XXV.—*Memoir to illustrate a Geological Map of Cutch.*

By C. W. GRANT, Esq., Capt. Bombay Engineers.

[Read February 22, 1837.]

CONTENTS.

Geographical Position, and Physical Aspect.

THE province of Cutch, in the East Indies, is situated between the 22° and 24° of north latitude, and 68° and 70° of east longitude*. It is bounded to the north by the Grand Runn, beyond which is the Thur or Little Desert; to the S.W. and S. by the Gulf of Cutch and the Indian Ocean; to the E. and S.E. by the district of Guzerat; and to the N.W. by the eastern branch of

* See Map, Plate XX.

the Indus and the territory of Sinde. Its extreme length from E. to W. is about 180 English miles, and its extreme breadth is 50 miles; but in one place it is not more than 15 miles across. It contains about 6500 square miles, independently of the Grand Runn, which ought, however, to be considered as a part of the province, and which, including the islands with the portion bounded by the Guzerat coast, occupies an area of at least 9000 square miles.

Physical Aspect of the Country.—The province is hilly and rocky, with the exception of the part forming the southern coast, which is a dead flat covered with a fine rich soil. Three distinct ranges of hills, having an easterly and westerly direction, may be traced (see Map, Pl. XX.). The most northern forms an irregular chain bordering the Runn, and, for the greater part, presents to the north a perpendicular cliff surmounting a sloping talus, and to the south an inclined plane. It is composed chiefly of rocks, containing marine remains. The next, called the Charwar range, passes transversely through the centre of the province, and is connected with the former, at its north-western extremity, by a cluster of hills. It consists partly of sandstone containing beds of coal, and partly of a series of strata of slate clay, limestone slate, and slaty sandstone. The third, or southern range, and composed entirely of volcanic materials, has the same direction as the other two; but it is of smaller extent, and a branch of it, striking nearly north and south, passes through the centre of the Charwar range. A number of isolated volcanic hills are also scattered over the plain and in other parts of the province, particularly on the borders of the Runn, where is situated the hill called Denodur, the largest in Cutch.

There are no constant streams, the river courses being merely channels for conveying the periodical floods to the sea, and containing, during the remainder of the year, only detached pools. The banks of these courses are, however, very high and precipitous, and afford excellent sections of the strata through which they pass.

FORMATIONS.

I have divided the country into the following eight distinct formations:—

1. Syenite and quartz rock.
2. Sandstone and clay, with beds of coal.
3. Red sandstone.—This formation I have not coloured in the Map, having been unable to trace its boundaries. In mineralogical characters it resembles the new red sandstone of England, and differs materially from No. 2., or the formation which contains the coal.
4. Upper secondary formation, consisting of slate clay, limestone slate, and slaty sandstone, and containing *Ammonites*, with other fossils characteristic of the secondary formations of Europe.

5. Nummulitic limestone and marl.
6. Tertiary strata.
7. Alluvial, or recent deposits.
8. Volcanic and trappean rocks, including all such as bear evident marks of a perfectly igneous origin, as basalt, &c.

These eight divisions, considering the red sandstone as one, represent generally the geological structure of the province, though many minor subdivisions might doubtlessly be made; and the surfaces coloured in the Map, must be considered rather as giving a general idea of the extent of the different formations, than as defining correctly the boundaries of each division.

1. SYENITE AND QUARTZ ROCK.

The only good example of syenite *en masse* is a hill called Calunja, near the town of Nuggur in Parkur, a district in the Thur, and not far from the mouth of the Loonee river. It is not in Cutch Proper; but as it forms part of the northern coast of the Runn, and is in other respects connected with the geology of the province, I have introduced it as one of the formations.

The Calunja hill is a confused heap of light red syenitic rocks, composed of quartz, red or white felspar, and large long crystals of hornblende; the compound being sometimes coarsely grained, and sometimes finely. The base of the main hill is surrounded with small conical mounds, which, at a distance, resemble the huts of a village. On entering the space occupied by these mounds, the hill presents a number of irregular, shattered masses, the sides of which are so steep, and are worn so smooth by the action of the elements, as to be extremely difficult of access. Between these masses the sand lies very deep. It is quite evident, that this hill has been violently acted upon by earthquakes.

