

## VII.—*On a portion of Dukhun, East Indies.*

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[Read January 23, 1833.]

MY personal observation of Dukhun (Deccan) and Konkun (Concan)\* is not confined to the boundaries laid down in the following geological memoir; but as the rock and mineral specimens remaining at present in my possession are from Dukhun only, I have not thought it proper to extend my details beyond the limits I here prescribe to myself, although I might venture to do so from notes taken at different periods, without exposing my accuracy to question. I will, however, in closing this paper, offer a few observations on the trap and other formations of India; the amazing extent of the former not appearing to have been appreciated hitherto in European geological works.

### *Boundaries.*

My tract† is bounded on the west by the range of mountains usually denominated by Europeans the “Ghàts”, from a misinterpretation of the term *ghàt*, which simply means a pass, the proper name of this range being the “Syhadree”; on the north by the Mool river, as far as Rahooreh; on the east by a direct line from Rahooreh to the city of Ahmednuggur, and subsequently on the north-east by the Seena river until its junction with the Beema river below Mundroop; on the south-east by a line from Mundroop to the celebrated city of Beejapoor; on the south by a line from Beejapoor to the town of Meeruj; and from this place the boundary in the south-west is the Kristna and Quina rivers, to the hill fort of Wassota, situated in the Ghàts. The western boundary line extends, as the crow flies, about 144 miles; the northern 72 miles; eastern and north-eastern 159 miles; south-eastern 41 miles; southern 80 miles; and south-western 88 miles. Agreeably to observations made by myself and the officers of the revenue survey in

\* With respect to the pronunciation of native words, the “u” is the u in “hut,” and the “a” the a in “all.”

† See Map, Plate XXVI.

Dukhun, the tract lies between the parallels of north latitude  $16^{\circ} 45'$  and  $19^{\circ} 27'$ , and east longitude  $73^{\circ} 30'$  and  $75^{\circ} 53'$ , and, roughly calculated, may be said to comprise an area of about 26,000 square miles.

### *Stratification.*

Previously to entering into descriptive details, I will state, in a few words, that the whole of the country comprised within my boundaries is composed of distinctly stratified trap rocks, without the intervention of the rocks of any other formation. Whether at the level of the sea, or at the elevation of 4500 feet, in all and every part, beds of basalt and amygdaloid are found alternating, whose superior and inferior planes preserve a striking parallelism to each other, and, as far as the eye can judge, to the horizon. Barometrical measurements and the course of rivers indicate a declination of the country to the east-south-east and south-east. From the town of Goreh, latitude  $19^{\circ} 03'$  and longitude  $74^{\circ} 05'$ , on the Goreh river, following a mean course for the river until it falls into the Beema, and subsequently, continuing a mean course for the Beema until its junction with the Seena river, the distance is about 200 miles, and the declination 671 feet: there may therefore be a trifling dip of the strata; but as a succession of low terraces occur in that distance, the apparent horizontal position of the strata may be unaffected by the above difference of level.

Dr. MacCulloch, describing the overlying or trap rocks, says, "these masses are generally irregular, but sometimes bear indistinct marks of stratification \*." As Dr. MacCulloch's language implies the *rare occurrence* of stratification, instead of its being a distinctive feature, at least of the Indian branch of the trap family, I deem it necessary to quote the few authors who have written on Indian geology, in confirmation of the fact I have stated †.

\* Classification of Rocks, p. 466.

† "These mountains (the Vindhya range), like every other in Malwa, appear to be distinctly stratified, consisting of alternate, horizontal beds of basalt or trap and amygdaloid. Fourteen of these beds may in general be reckoned, the thinnest at the top, and rapidly increasing in thickness as they lower in position, the basalt stratum at the bottom being about 200 feet thick." Again, at page 327, he says: "In the upper plains of Malwa every point of view presents the same uniform and distinctly streaked appearance noticed in the Vindhya range."—*Captain Dangerfield, in Geological Notices of Malwa*, in Appendix No. 2. to Sir John Malcolm's Central India, pp. 322, 327.

Dr. Voysey, in a paper on the Geological and Mineralogical Structure of the vicinity of Nag-poor, says: "From the summit of the hill of Sitabaldi the difference in the outline of the rocks eastward is very perceptible. The *flattened summits* and *long flat outline*, with the numerous gaps of the trap hills, are exchanged for the ridgy, peaked, sharp outline of the primary rocks."—*Physical Class of the Asiatic Researches*, p. 127.

In a second paper in the same work, on some petrified shells in the Gawelghur range of trap

*Ghàts.*

The Dukhun rises, by a succession of terraces or steps, very abruptly from the Konkun\*. Its valleys and table-lands have a mean elevation above the sea of about 1800 feet. The Konkun is a long strip of land from thirty to fifty miles in breadth, lying between the Ghàts and the sea; the mean elevation of this strip is less than 100 feet; but it is bristled with isolated hills, or short ranges, some of which attain an elevation equalling that of the Ghàts. Numerous shoulders or salient angles are thrown out from the Ghàts from the western or Konkun side, and by means of these the ascent to Dukhun is effected; with what difficulty, will be understood when I state that the military road of communication between Bombay and Poona, up the Bore Ghàt, rises nearly 600 feet in a mile. The western portion of my tract along the crest of the Ghàts is exceedingly strong: spurs of different lengths extend from the main range to the eastward and south-east, leaving many narrow tortuous valleys between them, some of which have the character of gigantic cracks or fissures; other valleys, although occurring less frequently, when looked at from the neighbouring ranges, appear as flat and smooth as a billiard-table, even to the crest of the Ghàts, but when traversed are found to be cut up by numerous narrow and deep ravines†. Stupendous scarps, fearful chasms, numerous waterfalls, dense forests, and perennial verdure, complete the majesty and romantic interest of the vicinity of the Ghàts. As the spurs extend to the east and south-east they diminish in height, until they disappear on approaching the open plains in my eastern limits, between the Beema and Seena rivers. The area of the table-land on their summit often exceeds that of the valley between them: such is the case with the spur bordering the left bank of the Beema river for forty miles from its source, occupying, in fact, the whole country between the sources of the Beema and Goreh rivers. The spurs are rarely tabular for their whole length, but narrow occasionally into ridges capped with compact basalt, and subsequently expand into extensive table-lands. The spur originating in the hill fort of Hurreechundurghur affords a good example. The fort is about eighteen miles in circumference: on the east it presents a salient

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mountains, extending for 165 miles along the left bank of the Tapti river, from its source to the city of Boorhanpoor, he describes the principal part of the range as formed of "compact basalt" very much resembling that of the Giant's Causeway. It is found columnar in many places, and "at Gawelghur it appears *stratified*"; the summits of several ravines presenting a continued stratum "of many thousand yards in length."—*Physical Class of the Asiatic Researches*, p. 189.

\* See Plate XXVIII.

† The valley of the Malsej Ghàt, for instance.

angle to the neighbouring mountain; absolute contact, however, only commences at about 400 feet from the top of the scarp, leaving a gap and an extremely narrow ridge, over which lies a difficult footpath of communication between the valley of the Malsej Ghât and that of the Mool river. The spur then widens; some lateral ramifications shoot out, on one of which is situated the fort of Koonjurghur; at the Brahmun Wareh pass it narrows considerably, but not into a ridge; it subsequently expands into the extensive and well-peopled table-land of Kanoor and Parneir, twenty-four miles long by twenty broad, having diminished in height, by a succession of steps, from 3894 feet in Hurreechundurghur to 2866 at Brahmun Wareh, 2474 at Parneir, and 2133 on the terrace of Ahmednuggur. From Ahmednuggur the spur bends southward until it is finally lost in the neighbourhood of Sholapoor. It is, in fact, the margin of a great plateau, which has a mean elevation of about 300 feet above the valley of the Godavery river, and over which the rivers Goreh, Beema, Seena, &c., take their course. The basaltic caps of the ridges appear more or less columnar, from numerous vertical fissures; the weathering of these exposed rocks produces pillars, spires, towers, houses, and other forms of works of art\*. Another feature of these spurs is the occasional occurrence on their table-lands of small hummocks or conical hills with a truncated apex. Dr. Voysey† mentions “groups of flattened summits and “isolated conoidal frustra” in the Gawelghur trap mountains.

One of the longest of the spurs originates in the Ghâts north-west of Sata-rah, and runs nearly east-south-east, about 110 miles, towards Punderpoor.

The spur immediately south of Poona, on the ramifications of which are situated the formidable fortresses of Singhur (4162 feet), Poorundhur (4472 feet), and Wuzeerghur, adjoining Poorhundhur (at nearly the same elevation), has an extent of ninety-five miles. The accompanying section, Plate XXVIII. fig. 2. represents this spur.

