper portion is very like the variety alluded to near Nundialpett, but wanted the rusty specks.

better acquainted with them; for their resemblance is sometimes so strong as to render recourse to a test absolutely necessary; an operation which would have occupied too much time to be constantly put in practice while actually on route.

An old pagoda at Wuntimettah is built of a dark blue limestone, of a fine and close texture, taking a good polish, and altogether a handsome, though rather a brittle building material. Some of the blocks were varied with shades of gray or white. Stratified masses of this limestone cross the road in great abundance for the first five miles, as far as the village of Baukrappett, from whence commences a considerable ascent, leading through the clay-slate range which forms the eastern boundary to the low and extensive flat country of the district of Cuddapah.

The deep covering of soil on the plains on the west side of this range concealed all traces of rocks; but the same dark blue limestone appeared to be the universal building material at Cuddapah, and must doubtless have been procured close at hand, although I did not myself meet with any quarries in the immediate vicinity. Varieties of this limestone were, however, common during all the rest of my progress to the north; although latterly, that is to say, after passing Poornamila, it altered considerably in its colour as well as in its texture, becoming more granular and crystalline, as well as of a light gray colour.

Calc-tufa, marls, and conglomerates were in great abundance from the first appearance of the regularly stratified limestone, in distinct depositions of considerable extent, as well as filling the seams of the clay-slate, particularly in the green variety near and subsequent to Poornamila. The red coloured, porphyritic-like limestone, which I have mentioned as occurring first near Rajampett, was met with frequently afterwards in the defile between Nundaloor and Wuntimettah, on entering the plains of the Saghilair, between Poornamila and Alinuggur, &c., and always in horizontal masses of very considerable extent, and from one and a half to two or three feet thick. Schist was generally found immediately below, and its seams filled with depositions of the same nature.

This conglomerate is composed principally of spherical nodules of a kind of calc spar of a dull reddish colour, from one-tenth to five- or six-tenths of an inch diameter, in an earthy basis of a light brown; small angular particles of quartz are also sparingly dispersed through it. This conglomerate is extremely hard, but not always compact, having frequently numerous vesicular cavities.

At Cuddapah I first noticed a very singular variety of calc-tufa

tufa in nodules, or blocks, of from six to eighteen inches diameter, extremely hard, and of a dirty white or gray colour, as if from an intermixture of clay. They were very vesicular internally, and externally covered with hard, knotty, irregular-shaped protuberances, which were of a size proportionate with that of their respective nuclei. They were used, loosely piled together, to form inclosures.

This variety of calc-tufa was met with frequently afterwards, and in great abundance; but I never had a good opportunity of examining it *in situ*.

In the banks of a nulla between Cuddapah and Chinnoor, as also in the bank of the Pennar at the latter village, I had a transient view of it in the mass; and it there appeared to form a horizontal stratum of two or three feet in thickness, a few feet below the surface.

Flinty slate and hornstone still remain for notice. I have mentioned the appearance of the latter at Curcumbaddy, in contact with the clay-slate; and the only recurrence of it that I recollect, possessing decidedly the character of that rock, was at the village of Yenapilla, three or four miles south-east of Nundaloor, where it appeared in large globular blocks, very much intersected by veins of quartz, over a space of four or five square miles. The flinty slate was much more abundant, being found interstratified with the clay-slate almost every march from Curcumbaddy to Wuntimettah.

The colour and texture of the hornstone were generally very uniform in each situation; but the flinty slate was frequently very much veined with different shades of gray or blue. The strata were sometimes, however, perfectly uniform in their colour, being occasionally of a dark blue, at other times of a light gray, and externally strongly resembling the dark blue limestone of the district of Cuddapah.

These were the principal rocks that occurred in the clay-slate of the second division.

Besides varieties of all the rocks hitherto enumerated, several others will be found amongst the specimens forwarded, which the limits proposed for this paper will not admit of describing at present.

The third division, or compact blue limestone, will easily be disposed of, as it occupies the whole of the flat country, extending from the Nulla Mulla range to Banaganapilly, to the exclusion of every other rock. Its texture within this tract was tolerably uniform, but it exhibited a considerable variety of colour; near the Nulla Mulla hills it was generally of a dull lead gray, and this variety, on fracture, presented a foliated appearance; about Jellila, and particularly in the bed
of

of the nulla at Tungtoor, where it was quarried for building, the limestone was of a dull brick red, and frequently also variegated with stripes and shades of a light gray or white.

In approaching Banaganapilly, and all about that town, the limestone was in great abundance, and its colour blue of different shades, but chiefly dark. The deposition of soil on these plains afforded only a few opportunities of examining the limestone; but, where visible, the strata seemed to be *nearly horizontal*. These varieties, especially the last, were very compact and fine grained, and with rather a conchoidal fracture. The fine village of Banaganapilly, and the celebrated diamond deposit, is situated near the base of a low range of tabular land, running about north and south, and forming the western boundary of the great limestone field just described. The range is here abrupt and precipitous, and very irregular and broken in its outline, running out into headlands, as well as having deep narrow valleys penetrating far within it to the westward.