In the bed of a river near the village of Koonerea, in the Puchum island, situated in the Grand Runn, I found some masses of precisely similar syenite, which were probably erratic blocks from the Calunja hill; and it will be seen, by referring to the Map, that this island lies nearly in the direction which would be taken by any sudden floods, coming down the Loonee river.

Quartz Rock.—This rock is principally developed in a hill of considerable height near the town of Mhurr, situated towards the western side of the province. The upper part of the hill is entirely composed of it, and huge masses are scattered about the base. A large cleft extends about half way up the western face of the hill, and displays its internal structure, consisting of a

centre of quartz rock, surrounded by horizontal strata of loose, quartzose sandstone. The quartz rock varies considerably in character, being sometimes perfectly compact, exceedingly hard, conchoidal in its fracture, and smooth or foliated on the surface; in other parts it is saccharoidal; occasionally it consists of larger particles, so firmly cemented together that they break with smooth surfaces: some masses, again, have a decidedly granular texture; and one variety is composed of rounded pebbles of quartz of the size of marbles; but in no specimen did I find any other material than pure quartz.

From the extremely fractured appearance of this hill, and from the quantities of basalt lying about, and forming the principal part of some small hills immediately adjoining it, there can be no doubt that it has been subjected to igneous influence; and to the same cause the variety in the texture of the quartz is also probably due, some portions appearing to have been sufficiently fused, for its particles to have agglutinated into a solid mass. This opinion may perhaps be further strengthened by an examination of the country near the town of Mhurr, distant about one mile and a half, where various dykes of basalt traverse the strata. Similar intermixtures of quartz with basalt occur in a hill called Peaka, from its piebald appearance, not far from Joorun, on the Runn, and nearly opposite the south-west extremity of the Bunnee: also in some low hillocks at the base of the Katrore hill in the Charwar range. At the village of Ghuranee, about ten miles east of Mhurr, a large dyke or vein of quartz protrudes from a level plain, and forms a ridge of solid rock about 30 feet in height. Basalt also crops out near the same spot.

2. SANDSTONE AND CLAY, WITH BEDS OF COAL.

This formation occupies a considerable portion of the country (see Plate XX.), and consists of a regularly stratified series of thick beds of sandstone, alternating with slate-clay, which contains, occasionally, bands of ironstone; and where the coal occurs, it is intermixed with blue clay or shale, and a greasy substance resembling fullers'-earth. South of the Charwar range, the general dip of the strata is S. by W. and S.W., at about one foot in twenty or thirty; but north of that range, the dip varies so much, that it is impossible to ascertain the prevailing direction; and the whole series is so broken, and intersected with dykes and dislocations, as to render fruitless all attempts to determine its general strike.

It will be seen by the Map, that the centre of the province is dotted with hills containing igneous rocks; and the disturbed state of the beds, in their vicinity, may easily be conceived. The smaller hills are composed of con-

fused heaps of a very ferruginous sandstone and ironstone, belonging to this formation, and the surface soil is a deep sand. The texture of the strata varies from a coarse, loose sandstone to a compact and extremely hard quartzose grit and conglomerate, cemented by ferruginous matter, some specimens being almost black.

Iron Ore.—In this formation, the iron ore smelted for commerce is procured. It is found in different parts of the country, but has been principally extracted near the town of Doodye, opposite the S.W. termination of the Bunnee. It there occurs in small lumps, which are of a spongiform texture, small specific gravity, and are very frangible. The natives, however, value this variety more than the heavier, from its yielding with greater ease to their imperfect means of smelting.