### *Valleys.*

Much having been said respecting valleys of excavation, I think it may be acceptable to offer a few observations on the valleys between the spurs. I shall describe only those that present the greatest contrasts to each other.

*Valley of the Mota River.*—The valley of the Mota river, south of Poona, originating in a mass of hills on the edge of the Ghâts, is so exceedingly narrow, that for some miles the bases of the opposite hills frequently touch each other, leaving, at intervals, little horizontal plots, of a pistol-shot in width. These plots occur in terraces, on lower levels as they extend eastward.

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\* See Plate XXVIII. fig. 1. and 2. on the Konkun; and Plate XXVII. fig. 1.

† Physical Class, Asiatic Researches, p. 189.



*Vale of the Under.*—The valley of the Under river, north-west of Poona, presents a perfect contrast to the last. It is level for twenty miles, running east and west to the very edge of the Ghâts; and a person can stand at the head of the valley upon the brink of a scarp rising almost from the Konkun. Here, at the source of the river, it is nearly six miles wide. The river Under runs down the valley 150 feet below the level of the cultivated lands.

*Vale of the Baum.*—The neighbouring valley of the Baum river, unlike that of the Under, originates about seven miles from the crest of the Ghâts, at a spot where the mountain masses separate into two spurs. Hence it continues level for fourteen miles, gradually widening eastward. The Baum river, like the Under, runs at a level of 150 feet below the cultivated lands; these lands, in fact, being upon one terrace, the river upon a second and lower terrace.

*Vale of the Beema.*—The next valley on the north is that of the Beema river. The river rises on the elevated table-land above the Ghâts, at 3090 feet, and within the first few miles it tumbles over several terraces. The valley, for eighteen miles, is occasionally as narrow as that of the Mota river.

*Vale of the Goreh.*—Next on the north occurs the valley of the Goreh river, which, from the source of the river to Munchur, (twenty-nine miles,) is exceedingly narrow and tortuous. Here it expands into the broad horizontal plain of Kowta, ten miles wide.

*Vale of the Malsej Ghât.*—In conclusion, as a contrast to the first part of the Goreh valley, I must mention the valley of the Malsej Ghât, on the south of the Dukhun-base of the fort of Hurreechundurghur. It is several miles wide, and literally as level, even to the brink of the Ghâts, as if smoothed by art. Many of the valleys of the Ghâts, particularly that of the Mool river, from the continued scarped character of the marginal mountains, and the flatness of the bottom for miles in extent, look like fosses to a Titan's fortress.

If all these valleys be valleys of excavation, the present rivers could scarcely produce such, were we to suppose their powers of attrition in operation from the origin of things even to the end of time!

Those of a fissure-like character might have resulted from the upheaving of the beds of trap from below the sea, and the consequent probable fracture of the surface; but the same explanation will not apply to those valleys associated with the preceding, broad, flat, and margined by scarped mountains, which valleys are as wide at their origin at the crest of the Ghâts, and at the sources of the rivers which run through them, as in any part of their length.

#### *Terraces.*

As the rise from the Konkun to the Dukhun is by terraces, so the declination of the country eastward from the Ghâts is by terraces; but these occur at much longer intervals, are much lower, particularly in the eastern parts, and escape the eye of the casual observer. In the neighbourhood of Munchur, on the Goreh river, there are five terraces rising above each other from the east to the west, so distinctly marked, that the parallelism of their planes, to each other and to the horizon, gives them the appearance of being artificial. An artificial character also pervades the form of many insulated hills: some of which viewed laterally, appear to have an extensive table-land on the summit,

but seen endways look like truncated cones. Conoidal frustra in the Gawelgurh range have been already noticed. Other insulated hills are triangular in their superficial planes, as the forts of Teekoneh (three-cornered) and Loghur.

#### *Escarpments.*

Stupendous escarpments are occasionally met with in the Ghâts. In these instances the numerous strata, instead of being arranged in steps, form a continuous wall. At the Ahopeh pass, at the source of the Goreh river, the wall or scarp is fully 1500 feet high\* ; indeed, on the north-west face of the hill fort of Hurreechundurghur, the escarpment can scarcely be less than double that height. On the other hand, the steps are sometimes effaced, and a hill has a rapid slope. This originates in a succession of beds of the softer amygdaloids, without any basaltic interstratification ; their superior angles disintegrate, and a slope results. But most usually three or four beds of amygdaloid are found between two strata of compact basalt ; the former disintegrates, leaving a slope, which is not unfrequently covered with forest trees, forming a picturesque belt : the basaltic scarp remains entire, or it may be partially buried by the debris from the amygdaloids above ; but its great thickness usually preserves it from obliteration, and it rises from the wood below with majestic effect, its black front being finely contrasted with the rich and lively green of its sylvan associate. It is these strata, arranged in slopes and scarps repeated three or four times, and so commonly met with in insulated and other mountains in Dukhun, that constitute the amazing strength of the hill forts of the country, leaving a succession of natural walls encircling a mountain. This feature did not escape the observation of Captain Dangerfield in Malwa, who says, " From the great difference in the resistance made to decomposition by " these trap and amygdaloid beds, their exposed ends acquire a very distinct " degree of inclination and character ; the amygdaloid forming a great slope, " and affording a loose mould covered with vegetation, the trap retaining its " original perpendicularity and dark bareness †."

In the alternation of the strata there does not appear to be any uniformity ; but the general level, thickness, and extent of a stratum are preserved, as in sedimentary rocks, on both sides of a valley ; the basalt and hardest amygdaloids being traceable for miles in the parallel spurs or ranges ; but the imbedded minerals, and even the texture, vary in very short distances.

#### *Columnar Basalt.*

A great geological feature of Dukhun is the occurrence of columnar basalt.

\* Plate XXVIII. fig. 1.

† Malcolm's Central India, Appendix, p. 322.

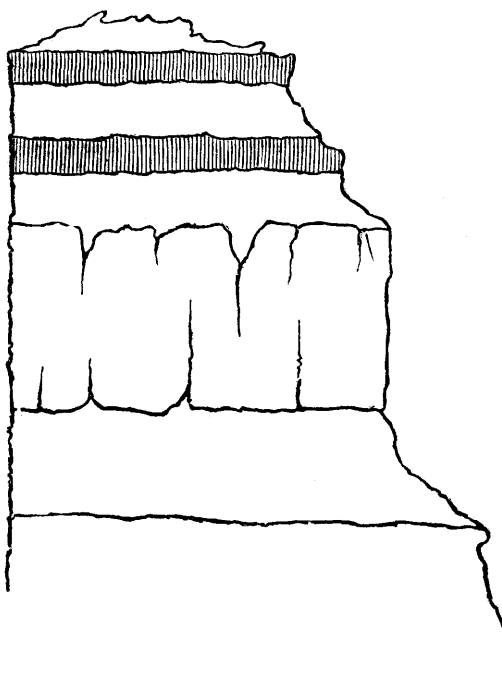
The basalts and hardest amygdaloids run so much into each other that the line of separation is not always readily distinguishable, excepting of course the lines of horizontal stratification. I observed the prismatic disposition more marked and perfect in the basalt strata than in the amygdaloids, and the more or less perfect development of determinate forms was dependent on the compactness and limited constituents of the rocks. Basalts and amygdaloids, however compact, with many imbedded matters, rarely formed columns. Perfect columns were generally small, of four, five, or six sides; but the prismatic structure sometimes manifested itself in basaltic and amygdaloidal columns many feet in diameter. A bare mention of the places where they occur will testify to their extended localities.

On the low table-land of Kurdah, near Serroor, between sixty and seventy miles east from the Ghâts, columnar basalt occupies an area of many square miles. Small columns are seen in most of the slopes of the very narrow sinuous valleys of the flanks of the platform, and frequently the tops or terminal planes of columns are observed on the table-land forming a pavement. The perfect columns in the flanks are generally small, four, five, or six-sided, and rest on a stratum of basalt or amygdaloid. In some spots the columns are articulated, in others not. In a mass of columns in the face of the table-land towards Serroor the columns are of different lengths, but spring from the same level. More articulations having been washed from the outer columns than from the inner by monsoon torrents dashing over them, a pretty flight of steps remains. The columns of this table-land are for the most part erect, but sometimes stand at various angles to the horizon, usually at  $45^{\circ}$ . In one instance, near the village of Kurdah, they lean from the east and west, towards a central upright mass: these are about fourteen feet in length, and are not articulated. In a mass of columns facing the west, and two miles south of the cavalry lines at Serroor, some are bent and not articulated; they are nevertheless associated with straight columns, which are articulated. At Karkullah, thirty miles north-west of Poona, between Tellegaon and Loghur, a hill has been scarped for the great military road. Very numerous small columns occur in the escarpment, and they lie piled upon each other in a horizontal position; the only instance of the kind within my knowledge in Dukhun. Two or three hundred yards west of the village of Yewtee Purgunnah Kurdeh, in the rocky banks of a rivulet, imperfect columns are seen. On the right bank they are so marked, as to have excited the attention of the natives (an unusual event); and they are daubed with red lead, in the manner of Hindoo deities, and venerated.