Banaganapilly lies under the point of one of these promontories, which projects five or six miles from the main range. These hilly tracts form the fourth division, or second of clay-slate, but, perhaps, do not terminate that of the limestone; for, although the depth of alluvium in this narrow valley is so great as to conceal all rocky strata, yet, from the numerous nodules of limestone on the surface, and the amazing depth and extent of the depositions of calcareous tufa, and the re-appearance of strata of limestone some miles east of Jeldroogum, which then continue, with little interruption, even on to the table land three or four miles west of that village, it is not improbable that a connection subsists throughout. With exception of the cap, which is of sandstone, and which has already been adverted to, the whole mass of land forming the right hand boundary of the valley commencing near Banaganapilly, and extending to Jeldroogum, appears to consist of clay-slate nearly to the summit. There appeared to be table land also to the left, or south, and which, I imagine, also to be covered with sandstone (the Banaganapilly promontory I ascertained to be so, by ascending three or four miles to the west); but the immediate boundary of the valley on this side, although, like the former, composed of clay-slate, instead of a sandstone cap, was crested in its whole length with a sharp black ridge of trap rock, formed of loose blocks piled upon each other.

The apparent base of the trap observed a pretty uniform level; nor was the ridge of much depth, the peaks, merely by rising somewhat higher occasionally, giving the bed an appearance

pearance of greater dimension. Its extreme narrowness, deep black colour, and the total absence of all traces of vegetation, formed a singular contrast to the rest of the hills, which were covered with long dry grass, and scattered jungle bushes. The connection of this singular bed of trap with the rocks at its two extremities, would probably offer a most instructive subject of investigation.

At the end, near Banaganapilly, it first offers itself to notice in a small, steep, conical hill, composed solely of greenstone. I had previously, however, immediately almost on leaving Banaganapilly, observed several partial appearances of lines of black rock, jutting out a few feet above the soil, in the plain on the north side of and near the base of the Banaganapilly promontory. These, I have now little doubt, were a continuation of the green-stone bed. But it is at the western extremity at the head of the valley, close to Jeldroogum, where the hills close in on all sides, and where the route is crossed by the bed of trap, and all the rocks with which it is associated, that the attention is most forcibly excited. About one-half or one-third of a mile west of Jeldroogum the route lies over a ghaut, or ridge, of 300 or 350 feet perpendicular height, and, descending nearly as much on the opposite side, continues up a pretty level narrow valley for a mile or two, and then finally leads up another ghaut, of about the same height, on to a continuous table land, extending to Piaplee.

Blocks of limestone, of a light blue or gray colour, are common in the interval between Jeldroogum and the ghaut; but the low hills, forming the foot of the ghaut, were covered with large dark masses of rock, which I had imagined to be trap, but which, on examination, also proved to be limestone of a very dark blue. Limestones of other colours were also found intermixed, such as green, gray, &c.; the former on fracture, at a little distance, resembling a good deal a fine-grained greenstone; but the whole of these were covered with a dark crust of clay-slate, so that, unless close to them, it was not easy to distinguish the line of separation between the limestone and trap, which was the next in the order of succession, and at only a short distance from the foot.

The trap was again succeeded by limestone, and the latter by clay-slate, nearly to the summit, which was capped with rock of a beautiful flesh colour, with specks and shades of a delicate green, as if connected with its vicinity to the trap, and of so close and fine a texture as to appear homogeneous even through a lens. It exhibited a conchoidal fracture. The descent of the ghaut on the opposite side consisted of clay-slate nearly to the foot, when the limestone reappeared, and these
two

two rocks then continued to alternate with each other to the foot of the second ghaut, which, like all the former, was composed of clay-slate, capped with quartzose sandstone. Limestone of a yellowish white colour was found in considerable quantity near the top of the ghaut. This high land appears to extend far to the north and south, and uninterrupted by hills; but on the west side, at the distance of three or four miles, was bounded by a chain of hills, running also nearly north and south, and marking the termination of the second tract of clay-slate. This line of hills appeared to be composed of clay-slate and the quartz sandstone, but neither of them exhibiting, at a distance, those distinct stratified appearances hitherto so common. The route lies over a low part of the chain, and almost immediately afterwards all traces of clay-slate disappear. The last rock, connected apparently with that formation, was a sandstone conglomerate, precisely similar to those singular nodules picked up between Naggery and Pootoor, and which here constituted two or three entire hills. Close to the road, a small open space of level ground, not more than three hundred yards wide, separated them from another small group of hills composed wholly of granite.