Manufacture of Iron.—In extracting the metal, layers of very small pieces are disposed alternately with others of charcoal, in a rude open furnace, and exposed to the blast of two small bellows made of sheep-skins. The metal, when fused, falls into a hole at the bottom of the furnace, whence it is transferred to an inclosed furnace, and subjected to similar blasts, until brought to a white heat, when it is taken out and beaten into a bar. No flux of any kind is used. A considerable quantity of iron was, at one time, made from a totally different description of ore, found near the village of Punundrow, in a plain which extends to the sea or eastern mouth of the Indus. This plain is bounded to the south by low hills covered with fragments of basalt, being outliers of a basaltic range further to the south-east. The surface of the plain is composed of a fine smooth gravel, composed of comminuted particles of iron ore, and has every appearance of having been, at no distant period, covered with water. The iron ore is found near the surface of the low hills above mentioned, in small tabular fragments imbedded in a purple-coloured earth; and those pieces are selected, which give a bright streak on being struck by a pointed instrument. Externally the ore is of a purple colour, and internally presents small dark blue fibres, arranged at right angles to the surface of the specimen. In another place a variety occurs, which resembles small fragments of tile, but has the same internal structure. It is very hard, and of considerable specific gravity; and is said by the natives to have yielded a much greater per centage and much better iron than the ore found at Doodye; but the manufacture of it has been suspended, owing partly to the scarcity of fuel, and partly to English iron being procured at a cheaper rate, as well as in much more convenient forms.

Coal.—Coal has been found in this formation in various places, but not in beds sufficiently thick to be worth working. It was first discovered in the bank of a river near the city of Bhooj, forming a bed about 18 inches thick, and associated with strata of sandstone and blue clay, the dip being, to the eastward, one foot in twenty. This bed was worked for some time, and considerable quantities of its produce were sent to Bombay, but the quality was bad, being very slaty, and containing a large proportion of incombustible matter. Attempts were afterwards made to discover coal in other parts of the province; and although various beds were met with, they were too thin to be of any value. This search was carried on principally to the south of the Charwar range, a few miles from the town and fort of Seesaghud.

One bed was found of a very good quality, but only 9 inches thick. It consisted of masses composed of small cubical pieces, which soiled the fingers very much, had not the slightest appearance of a lignite, and ignited quickly, burning with a bright flame, and leaving a small residuum, but it would not cake. It was found on trial to get up the steam of an engine-boiler very well and quickly, but a much larger quantity was required than of English coal, owing, partly, to its breaking into so small fragments as to fall through the bars of the grate.

Borings for Coal.—A boring for coal was made near this bed; and although 270 feet of sandstone and blue clay were penetrated, no coal was found. A similar attempt was made six miles further to the eastward, and to the depth of 191 feet, but with no better success; and similar researches were made in one or two other places. The second trial passed through a regularly alternating series of sandstone and blue clay. Some of the sandstones were so extremely hard (being composed of quartzose particles cemented by ferruginous matter) as to be almost impenetrable. A jumper, worked by a lever-bar, making eighteen strokes in a minute, penetrated, after eight hours' work only, from 1¼ to 2 inches. Other specimens of sandstone varied both in hardness and quality; and at a depth of 190 feet, a bed of white, pure quartzose sand was entered, when water immediately rushed to the surface, and continued to flow in such quantities as to stop the work. The shale was of a very dark blue when first brought up, but it lost the greater part of its colour after exposure to the sun. Iron ore and iron pyrites were found. All the banks of the rivers in the neighbourhood present strata of sandstone and slate-clay, with bands of ironstone, and, in places, thin beds of coal. The general dip is, to the south-west, about one foot in twenty; but the strata are greatly shattered and dislocated by dykes, slips, and hitches.

Vegetable Impressions.—The slate-clay, and, in some cases, the sandstone, contained numerous impressions of ferns and reeds*, occasionally of a large size. One specimen, which was flattened, was four inches in breadth, and the outer surface was carbonised, but the interior was filled with sand: this was generally the case, though other specimens were carbonised throughout, and some were mere impressions. In digging wells within the limits in which they occur, coal was frequently found, but always in thin beds; and some of it ought more properly to be called lignite.