At Kothool, twenty-two miles south of Ahmednuggur, there is a thick stratum of close-grained gray homogeneous basalt in the face of the hill on which is seated the temple of Kundobah. Vertical and horizontal fissures are seen in the lateral plane or exposed edge of this stratum, but they are so far from each other as to leave huge blocks between them, giving the appearance of the superstratum of the hill being supported by massive articulated pilasters. Parts of the exposed edge are detached from its mass, leaving rude columns four or five feet in diameter, eight or ten high, and composed of three or four weighty stones disposed to assume geometrical forms. In the water courses near Kurroos Turruf Ranjungaon, columns are observable. The basalt is bluish gray, compact, has a vitreous hue, and sharp fracture. The columns occur very abundantly in the slope of the hills, on either side of a very narrow valley running westward from the village of Ankoolner, Ahmednuggur Collectorate. They are five- or six-sided, articulated, and from a foot to two feet and a half in diameter, and of various lengths; the lateral planes perfect, but in

some instances the sharpness of the angles has been affected by weathering. The texture is close-grained, colour almost black, and they affect the needle.

At Jehoor, near the source of the Seena river, in an insulated hill, an obscure columnar disposition is met with in a rock, in which in other places I had not seen the slightest trace of it. A stratum of red, cellular, amygdaloid fifteen feet thick has subcolumns in its exposed edges eight or ten feet in diameter. In the banks of a water-course running into the Hunga river, half a mile east of Parneir, on the elevated table-land between the cities of Ahmednuggur and Joonur, basaltic columns are very numerous; they are five or six feet high, not articulated, and are not quite perpendicular. This formation is evidently extensive, as the ends of columns, chiefly pentangular, appear in the bed of the water-course for some distance, forming a pavement of geometrical slabs. The ends of columns of different lengths also appear in the southern bank at intervals, forming flights of steps. The basalt of which these columns are composed is very close-grained, almost black, with shining specks of a metallic lustre. The rocky banks of the Kokree river at Jambut, in the plain of Joonur, exhibit a strong inclination to a large columnar structure. In the hill fort of Singhur, at an elevation of 4162 feet, at the western end of the fort, there is a sheet of rock which has the appearance of a pavement of pentangular slabs. The slabs are no doubt the terminal planes of basaltic columns. The same is observed in the hill fort of Hurreechundurghur, about seventy miles north of Singhur; also in the bed of a water-course one mile north-east of Barlonee, near the fortress of Purrunda, 112 miles east-south-east of Singhur; and, lastly, in the bed of the Mool river at Gorgaon, Poona Collectorate. These pavements extend to Malwa, as Captain



Dangerfield mentions their occurrence in the beds of the Chumbul and Nerbuddah (Nermada) rivers\*. The other localities of basaltic columns, or a marked disposition to this structure, were in a well at Kumlepoor, between the fortress of Purrunda and Barlonee, near the left bank of the Seena river; at Kheir Turruf Rasseen, in the face of a headland, abutting on the Beema river, on which the town stands; in the ascent to the temple of Boleshwur Turruf Sandus, Poona Collectorate; and, finally, in the scarps of a mountain running down into the Konkun, and seen from the Naneh Ghât, about three miles distant. Here the Giant's Causeway in Ireland is brought to mind; but the scale of the mountain is infinitely more magnificent, being fully 4000 feet high. There is a double row of columns; but from their inaccessible situation, I could only examine them through my telescope, and cannot testify, therefore, to their perfect development; but the accompanying sketch will give a just idea of their appearance to me.

Captain Dangerfield only once speaks of columns. They lie about a mile from the Nerbuddah (Nermada), between Mundleysir and Mhysir, at 696 feet above the sea: they are either

\* Malcolm's Central India, Appendix, pp. 329, 330.

vertical or highly inclined. General Hardwick has published a lithographic sketch of them\*. I have already stated that Dr. Voysey found columnar basalt in many places in the Gawelghur range.

*Schistose Structure.*

Following the preceding formation, I may mention, that in some few places a schistose structure was met with ; but its extent was limited to a few yards, the lamellæ were vertical, from an inch to three inches in thickness, being perfect tables, with parallel bounding planes. The rock in which this structure occurs, is a simple, indurated, gray clay, which flies into fragments under slight blows from the hammer. At Dytneh near Serroor some very perfect specimens have led the inhabitants to connect mystic influences with so artificial a development of inorganic matter. The spot is daubed with oil and red lead, and venerated.

*Basalt en boules.*

Another characteristic feature is the general diffusion of those rounded or oval masses of compact basalt, with concentric layers like the coats of an onion, which the French geologists denominate "Basalt en boules", and ourselves, nodular basalt.

These concretions are usually found at the base of hills, buried in the debris from the decomposing strata; but in the Konkun, between Choke and Campolee, (the latter at the foot of the Bore Ghât,) two villages on the high road between Bombay and Poona, I met with them lying on the surface over a considerable area. They occur in a similar manner on the table-land of the ball-practice hill at Poona. At Koothool (already mentioned), in the slope of the hill, and in the debris at its base, and along the edge of the table-land near Paubul, they are abundant ; but the finest specimens are seen near the village of Karkullah, thirty miles north-west of Poona, associated with horizontal basaltic columns. The hill has been cut away, to form the great military road. In making the escarpment the balls were met with, and it being impossible to cut through the nuclei in vertical sections, it was either necessary to leave them projecting or to remove them altogether : in the latter case cavities remained equal to the hemispheres of the nuclei ; and the vertical sections display from ten to fifteen concentric layers of friable gray stone, which in some instances I have found to affect the needle. I compared specimens of the nuclei with a mass brought by me from the Solfatara at Naples, and found them quite similar in aspect, colour, hardness, and great weight. This formation excited the attention of those gentlemen who have visited the northern and eastern parts of the great trap region† ; but Dr. Voysey was quite mis-

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\* Malcolm's Central India, Appendix, p. 323.

† Dr. Voysey says, "The nodular wacken or basalt is one of the most common forms of trap in the extensive districts composed of the rocks of the family south of the Nermada (Nerbuddah) river. It occurs perpetually in the extensive and lofty range of mountains, (the Gawalghur) situated between the Purna and Tapti rivers, and appears to form their principal mass. It is found equally abundant throughout the whole of Berar, part of the provinces of Hyderabad, Beder and Sholapoor, and appears to form the basis of the great western range of trap hills which separate the Konkun from the interior of the Dukhun."—*Physical Class, Asiatic Researches*, pp. 126, 189.



taken in supposing it formed the basis of the Western Ghâts. Captain Coulthard speaks of it in Sagar\*. Major Franklin also noticed it in the trap of Sagar, in lat.  $23^{\circ} 51'$ , and long.  $78^{\circ} 44'$ , at 1933 feet above the sea, as "frequently globular; the nuclei of the decaying masses, varying in size from an egg to a large bombshell, and their decomposing concentric lamellæ being generally very thin, and often very numerous"†.

### *Dykes.*

I now pass to the basaltic dykes, several of which came under my notice in different parts of the country. They are all vertical, and I did not observe that they occasioned any disturbance or dislocation in the strata of basalt and amygdaloid, through which they passed.

Two dykes run obliquely across the valley of Karleh, (35 miles north-west of Poona), and intersect each other: they are about four feet thick and cut amygdaloidal strata. A prismatic disposition is generally observable in the fracture, and from one of them I obtained a square prism, which lay at right angles to the walls of the dyke. The texture is compact. The military road running through this valley and down the Bore Ghât to Panwell, is frequently crossed by ridges which I presume to be the outcrops of dykes. A dyke is seen on the southern slope of an insulated hill, near the villages of Bosree and Digghee,  $7\frac{1}{2}$  miles north of Poona‡. It is about four feet thick, has a transverse prismatic fracture, is compact, and runs from the bottom to the top of the hill; but it is not discoverable in the northern slope. It is visible from the cantonments at Poona. A similar dyke occurs in the hill at Ombreh, twenty miles north-north-west of Poona. But the most remarkable dyke runs vertically, from east to west, through the hill fort of Hurreechundurghur. It is first seen, of a thickness of six or seven feet, in the ascent of the mountain on the south-east from Keereshwur, about 400 feet below the crest of the scarp. The path of ascent into the fort is intersected by it, and its prismatic fracture, at right angles to its planes, offers a few available steps in the ascent. It is traceable for about 300 feet in perpendicular height. On the top of the mountain, within the fort, about a mile to the westward, it is discoverable at intervals, cutting through basaltic and amygdaloidal strata. I could not ascertain whether or not it appears in the western scarp of the mountain, the point to which it directs its course being wholly inaccessible.