From this point commences the fifth, or granite division, the rocks prevailing, I believe, over the whole remaining interval to Bellary. I can, however, only speak with perfect certainty of the first fifteen or twenty miles, and of the last eight, having passed over the remaining part at night. The trap dykes, holding their usual course, were very common during the first-mentioned portion of granite.

Regarding the æconomical purposes to which the several rocks met with in the course of the foregoing route might be applied, I believe I shall best consult the pleasure of the Society in simply referring to the specimens which have been forwarded. These, although individually extremely small, may enable persons better acquainted with the subject than myself, to form a judgement of the probable degree of their utility. The principal rocks, granite, trap, sandstone, schistus, and limestone, were, it will have been observed, in great abundance, and in considerable variety, even on the high road; but a little inquiry would probably discover numerous other varieties, more useful, as well as more ornamental. The limestone particularly, of which there would appear to be a great variety, in colour as well as texture, from its facilities of working, would seem to merit some attention. I have seen some very handsome tablets of black or dark blue limestone from Kurnool. It has already been noticed, that the whole of the plain between the meridians of Kurnool and Cumnum, and from

the Kistnah to the Pennar, is composed of that rock. Some of the limestones, or marbles, may prove to possess that peculiar combination of clay, silica, and carbonate of lime, which is found to afford those valuable cements having the property of setting under water. Major De Haviland, of the Engineers, had, I believe, already directed his attention to the discovery of such varieties.

From my imperfect acquaintance with the subject, I am aware, that in the above summary of the situations of the rocks over so great a space, I must necessarily have omitted noticing many circumstances which it would have been of consequence to record; but daily marches of from fifteen to twenty miles in the hottest season of the year, may of themselves be deemed an apology for those, as well as other inaccuracies that may, perhaps, hereafter be discovered. I have, however, endeavoured to be faithful in my narrative of facts; and as such, in the present limited state of published information on these subjects in this country, they will, I trust, be received with indulgence.

W. CULLEN,

Bellary, May 1823.

Captain of Artillery.

The altitudes, in the section which accompanies this paper, are deduced from barometrical observations, regularly made throughout the march. Observations of the maximum and minimum heights of the column of mercury were taken daily at each stage, and the mean of these was generally used in the calculations. Corresponding observations were obligingly furnished to me by Mr. Goldingham from the observatory; from a comparison with which, and with another series of observations made by Major Beckett at Bellary, the altitudes of the several stations have been determined.

In former instances, most of the approximate altitudes which I have had opportunities of ascertaining in different parts of the peninsula, have been deduced solely from my own observations, a mode originating in some degree in necessity, and subsequently adhered to, partly from the same cause, but partly also from choice, from a desire to ascertain how far such approximations might be depended upon.

Few or no barometrical observations were at that period regularly made at any of the inland stations under this Presidency; and the stations where such records were kept were so remote from each other, as well as from my routes, as to occasion frequently very great differences in the altitudes derived from them.

I proposed accompanying this paper with a copy of my own barometrical observations, as well as of the corresponding
ones

ones at Madras and Bellary, with the several altitudes deduced from them; but I have not been able to accomplish my intention.

Colonel Lambton's base line near Gooty is nearly 1200 feet above the sea, and he assumed this as the mean altitude of the interval between that station and Bellary; an inference to which he was perhaps led by the plain, open appearance of the intermediate country. The barometer, however, stood on the 2d June at

Guddicul, 28600 m.	99°	Goontacul, 28528 m.	91°
29920	92½	29910	87
Feet.			
making Guddicul	1420	} nearly above the sea.	
Goontacul	1479		

Madras, July 1823.

W. CULLEN.

Although the section referred to above, is not given in the Madras Transactions, we have thought it right not to suppress the Postscript, in which some of the altitudes in question are stated.—EDIT.

LXXIII. On the Figure of the Earth. By S. SHARPE, Esq.
F.G.S.*

MOST of the investigations into the figure of the earth have been on the supposition that its section through the poles were an ellipse, which, however, several mathematicians have shown not to be exactly true.

Thomas Simpson has shown, that in an elliptical globe, with a given axis major, and a given period of rotation on its axis minor, its ellipticity is given also.

There is water enough on our earth to show that its shape is that which it would take if liquid, therefore the plumb-line is every where perpendicular to the tangent.

Let PT be perpendicular to the tangent at P on the ellipse ÆNQS : then if the earth were at rest, the plumb-line would point nearer to the centre, as PL; and the angle LPT is the measure of the centrifugal force caused by the rotation on its polar axis NS. Hence the connection between the ellipticity and velocity of rotation.

I have gone over Thomas Simpson's work, and find:

1st, If the pendulum at the equator be 39.014 inches, a

* Communicated by the Author.