Extent of Coal-field.—The coal-field, if it may so be termed, is bounded to the north by the upper secondary or laminated slate-clay and limestone slate formation; and to the south it is cut off abruptly by a low range of volcanic and trap hills. I could not ascertain whether it had ever been covered by any conformable, stratified deposits. Thin beds of coal have been found in various other parts of the formation. The general structure of this series of strata, the quality of some of the coal, the nature of the sandstone and slate-

* Plate XXI.

clay, the impressions and remains of reeds, ferns, &c., the bands of ironstone, the dislocations by dykes, slips, &c., all bear an analogy to the coal-fields of England; but I am inclined, from the vegetable remains, to consider this deposit an equivalent of the oolitic coal of England, and not of the regular carboniferous system.

ALUM WORKS NEAR MHURR.

The ground on which Mhurr is built, consists of high, irregular banks of marl of every variety of colour, but in a most confused and shattered state. It is surrounded on three sides by steep hills, forming a kind of amphitheatre; and nothing can be more desolate than its appearance. North of the town is a high table-land, which extends to some hills about one mile and a half distant. It is composed, near their base, of a ferruginous quartzose sandstone, on which the variegated marls rest; the latter being covered, in many places, with a bed of coarse gravelly detritus, six or eight feet thick. Imbedded in this gravel, are some very large masses of basalt, and of a very hard, black stone, composed of grains of quartz cemented by an almost black oxide. They are cut into mill-stones for grinding flour. The whole are evidently boulders from the hills to the northward, which were mentioned in the first part of this memoir, as consisting of quartz and basalt. This plain terminates, to the southward, in a high bank overlooking the town, and intersected in one part by a large dyke of spheroidal basalt, which has apparently so indurated the strata of variegated marl in its vicinity, as to permit them to be quarried for building. A large quantity of alum is made at this place, and exported to different parts of India.

Manufacture.—The shale from which alum is obtained, forms beds in the variegated marl; and in a kind of blue clay. Long galleries are cut for the purpose of extracting it; but so plentiful is the supply, that no means are taken to support them, and they generally fall in during the rainy season. The manner in which the alum is prepared is very simple. The earth is exposed in heaps to the sun and air for about five months, during which it burns spontaneously. It is next laid out in little beds similar to those of a field prepared for irrigation, and it is watered by a small stream for ten or fifteen days, by which time the aluminous matter accumulates into semi-crystalline plates. This substance is boiled in water for about seven hours; after which, a third, or one half, by weight, of potash is added, and it is again boiled for a few hours, according to the strength of the ley. It is then poured into large open vessels, where, after settling for some time, it is washed, and the liquid drawn off, leaving an impure crystalline sediment. This is once more boiled, and when it arrives at a proper state, which is learned by practice, it is poured into large earthen vessels with a small mouth, and sunk into the ground to prevent their breaking. After a time, the vessels are dug out, broken to pieces, and a lump of pure alum extracted. Six or eight measures, by weight, of alum, are produced from ten measures of the substance from

the irrigating beds, and four or five measures of potash. It is not so much esteemed in the Bombay market as that brought from China, on account of its yellow tinge.

Some of the marls resemble chalk, being white, and soiling the fingers; and some are very calcareous, whilst other varieties scarcely effervesce with diluted muriatic acid. In one mass I found a very minute specimen of *Buccinum pumilum* (sp. n. Pl. XXIII. fig. 1.). These marls also occur of every variety of colour as well as texture; some of them consisting of innumerable thin laminæ curiously twisted and arranged in the most intricate manner; and others of a kind of breccia, composed of small broken portions of marls. Several dykes of basalt cut through these beds; the whole presenting a most confused assemblage, partly due to natural causes, and partly to the numerous mines which have fallen in. One of the banks has been burning spontaneously for several years, in a similar manner to that at Ruttrea, and apparently from the same cause. The exact geological position of these marls I could not determine.