The gentlemen whose geological memoirs I have quoted, rarely advert to the subject of trap dykes, and their notices are very brief. Capt. Dangerfield says, "The trap of the southern boundary of Malwa is much intersected by vertical veins of quartz, or narrow seams of a more compact heavy basalt, which appears to radiate from centres§." Beyond the continuous trap region of the peninsula, Dr. Voysey notices a basaltic vein in sienite, near the Cavary river

\* "The base of the hills is invariably broader than the summit; and if the sides of a hill are smooth and even, balled trap, often a concentric lamellar variety will be the principal component matter, decomposing and decomposed into a predominating workable clay, still showing the parallel converging layers."—*Physical Class, Asiatic Researches*, p. 78.

† *Physical Class, Asiatic Researches*, p. 30.

‡ See Plate XXVIII. fig. 1.

§ Malcolm's Central India, Appendix, p. 330.



at Seringapatam, which must have been propelled upwards, as it broke through an oblique seam of hornblende in the sienite, and carried the pieces up above the level of the hornblende vein\*. “On the eastern coast,” Mr. Calder says, “from Condapilli northward, the granite is often penetrated “and apparently heaved up by injected veins or masses of trap, and dykes of “greenstone †.”

### *Ferruginous Clay.*

The next distinctive feature is the occurrence of strata of red ochreous rock, in fact, Mac Culloch’s ferruginous clay underlying thick strata of basalt or amygdaloid, precisely as is seen to be the case in the Giant’s Causeway in Ireland. It passes through every variety of texture, from pulverulent, friable, and indurated, to compact earthy jasper. The stratum is from an inch in thickness to many feet. The rock makes a red streak on paper, with the exception of the very indurated kinds, and does not affect the needle. It is pulverulent near the basaltic columns at Serroor, friable under sub-columnar red amygdaloid, near the source of the Seena river, indurated under basalt at Kothool. Although hard, it is here so cellular as to have the appearance of sponge, and reduced to powder, looks like brickdust.

In the scarps of the hill fort of Hurreechundurghur and a mountain near Joonur in which are excavated numerous Boodh cave temples, it is found compact and homogeneous, and is, in fact, an earthy jasper. In these localities it lies under from 300 to 600 feet of basalt. In the former locality it is about three feet thick, in the latter one foot. At Nandoor, north-north-west of Ahmednuggur, in the valley of the Godavery river, it is found as a porphyritic stratum many feet in thickness, and is used as a building stone. The imbedded matter consists of very minute crystals of lime. At Wangee, lying nearly in the latitude of Barlonee, but differing 18 miles in longitude, and at Barlonee it occurs as an earth: as both places lie on the same level, I have no doubt the stratum is continuous between them. It occurs abundantly in the Ghâts, frequently discolouring the rivulets, and giving a ferruginous character to the soil over a considerable area. When thin, and under heavy beds of basalt or amygdaloid, the exposed edge of the stratum projects, is rounded, and double the thickness of the stratum itself; as if it had once been in a tenacious fluid state, and squeezed out by the superincumbent basalt. Such is the case at Jehoor, and an illustrative specimen accompanies this paper.

### *Pulverulent Limestone.*

Limestone is met with, in the Dukhun, only in three states: pulverulent, nodular, and crystalline. The first occurs in thin seams on the banks of rivers and water-courses and at the base of hills in debris. The seams are from an

\* Physical Class, Asiatic Researches, part i. p. 22.

† Ibid., part i. p. 10.

inch to three feet in thickness, covered by a few feet of black earth. Sometimes in whiteness it resembles pounded chalk, and is then used by children to smear their writing boards.

In this state it occurs at Jehoor and Islampoor near Ahmednuggur. At Kurkumb and at Salseh, ten miles south of the fortress of Kurmaleh, it is met with under black earth in unusually thick strata, and of a peculiar whiteness. Major Franklin notices "a stratum of earthy limestone, white as chalk, at Sagar, occurring under a stratum of amorphous trap\*."

### *Nodular Limestone.*

The nodular limestone, which is the well-known kunkur† of India, (*kunkur* being a native word for nodule,) occurs, like the preceding, disseminated or diffused in the soil, and also on the surface. I have never seen the nodules of a regular crystalline form. They vary in size from a marble to a twelve-pound shot, and many of them are exceedingly irregular in shape, particularly those dug from the banks of rivers. They are sometimes obscurely lenticular. They are so abundant in certain localities that they appear as if showered upon the earth, and disguise its colour. Dr. Buchanan mentions the same in Rajmahl. When upon black soil, they are usually minute and tolerably uniform in size: on other soils their form is variable. In the Ghâts neither pulverulent nor nodular lime is met with. It is unnecessary to particularize the localities of the nodular kind, as it is of common occurrence eastward from the hilly tracts of the Ghâts, and is the only source of lime for mortar, a class of persons making a livelihood by collecting the larger nodules. When carefully burnt, they make an excellent cement. Captain Dangerfield describes "the occurrence (in Malwa) in some parts, particularly near the bottom of the small hills and banks of the rivulets, of a thin bed of loose marl or coarse earthy limestone‡".

Captain Coulthard says, "In Sagar a white patch of this limestone mouldering by the weather is the source from whence comes the particles of kunkur, mixed with the black basaltic earth of the neighbouring valley, in such proportion as to add increased fertility to it; and if a rivulet meanders through that valley (and such is generally the fact), patches made up of aggregated particles of the same, will here and there be found; and this it is which the native families pick out and work into lime§". Captain Coulthard refers the origin of the nodules to limestone rock underlying basaltic strata, but I

\* Physical Class, Asiatic Researches, part i. p. 30.

† The Mahratta word is not spelt with an "a."

‡ Malcolm's Central India, p. 328.

§ "Trap of the Sagar District," Physical Class, Asiatic Researches, p. 60.

cannot trace them to such a source, not having seen strata of compact limestone, properly so called, in the Dukhun. The only specimen of compact limestone met with by me was in the bed of the Beema river near Pundurpoor. It was an insulated, amorphous, gray mass, four or five feet in diameter. I looked upon it as an aggregation of the pulverulent particles of the lime disseminated in the neighbouring banks. A specimen of it accompanies this paper.

### *Crystalline Limestone.*

Lime in a crystalline state occurs only as an imbedded mineral in the amygdaloidal strata, in quartz geodes, and in the nucleus or compact part of masses of mesotype or stilbite. It is rare compared with the preceding varieties.

### *Loose Stones.*

Another feature of Dukhun is the occurrence of immense quantities of loose basalt stones, as if showered upon the land; also masses of rock heaped and piled into mounds as if by the labour of man. Their partial distribution is not less remarkable than their abundance. For the most part, the stones have a disposition to a geometrical form, and it is by no means rare to meet with prisms of three or four sides and cubes almost perfect: stones with one or two perfect planes are very common. Their texture is close-grained and the colour verging to black.

At Dehwuree, Hungawaree, Behloondee, Kothool, and Dytneh in the Ahmednuggur Collectorate, they are very abundant. At the last place they cover fields several acres in extent, so thickly that the black fertile soil on which they rest is not discoverable: they vary from an ounce to several pounds in weight. Amongst these I picked up a perfect square prism. In neighbouring fields, most unaccountably, there is not a stone to be seen: patches of sheet rock occur in their vicinity. Other localities are the top of the Neem Durra Ghât near Ahmednuggur; the junction of the Beema and Seena rivers below Mandroop; right bank of the Seena at Kurmaleh; between Kurjut and Meerujgaon; and generally it may be stated that the precipitous slopes of the low table-lands of the Desh (open or flat country) are very strong and rocky. For ten miles between Jeetee and Soagaon, Ahmednuggur Collectorate, the fields, and even the road, are so thickly strewn with large basalt stones as to render cultivation difficult and travelling penible.

### *Rocky Heaps.*

The singular heaps of rocks and stones above noticed occur at Kanoor, Patus, Kheir, between Kurjut and Meerujgaon, and at other places in the Desh, but not in the Mawals, or hilly tracts of the Ghâts. The heaps are from twenty to seventy feet in diameter, and the same in height: when composed of rocky masses without small stones, blocks of three or four feet in dia-

meter and with a disposition to determinate forms, are piled upon each other, constituting rude pillars. In certain parts of the country from fifty to sixty of these heaps are seen within the area of a couple of square miles, and it excites surprise that the intermediate ground is destitute of stones.

### *Sheets of Rock.*

Mention must not be omitted of the constant recurrence of sheets of rock of considerable extent at the surface, and totally destitute of soil : this is particularly the case in the Mawals, or hilly tracts along the Ghâts. They abound with narrow vertical veins of quartz and chalcedony. When of sufficient thickness, the vein splits in the centre parallel to the surface of its walls, the interior being drusy with quartz crystals : the walls consist of layers of chalcedony, cachalong, hornstone, and semi-opal. These veins supply the majority of the siliceous minerals so abundantly strewed over Dukhun.

The localities where the sheets of rocks particularly struck me were Lakungaon, on the plain of Joonur, and generally in the valley of the Goreh river ; at Kothool, Pergunneh Kurdeh ; at Kheir and Raseen ; in the hill fort of Hurreechundurghur ; most markedly between Kooldurrun and Pairgaon on the Beema river. At Aklapoor, on the Mool river, they were very extensive ; and at Angur, Mohol, Kurjut, and Patkool. Generally in the eastern and south-eastern parts of my tract, much decomposing amygdaloid is found at the surface of the low table-lands or terraces, which, in favourable monsoons, is equal to the support of Jowaree\* ; but a small deficiency in the rains occasions the destruction of the crop.

### *Structure and Mineral Composition of the Trap Rocks.*

The structure and mineral composition of the trap rocks in Dukhun vary exceedingly in short distances, even in the same stratum ; nevertheless, the predominant character does not disappear, although the basalt in a continuous bed may pass several times from close-grained, compact, and almost black, to gray, amygdaloidal, and externally decomposing. The same observation applies to the amygdaloids. A variety of compact basalt, of an intense green colour, is susceptible of a brilliant polish, and rivals the celebrated Egyptian kind. It is of great weight and remarkable hardness : the natives use it to work into idols for their temples, pedestals to the wooden columns in their mansions, and slabs for inscriptions. The bulls of the size of life, always placed before the temples of Mahadeo, are cut out of this variety at Raseen, Wurwund, and the renowned Boleshwur. Some of the pedestals in the gateway of the Mankeswur palace at Teimboornee look like

\* *Andropogon Sorghum.*

mirrors. In the temple at Pooluj south of Punderpoor, there is a slab six or seven feet long and  $2\frac{1}{2}$  broad, covered with an inscription in the Kanree language; and in Punderpoor the streets are paved apparently with the same basalt. At Jehoor and near Ahmednuggur is found a compact kind like the last, but not so heavy. It has a crystalline character and sharp fracture, and has angular siliceous pebbles imbedded: an occasional pebble is loose in its cell. In the Happy Valley near Ahmednuggur the basalt is compact and smooth, with reddish flat transparent crystals imbedded. It opposes a feeble resistance to the hammer, and flies into fragments, some of which have right angles. The basalt, even of the true columns, is not of a uniform texture in different localities: at times it is blackish or gray, and very small, granular or compact; at others, earthy and ferruginous, particularly externally. The basis of the amygdaloids is clay, with more or less hornblende disseminated: they embrace the cellular, porphyritic, hard, friable, and decomposing. I endeavoured to class them agreeably to the prevalence of quartz, chalcedony, lime, mesotype, or stilbite, as imbedded minerals, but found the method of very limited application. Sometimes one mineral only is imbedded, occasionally two, and often the whole.

In Hurreechundurghur quartz amygdaloid prevails: at Aklapoor on the Mool river it is characterized by mesotype, that mineral being imbedded in large masses, and the radii (six or seven inches) are the longest I have seen. At Nandoor it is porphyritic with minute crystalline specks of lime: near Ahmednuggur is seen a cellular, indeed spongiform kind, which is hard, and the cells are empty. A small cellular and pisiform variety is found in the wonderful cave temples of Ellora, and some of the sculptured figures appear as if marked by the smallpox. This observation is partially applicable to the Boodh and Hindoo cave temples of Elephanta, Salsette, Karleh, Joonur, the Naneh Ghât, and the Adjunteh Ghât; all of which are excavated in basaltic or amygdaloidal strata. The stilbite or Heulandite amygdaloid is of very common occurrence; but the most prevalent kind is that in which all the minerals noticed above are associated. The stone usually selected for building is of various shades of gray or bluish gray; has hornblende disseminated in very small crystals; works much easier than some of the compacter basalts, but takes a good polish. The entire temples of Koorul and Boleshwur, with their innumerable alto-relievo figures and laboured ornaments, are built of this variety of trap, which is, in fact, a greenstone, although less crystalline than the European rock. There is a variety selected carelessly, also used in building, which has the structure and nearly the external characters of the last, but which, in weathering, exfoliates, and the

buildings fall to ruin ; such is the case with the great temple in Hurreechundurhur.

I must not omit mention of two remarkable rocks which, as far as my reading extends, have not been noticed by authors on European geology. The first is an amygdaloid in which compact stilbite is imbedded in a vermicular form. One of its localities is the insulated hill on which stands the temple of Parwuttee in the city of Poona\* ; and it is met with in many other places. Captain Dangerfield observed the same peculiar stratum near Sagar. He says, "There occurs an amygdaloidal or porphyritic rock consisting of a compact basis of wacké, in which are imbedded in great abundance small globular or uniform masses, but more usually long *curved* cylindrical or vermiform crystals of zeolite †."

The other rock occurs as a thick stratum of amygdaloid at the elevation of 4000 feet, in the hill forts of Hurreechundurhur and Poorundhur ; and in the bed of the Goreh river at 1800 feet, near Serroor. The matrix resembles that of the other amygdaloids, but the mineral imbedded is a glassy felspar in tables resembling Cleavelandite, crossing each other at various angles, and so abundant as to occupy a moiety of the mass. I have only remarked it in the above localities, and it does not appear to have come under the notice of the gentlemen I have so often quoted in other parts of the peninsula.

#### *Minerals.*

Minerals are not uniformly dispersed in Dukhun. In one part quartz predominates, in another chalcedony ; and these are more or less associated with jaspers, agates, hornstones, heliotrope, and semi-opal or cachalong. In other places particular members of the zeolite family prevail, nearly to the exclusion of the siliceous class ; and elsewhere there is a diminution of minerals amounting almost to privation. Amethyst quartz is rare in Dukhun ; when met with it constitutes the crystal, lining the interior of geodes of agate. I have not seen it in veins. Pseudomorphous quartz is common ; the most frequent impression is that of rhomb spar. Lime occurs only in three crystalline forms : rhomb, dog-tooth, and the dodecahedron. The first is found on the surface, and imbedded in masses of quartz and compact mesotype ; the two latter forms are associated with ichthyophthalmite in cavities in the amygdaloid strata ‡.

\* See Plate XXVIII. fig. 2., near to the city of Poona.

† Central India, p. 328.

‡ That comparatively rare European mineral, ichthyophthalmite, is most abundant and of great beauty in the neighbourhood of Poona.



The following are a few of the mineral localities :

At Kothool, south of Ahmednuggur, the numerous quartz and chalcedony veins cover the country with agates, colourless quartz-crystals, and chalcedony; some of the specimens are fully a foot thick, including both walls of the vein. Here are met with some few crystals of calcareous spar inclosed in quartz. At Ahmednuggur, to the above siliceous minerals, some members of the zeolite family are to be added, principally stilbite. At Nandoor, on the plain of the Godavery river, the zeolites disappear, and the siliceous minerals are limited in number. On the contrary, at Jamgaon, eighteen miles west of Ahmednuggur, on the upper terrace or plateau, in addition to all the minerals enumerated, bits of yellow and red jasper and heliotrope occur. Ascending the Mool river from Nandoor, at Aklapoor, great masses of mesotype, with radii several inches long, are found imbedded in friable amygdaloid. North of Aklapoor, at Gorgaon, a new mineral occurs in a mass two feet in diameter. Its depth I do not know, as it lay partly buried in the amygdaloid bed of the river: its colour green, and breaking into rhombs. Gorgaon is the only locality known to me of this mineral. Its measurements are those of calcareous spar, but the specific gravity is less. It is stated to be coloured by green earth. It is interesting from being unknown in the cabinets in England.