3. RED SANDSTONE.

I have mentioned a red sandstone formation, which may be described now. It occurs to the southward of the coal series, and is separated from it by a low range of hills about six miles broad, composed partly of basaltic rocks, and partly of a variety of porphyry. This sandstone is regularly stratified, and has the same dip and inclination as the sandstone and coal series, but differs very materially from it, in being much softer, generally finer-grained, of a vast variety of colours, and by containing no organic remains. Associated with the sandstone are beds of clay, varying in colour from purple to deep red. One of the beds is aluminous, and has been burning spontaneously for a long period. The smoke issues from a deep crevice in the bank, and the fumes are highly sulphureous. A stick thrust into the crevice soon ignites, and the whole bank has a burnt appearance; the red clay, which rests immediately upon the stratum, having been converted into a perfect brick, and the other variegated clays having been variously acted on. Although this bed would yield a large per centage of sulphate of alumina, it has never been worked. The strata dip at an acute angle to the south, and are covered, in that direction, by beds of gravel, succeeded by others of sand and soil, which extend to the sea.

4. LAMINATED SERIES OR UPPER SECONDARY FORMATION.

Alternating strata of slate-clay, limestone-slate, and occasionally slaty sandstone, constitute this formation. The more calcareous beds are very hard and compact, whilst some of the others are very earthy and friable. In many of the calcareous slabs, the upper and under surfaces are argillaceous, hard, and compact, but the centre is a grey limestone, which takes a good polish, and might be used for lithography. The slate-clay is of a dark blue colour, and generally peels in thin flakes, leaving a flat, lenticular nodule or centre. In many places, vast thicknesses of this laminated slate-clay occur without the

least admixture of the sandstone-slate, whilst in others, the latter alternates very often with it.

The beds being horizontal, except where they have been disturbed, the formation occupies considerable tracts; and where it rises into hills it is generally capped by a thick bed either of coarse, soft sandstone, as in the ghàts of the Charwar range, the Bhooda hill (near Bhooj), the Jarra (near the Indus), and other hills; or of a very compact, hard, crystalline sandstone, with a conchoidal fracture, as in the Chuppal hills, the Jarra, and in other places, including the natural walls of the Runn, described in a subsequent part.

Relative Position with respect to the other Strata.—I searched diligently to find the relative position of this formation distinctly defined, but in vain, as, at its apparent junction with other beds, the whole of the strata were broken up, and so confused as to baffle every attempt to ascertain the boundary. I am induced, however, to believe that it occupies hollows in the sandstone and coal formation, or abuts against it. It cannot underlie that series, because its strata are always *horizontal*, except where locally disturbed; while the beds of sandstone and coal are as invariably inclined at a considerable angle, and are everywhere intersected with dykes, slips, and other dislocations, from which the upper secondary strata are generally free. In one instance the formation evidently occupied a hollow in the coal sandstone.

In many places it appears to abut against the sandstone, occupying large tracts which may, at some period, have been covered by beds of that formation, subsequently washed away. From what has been stated above, it is at all events newer than the coal beds; and this conclusion is also borne out by its imbedded fossils.

Apparent Position with respect to the English Series.—In its mineralogical character and general appearance, this formation greatly resembles the English lias; but its fossils have been found, after a careful examination by Mr. James Sowerby, to assimilate very closely to those of the oolitic beds; and a very few belonging to the green sand.

Fossils.—Of the fossils found in these beds, the Ammonites are the most characteristic, occurring in vast quantities, particularly in some hills bordering the Runn. Of the eleven species which I collected, eight are unknown to Mr. James Sowerby, to whom I am entirely indebted for all my information regarding them. (See Plates XXI., XXII., and XXIII.) Of the other three species, one so closely agrees with *A. Herveyii* (Plate XXIII. fig. 5.) of the English cornbrash, that he is induced to consider it only a variety of that species; another in the outer whorl (Plate XXIII. fig. 13.) resembles *A. perarmatus* of the coral rag, but differs in the structure of the inner whorls; and the third, of which there is only one imperfect specimen (Plate XXIII. fig. 12.), is like *A. corrugatus* of the inferior oolite of England. They generally vary in diameter, from three to