A few miles further up the Mool river, at the village of Chas, in the shoulder of a hill formed of numerous thin horizontal beds of decomposing amygdaloid, many specimens of cloudy calcareous spar, imbedded in stilbite, are found, and the siliceous minerals are rare. Ascending to the source of the river the same scarcity prevails. Three miles south-south-west of Chas, at Brahmunwareh, great masses of stilbite, of the radiating foliate kind, are imbedded in hard amygdaloid. In the hill fort of Hurreechundurghur, although siliceous minerals are not abundant, crystallized quartz of various colours is seen, a feature not characterizing the Desh or open country. South of Ahmednuggur, as far as Soagaon on the Beema river, and Meerujgaon on the Seena river, the Ahmednuggur minerals prevail; hence descending the Beema to its junction with the Seena, a gradual diminution takes place, and at the junction they almost disappear; returning north, at Ashtee, between Kurkumb and Mohol, a few are met with. At Oondurgaon, and up both banks of the Seena river to Purrunda, numerous and very fine specimens of milk opal, with a flame-coloured tinge in transmitted light, are found on the surface; and this is the only locality where I met with opal as a distinct mineral; and here the members of the zeolite family are very rare. At Tudwull, between Oondurgaon and Barlonee occur the only specimens of black calcareous spar seen by me in Dukhun; it is associated with transparent calcareous spar. In excavating wells in the cantonments at Poona, splendid specimens of ichthyophthalmite were brought to light; and generally in the bed of the river Mota-Mola and the neighbourhood, fine specimens of heliotrope and coloured quartz occur. The other minerals are *nadelstein*, *analcime*, *chabasite*, and *laumontite*. Captain Dangerfield's details prove that the minerals of Malwa are identical with those of Dukhun.

### *Natural Salts.*

Only two kinds of natural salt came under my notice, namely, muriate and carbonate of soda.

With respect to the former, many of the wells at Ahmednuggur are brackish; and there is a rivulet running into the Seena river about two miles north-west of the city, which has its source a few miles distant, called the Salt Brook. It passes over a saliferous soil; and in its dry bed, or

on insulated stones standing in its stream, are incrustations of common salt intimately mixed with carbonate of lime. No use is made of this salt. The saline impregnation of the soil extends to some distance west and north-west of Ahmednuggur, as I found a handsome well at Kurjooneh, eight miles distant, filled with water so brackish as not to be available for domestic use. At Wurgaon, between Kurjut and Pairgaon, a peculiar hoary appearance of a patch of ground in the midst of withered grass, led me to examine it. The whiteness was occasioned by lime in minute particles, mixed with a little muriate of soda.

The third locality of common salt was in the bed of a rivulet at Koond Mawlee, near the falls on the Kookree river, between Serroor and Kowta. A little common salt, with a trace of carbonate of soda, appeared, incrusting the rocky bed for a few feet near the water line. I did not observe common salt elsewhere. My attention was first directed to carbonate of soda at Serroor, by observing washermen digging for earth in the banks of a rivulet; learning that they used it to wash their clothes, I obtained a quantity; lixiviated the earth, boiled down the lixivium, and on cooling obtained a large crop of crystals, which the usual tests indicated to be carbonate of soda. I only met with one other bed, although I have no doubt they are numerous. At Kalbar Lonee, twelve miles east of Poona and two miles south of the Mota-Mola river, within an area of 200 yards, a constant moisture and partial absence of vegetation is observed. An efflorescent matter appears on the surface every morning, which is carefully swept up and sold to washermen: it is carbonate of soda. The occurrence of salts in the trap formation did not escape Captain Dangerfield's notice. He states that "the banks of the Nerbuddeh (Nermada) near Mundleysir, consist of an upper thin bed of vegetable mould; a central bed, chiefly of indurated marle, strongly impregnated with muriate of soda; and a lower bed, of a reddish hue, with much carbonate of soda. In the dry season these salts form a thick efflorescence on the surface of the bank\*." Saltpetre is manufactured in Dukhun, not from nitrated soils, but from the scrapings of old walls. I have also seen specimens of muriate of ammonia obtained by the brick and tile makers in burning dung, stable and other refuse matters in their kilns.

#### *Ores.*

No other ore than that of iron is found in Dukhun. It is only worked, to my knowledge, at Mahabuleshwur, at the source of the Krishna river. It occurs as a nodular hematite, associated, I understand (for I have not been at the spot myself), with laterite. This ore produces the celebrated Wootz steel.

#### *Organic Remains.*

I did not meet with organic remains of any kind whatever. Captain Coulthard† in Sagar, Major Franklin in Bundelkand, and Captain Dangerfield in Malwa, were equally unsuccessful. Dr. Voysey, indeed, mentions a bed of freshwater shells in a stratum of indurated clay near the Tapti river in the Gawelghur hills; also at Medconta, 2000 feet above the sea, on trap; but these may have been recent, as he does not say to the contrary‡. Mr. Calder, in his general observations on the Geology of India§, says, "But hitherto the

\* Malcolm's Central India, p. 324.

† Physical Class, Asiatic Researches, p. 81.

‡ Physical Class, Asiatic Researches, p. 194.

§ Ibid., p. 16.

most striking phænomenon in Indian geology is the almost total absence of organic remains in the stratified rocks and in the diluvial soil." As this must have been written with a knowledge of Dr. Voysey's paper, it being in the same volume with his own, it is probable he considers the shells recent.

### *Thermal Springs.*

Thermal springs do not exist in Dukhun within my limits ; but there are three distant localities in the Konkun below the Ghâts, where hot water gushes up from numerous crevices in trap rocks over an extensive surface.

The first is at Vizrabhaee, forty-eight miles north of Bombay, where the principal springs are in the bed of a river, and in the monsoon are consequently lost in the swollen stream ; but in traversing the jungle in the vicinity I have met with detached pools of hot water, which are unaffected by the rains ; their temperature is very high. The second locality is that mentioned by the late Dr. White, of the Bombay army. The hot wells are called Devaki Unci, and are fifty miles south-east from Surat\*, at the foot of some hills ; the temperature in the different springs ranges from 111° to 120° Fahr. They are spoken of as being in the vicinity of Anaval and Veval, but as these places, agreeably to the map of India, are only thirty miles from Surat, there is evidently some mistake with regard to the distance. The third locality is at Mahr, on the Bancoot or Fort Victoria river, about seventy-five miles south of Bombay. I know of these springs only from report. The whole of the above springs, extending through 3° of latitude, lie nearly in the same parallel of longitude (73°), and are within twenty-five miles of the sea.

In a manuscript report to the Government of Bombay, on the province of Khandeish, Colonel Briggs has the following passage testifying to the occurrence of thermal springs above the Ghâts :

"Among the natural curiosities of Khandeish are the hot springs of the Satpoora hills, particularly those of Soonup Deo and Oonup Deo, the former in the district of Arrawud, and the latter in the deserted Pergunneh of Amba. The former is so hot that the hand cannot be borne in it ; the latter is less ardent, and is used as a hot bath ; they are both said to possess medicinal qualities, and are considered useful in the cure of cutaneous disorders,—amongst others leprosy."

Dr. Buchanan speaks of hot springs at Rishikunda and Bhimban† in the trap mountains of Rajmahl‡ ; and the Rev. Mr. Everest mentions a thermal spring associated with a trap bed at Katcansan, between the 23rd and 24th parallels of latitude, and longitude 86° and 87°‡. Dr. Adam mentions that of Sitakhund near Monghyr on the Ganges§. Dr. Davy speaks of one at Cannina, Ceylon|| ; and I am informed they are to be met with in Canara. Mr. Crow, formerly commercial agent of the Bombay Government in Sind, in his manuscript reports, mentions a thermal spring near Corachee on the Indus, of which the water is almost boiling hot. In Major Cruickshank's manuscript revenue map of part of Goojrat a hot spring is placed at Tooee, near Ruttenpoor on the Mhye river, in latitude north 22° 49', and longitude east 73° 30' ; and there is another at Lawsoondra, eighteen miles west-north-west of Tooee. These instances, which I am satisfied could be multiplied by diligent inquiry, afford ample proof of the wide occurrence in the peninsula of India of those singular phænomena, the satisfactory explanation of the causes of which is still a desideratum in geology.

\* Transactions of the Royal Asiatic Society, 1833.

† Gleanings of Science, May 1831, p. 135.

‡ Geol. Trans., 1st Series, vol. v. p. 313.

§ Gleanings of Science, vol. i. p. 36.

|| Geol. Trans., 1st Series, vol. v. p. 349.

*Craters.*

Volcanic products were not seen by me, nor any conformation of the hills that might be deemed an extinct crater; although the porcelain and ferruginous clays, and the exterior coat of the various quartz and jasper minerals indicate their having been exposed to igneous action. Captain Dangerfield did not meet with volcanic matters or craters in Malwa or the Vindhya range, but states a tradition exists of the celebrated city of Oogoin, and eighty other places having been destroyed at a remote period by a shower of earth; and the people say that in the Vindhya range and Rajpeeply hills there are hollows near their summits "sometimes filled with water, which may be craters\*." As the old city of Oogoin stood upon a river constantly overflowing its banks, it was probably buried in alluvium. Mr. W. Hunter attributed its destruction to one of three causes,—earthquake, overflowing of the Seeprah, or drift earth by high winds; and, although the least probable of the three, inclines to drift earth. He states there are not any traces of volcanic agency in the buried city, nor in the neighbourhood†. The remains of the city of Mhysir, on the banks of the Nerbuddeh (Nermada), are found in alluvium. We may safely say, therefore, there are not any indications of volcanic action of a comparatively recent date.

*Extent of Trap Region, &c.*

I will now offer a few observations on the amazing extent of the trap, laterite, nodular limestone, granite, and gneiss formations in the Peninsula, limiting their application to  $25^{\circ}$  of north latitude. My personal knowledge of the country extends from the sea on the western side, to Arungabad, in  $75^{\circ} 33'$ , and Sholapoor,  $75^{\circ} 53'$  east longitude; north, nearly to Kandeish, and south, to Beejapoor and the Kristna river. Captain Dangerfield takes up the country on the north, nearly where my knowledge of it terminates, and says, "It (Malwa, including the Vindhya range) appears to constitute the northern termination of a very extensive secondary trap formation, which extends from the extremity of the Dukhun, and probably even Mysore, forming all the country above the Ghàts, and part of the plains below, on the western side of the Peninsula, including the islands of Bombay, Salsette, Elephanta, &c.‡" He carries the continuous trap north to Neemutch, in latitude  $24^{\circ} 27'$ , at 1476 feet above the sea. Its western limit is at Dohud, longitude  $74^{\circ}$ . Major Franklin and Captain Coulthard take it up in the eastern limits of Malwa, and trace it through Sagar; and it continues to an unknown extent towards Sohagpoor and the source of the Nerbuddeh river, on the table-land of Amarakantah, in longitude  $82^{\circ}$  east. Dr. Voysey describes its eastern limits at Nagpoor, latitude  $21^{\circ} 10' N.$ , and longitude  $79^{\circ} 14' E.$  at 1000 feet above the sea. Mr. Calder states it passes from Nagpoor southward by the confines of Hyderabad, as low as the 15th degree of latitude, and taking a north-west direction terminates on the sea-coast at Bancoot or Fort Victoria, in latitude  $18^{\circ}$ . But specimens of rock shown to me from the Kolapoor country above the Ghàts, between

\* Malcolm's Central India, Appendix, p. 325.

† Asiatic Researches, vol. vi. p. 39.

‡ Malcolm's Central India, Appendix, p. 320.

the parallels of latitude  $16^{\circ}$  and  $17^{\circ}$  N., bear testimony to the trap extending nearly a degree and a half further south along the Ghâts than Mr. Calder supposed. Indeed its southern limit in the Konkun, Mr. Fraser states to be at Malwan, fifty miles north of Goa\*. From the above evidence we have proofs of a continuous trap formation covering an area of from 200,000 to 250,000 square miles, a phænomenon unexampled in any other country whose geological structure has been examined. It appears to me, however, that the above are not the absolute limits of the trap. Dr. Buchanan† and Mr. Jones‡ describe the Rajmahl hills in latitude  $25^{\circ}$  and longitude  $88^{\circ}$  to  $89^{\circ}$  E. as trap; the latter says the basalt is of amazing thickness. The Rev. Mr. Everest§, in a journey from Calcutta to Ghazipoor, passed four distinct broad beds of trap between the parallels of north latitude  $23^{\circ}$  and  $24^{\circ}$ , and longitude  $84^{\circ}$  and  $87^{\circ}$ . He states these beds to have an inclination to a common axis, and he thinks it probable they are connected beneath the granite and gneiss. Mr. Royle travelling the same route, observed the same beds. Mr. Everest's diagram shows their longitudinal axis on a line between the Rajmahl hills and the sources of the Nerbuddeh and Soan rivers; and as the trap of the Vindhya range and Sagar extends towards these sources, it is very probable the ramifications are connected with the beds (seen by Mr. Everest) and the Rajmahl hills, forming a belt across India from the  $73^{\circ}$  to the  $89^{\circ}$  of longitude, extending, in fact, from near the mouth of the Nerbuddeh river to the Ganges at Rajmahl. The southern limit of trap is much lower than is assigned to it by Mr. Calder, as Dr. Voysey describes a basaltic dyke at Seringapatam, in latitude  $12^{\circ} 26'$ ; and Mr. Calder himself mentions partial deposits of overlying rocks as far south as Cotallum, at the extremity of the great western range, between the parallels of latitude  $8^{\circ}$  and  $9^{\circ}$ . Mr. Babington, passing through Mysore, describes all the black rocks he met with as hornblende passing into basalt. He evidently adverts also to nodular basalt||.

#### *Age of Trap.*

With respect to the age of the great trap formation of India, it would appear from Major Franklin's Memoir on Bundelkund, that its northern extremities rest on sandstone, which he considers identical with the new red sandstone of England; the trap would therefore be posterior to the carboniferous series and belong to the supermedial order. But the Rev. Mr. Everest¶ adduces valid reasons for questioning the correctness of Major Franklin's opinion; and it may be inferred, that he is doubtful with respect to the exact

\* Geol. Trans., 2nd Series, part i. p. 153.

† Phys. Class, As. Researches, p. 165.

|| Geol. Trans., 1st Series, vol. v. p. 325.

‡ Gleanings of Science, vol. iii. Jan., 1831, p. 1.

§ Gleanings of Science, vol. iii. p. 135.

¶ Gleanings of Science, vol. iii. p. 211.



equivalent in Europe of the Indian sandstone, as it is much associated with the primitive rocks \*. In fact, where are the oolitic rocks above, and the magnesian below the red sand, where the rock salt and gypsum, and where, above all, the characteristic organic remains of the lias and magnesian limestone? It would be idle, therefore, to speculate on the era of a formation without a standard of comparison to direct the judgement. The question of the manner of the formation of the horizontal beds of trap with their vertical edges is very interesting. It will be said they were ejected under the pressure of an incumbent ocean. If such had been the case, where are the marine remains, and would not there have been sedimentary deposits upon them? Moreover, if viewed as coulées from craters, would not the beds have thinned out, instead of preserving the parallelism of their superior and inferior planes and their vertical edges?

#### *Laterite.*

Laterite is a ferruginous clay mottled red and yellowish. When first dug from its bed, it is soft and is easily fashioned into the form of bricks or large square masses for building; and if my recollection serves me right, it constitutes the material of the walls of the fort at Tellicherry and the jail at Calicut. It rapidly indurates on exposure to the atmosphere. It is destitute of fossils, as far as is yet known.

That curious and very extensive rock, aptly denominated laterite, (I learn from the information of a friend,) occurs at the source of the Kristna river in latitude  $17^{\circ} 59'$ , at an elevation of 4500 feet above the sea. It covers the low land between the sea and the great western range from the southern Konkun to Cape Comorin, and, agreeably to Dr. Davy, passes into Ceylon. I casually observed it at Tellicherry and Calicut, respectively 744 and 756 miles south of Bombay; and at Calicut granite rises through it. On the low land at the base of the great *eastern* range, Mr. Calder says it reappears between the  $11^{\circ}$  and  $12^{\circ}$  parallels of latitude, and recurs in increasing patches passing northwards, covering granite. The Rev. Mr. Everest speaks of laterite forming a fringe to great part of the bay of Bengal and covering the edge of the granite of either peninsula †.

#### *Nodular Limestone.*

In addition to the evidence already adduced of the extensive occurrence of nodular limestone, Dr. Buchanan mentions having met with it in Rajmahal trap hills, in Bengal, and in Mysore. A writer in the 'Gleanings of Science' ‡ states that it occurred in repeated borings for water in Calcutta, at from 50 to 112 feet below the surface. Another writer § says, it is "very extensively distributed throughout Hindoostan," and further asserts that it is a "most distinguished feature of Indian geology." The Rev. Mr. Everest and Mr. Royle remarked it in their journey before adverted to. The few organic remains

\* Gleanings of Science, vol. iii. p. 213.

† Ibid., vol. iii. p. 135.