five inches: the largest I found being eight inches. It was imbedded in a mass of gold-coloured oolite. The genus next abundant is the Terebratula. Of the seven species collected by me, five bear so close an analogy to the *T. biplicata, T. dimidiata, T. sella, T. intermedia,* and *T. concinna* of the green sand and oolitic series, that it has been found impossible to consider them distinct species. The Trigonias are numerous, though confined to two species, one of which differs so very little from *T. costata* of the lower oolites of England, that Mr. Sowerby considers it only a variety of that fossil. The genus *Pholadomya* also abounds, but the specimens are generally broken. Of the three species I collected, Mr. Sowerby has not been able to establish an identity with any known Pholadomya in England, although there is a general resemblance to the oolitic and lias fossils. I found two species of Belemnites, one of which resembles *B. canaliculatus* of the inferior oolite; the other is not determinable. Of the species of oysters, one resembles the *Ostrea Marshii* (see Plate XXII. fig. 9.) of the English cornbrash. I found it in a bank high up the Katrore hill, in the Charwar range, in friable, laminated strata of slate-clay and sandstone slate, associated with Ammonites of the same description as those at Charee and along the Runn*. I did not find a single specimen of a Gryphæa, although numbers of the genus have been collected from this province. Some crinoidal stems, which I collected from the same localities (see Plate XXIII. figs. 14, 15, 16.) resemble those of a species found in the mountain limestone; but as the fossils above enumerated characterize the middle series of the English upper secondary rocks, fossils belonging to so much older a formation can hardly be associated with them. These crinoidal remains, therefore, probably belong to an undescribed species. The only fossil bone which I discovered, Messrs. Clift and Owen consider to be a caudal vertebra of a Saurian. This determination is, however, very interesting, as it shows how widely these animals were distributed; being, in this distant country, also associated with the same mollusca (one valve of a *Trigonia costata* is imbedded in the mass containing the bone) as accompany their remains in the English strata.

In the Appendix to this paper I have given a complete and systematic list of all these fossils, stating the localities where I collected them.

General Shape of the Hills belonging to this Formation.—Many of the hills in Cutch present, on the north side, a perpendicular cliff surmounting a sloping talus, and on the south an inclined plane; and they owe this peculiar outline to their being composed of a base of laminated clay or sandstone, capped by a thick bed of coarse and brittle sandstone. This is particularly the case in the Jarra hill, and the hills of Hubbye, Lodye, and Roha-ké-Koss, near the village of Joorun, on the Runn; also those of the Puchum and Khureer islands in the Runn, particularly the latter; likewise those near Beyla, at the north-eastern extremity of the province, and many others. The Katrore hill, forming the eastern extremity of the Charwar range, belongs to this formation, and, therefore, differs materially from the greater part of the range, which is composed

* At the base of these hills, and forming the immediate borders of the Runn, fossil shells are found of a very different description, among which I may enumerate *Cardium, Pecten, Corbula, Venus, Globulus,* and vast quantities of *Turritella*; which last form large masses of rock protruding every here and there above the bed of the Runn.

principally of sandstone, except in the portion opposite Bhooj, where this laminated series also occurs. The strata being principally horizontal, the hills have a conical form.

It is a curious circumstance, that, in the same group, some of the hills of the laminated strata have a thick capping of sandstone, whilst an immediately adjoining peak, of equal height, has none. I conceive the thick beds of the sandstone once covered the whole surface, and that on their upheavement they broke into masses, which have been since denuded from some of the hills, the debris forming the deep sandy plain around Bhooj.

In the hill of Jogé-ki-bit, near Nurra, on the Runn, the beds dip from 40° to 50° to the north, and alternate three times with basalt. The strata vary greatly in character, some of them being very hard and crystalline, particularly those containing calcareous matter; whilst other parts of the series, immediately adjoining, are very friable and earthy. Some of the schists assume the character of a roofing-slate, and others are only soft, laminated blue clay.