‡ Ibid., vol. i. p. 169.

§ Ibid., vol. i. p. 365.



hitherto found imbedded, belong to living species. The following is the analysis of "Kankar" \* (nodular limestone) by Mr. Prinsep †.

Water of absorption .....	1·4
Carbonate of lime .....	72·0
Carbonate of magnesia .....	0·4
Silex .....	15·2
Alumine and oxide of iron .....	11·0
	<hr/>
	100·0

Kunkur, or nodular limestone, has been likened to the cornbrash of the English strata ; but its geological position (principally superficial), and the absence of characteristic fossils, present insuperable objections to their identity.

### *Granite.*

The late Dr. Voysey states, that he "had reason to believe, partly from personal observation and partly from specimens obtained from other sources, that the basis of the whole peninsula of India is granite ; he had traced it along the coast of Coromandel, lying under iron clay (laterite) ; also in the bed of the Godavery river, from Rajamahendri to Nandair ; and he had specimens from the base of the Sitabaldi hills of Nagpoor, from Travankur, Tinneveli, Salem, and Bellari." Mr. Stirling in his memoir on Cuttaek says, "The granite where my specimens were principally collected appears to burst through an immense bed of laterite (iron clay) rising abruptly at a considerable angle ‡." Major Franklin adds to the above quotation, "the plains of Bundelkhund attest that granite is there the basis rock." Ceylon is exclusively granite and gneiss ; finally, I observed granite rising through laterite at Calicut on the Malabar coast. With these facts before us, we can scarcely question the truth of Dr. Voysey's opinion ; an opinion involving the belief, with reference also to the extent of trap, that the whole peninsula of India and Ceylon, covering an area roughly calculated of 700,000 square miles, is of igneous origin.

### *Sedimentary Rocks.*

I am not aware of the existence of any sedimentary rocks in Western India, south of Baroach, excepting such as have probably originated in the consolidation of comparatively recent alluvium.

### *Recapitulation.*

I close this paper with a recapitulation of the characteristic geological features of the peninsula ; namely,—the amazing extent of the trap region, and the horizontal position of its stratified beds the granitic basis of the whole

\* Properly *Kunkur*.

† Gleanings of Science, vol. i. p. 278.

‡ Phys. Class, Asiatic Researches, p. 37.

country ; trap veins in granite ; the absence, as far as is known, of that uniform series of rocks which constitutes the formations of Europe ; the extended and peculiar nodular limestone and laterite formations ; the occurrence of pulverulent limestone in seams ; and finally, the non-discovery hitherto of the fossil remains of extinct animals within the limits of the Peninsula.

*London,*  
*January 21st, 1833.*

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A few words are necessary in explanation of the sections which accompany this paper. They represent two principal spurs from the Ghâts, and converge to the same point at the junction of the Goreh and Beema rivers. In strictness they are not sections ;—ramifications of the spurs, and hills at short distances north and south of the central vertical plane being inserted : they partake, therefore, of a slightly perspective character, but this does not affect the general correctness of their geological features. Fig. 1. comprises the range of hills between the Under and Beema rivers, and has a length of about seventy-five miles. Fig. 2. shows the mountains between the Bore Ghât and the source of the Mota river, and extends nearly eighty miles. The length and elevation are expressed by different scales, and from this cause the outlines of the mountains are not rigidly correct. A bare outline is traced from the Ghâts westward to the sea, for the purpose of showing the curious forms of the weathered basaltic caps and ridges of the mountains in the Konkun.

The elevations were determined either barometrically, or thermometrically. Those marked "B." are barometrical, and result from simultaneous observations with previously-compared barometers ; all the necessary corrections having been applied, for temperature, moisture, and latitude. Those marked "W." were obtained by ascertaining the boiling-point of water at different elevations with delicate thermometers : they are not to be relied upon within 100 feet, although in some instances, when tested by barometrical measurements, they corresponded within a few feet.

Of the Panoramic Sketches, Plate XXVII. No. 1. is a distant view of the mountains, on which are situated the celebrated hill forts of Jewdun, Hurreechundurghur, Koonjurghur, and Sewneir, in which Sewajee, the founder of the Mahratta empire, was born. It is taken from the hill N. of the town of Goreh.

No. 2. is a view of the hills, to the North and East, as seen from Lakungaon in the flat broad valley of Jooneir (Sewneir).

No. 2\*. is a continuation of the view No. 2., from the N. round to the West.

No. 3., a sketch of the hills, to the North and East, as seen from the summit of the armoury, in the fort of Ahmednuggur.

No. 4. is a sketch of the northern flank of the plateau, on which the city of Ahmednuggur stands ; as seen from Wamooree, in the plain of the Godavery river.

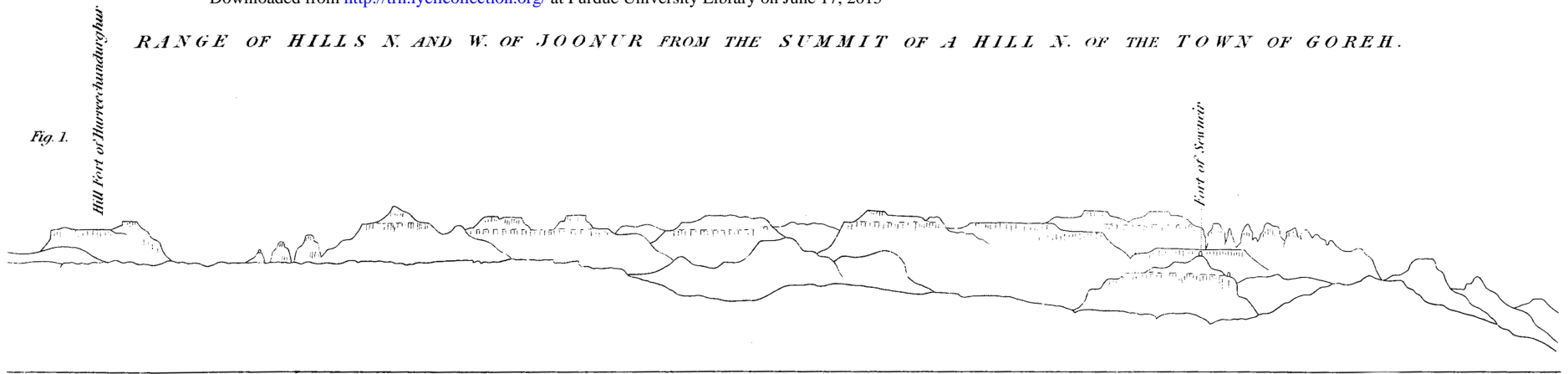
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RANGE OF HILLS N. AND W. OF JOONUR FROM THE SUMMIT OF A HILL N. OF THE TOWN OF GOREH.

Fig. 1.



N. TO E. RANGE OF HILLS AS SEEN FROM LAKUNGAON IN THE VALLEY OF JOONUR.

Fig. 2.

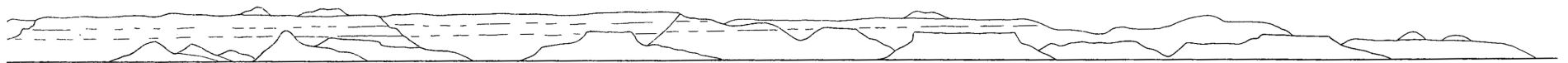


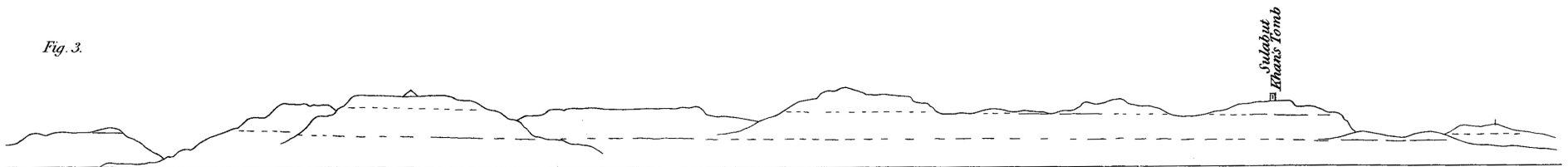
Fig. 2. CONTINUED FROM THE N. TO THE W.

Fig. 2.\*



HILLS TO THE N.E. AND E. AS SEEN FROM THE ARMOURY IN THE FORT OF AHMEDNUGGUR.

Fig. 3.



NORTHERN FLANK OF THE PLATEAU ON WHICH THE CITY OF AHMEDNUGGUR STANDS AS SEEN FROM WAMOOREE.

Fig. 4.