A cluster of hills, occupying a surface of three or four square miles to the north-west of the city of Bhooj, called the Bhoodha hills, also belongs to this formation, being composed of slate-clay, tabular sandstone, and limestone slate, in many parts assuming a very friable, earthy texture, and frequently capped with thick beds of coarse, soft sandstone. The strata are often horizontal; in which case the hills are conical; but in many instances the beds incline at a considerable angle; and the hills assume, when capped by the sandstone, the usual form of an abrupt escarpment, with a long inclined opposite side. They are intersected by numerous ravines and nullahs; the looseness of the soil, and peculiar tabular construction of the strata, offering a very slight resistance to the action of the rains. The Chuppal hills, between Guranee and Nurra, in the north-western division of the province, afford another example of the elevation of these strata into hills. They consist of beds of a very earthy and friable description, covered by a thick stratum of hard crystalline sandstone, slightly calcareous; and the lower part forming a sloping talus, capped by the hard rock, in masses 20 feet thick; they appear as if they were surmounted by old ruins or turrets.

Manner in which the Hills have been formed.—From an attentive examination of these hills, I am led to infer, that they have all been uplifted by a movement which proceeded from below; the laminated series having yielded to the upheaving power, and the loose brittle sandstone having broken off abruptly. That this has been the case with the minor ridges, and what I may

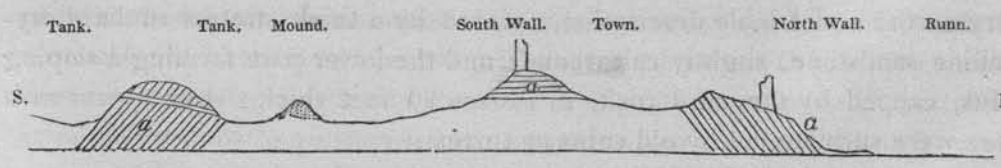
term the *natural walls* in the Runn, described in treating upon that district, there can be no doubt, as I have found them at angles, varying from a few degrees above the horizontal position to the vertical, and even turned over beyond that point.

That these beds have been disturbed and broken through by igneous agents is quite evident from the dykes of basalt, which occasionally intersect them.

5. NUMMULITIC LIMESTONE AND MARL.

Although the imbedded fossils of the Nummulitic group resemble those of some tertiary beds of England and France, still the strata of which it consists, differ so totally in mineralogical character and general appearance from any of the other formations in Cutch, that it deserves a separate notice. It is bounded partly by the second or sandstone and coal formation, partly by beds which I have coloured as tertiary, and partly by the alluvial banks of the eastern branch of the Indus, extending from Luckput to a plain between the villages of Wagé-ké-Pudda and Eyeraio, about thirty miles to the southward. It consists of a mass of small Nummulites mixed with Fasciolites; and some of the river banks present a perpendicular section of solid rock, from 60 to 70 feet in height, entirely composed of these small fossils agglutinated together, and varied only by a species of Orbitolites, frequently bent into a saddle shape. This stone has much the appearance of chalk, and the beds are horizontal, except where they have been disturbed. In some parts, however, it is much harder, particularly near the town of Luckput, where it is quarried as a building stone, and is also burnt for lime. The surface-soil is entirely composed of the small fossils lying loose, and generally known by the name of Luckput sixpences.

The beds of nummulitic limestone on which Luckput stands have been affected in a manner deserving of notice.



The high ground to the east of the town sends off three parallel ridges to the westward, ranging nearly east and west. On the two northernmost of these ridges, the north and south walls of the fort of Luckput are built; whilst the southernmost lies at a distance of about 200 yards from the south wall. A kind of valley runs through the town, ending, at its western side, in a

swamp, which is crossed by the western wall of the fort. A cut through the northern ridge exposes a very good section of the nummulitic stone, dipping 40° to the north; whilst, in a similar cut through the southern ridge, made for the purpose of connecting two tanks, the same beds dip from 40° to 50° due south. In the centre ridge the section is not quite so perfect, but the beds are nearly, if not truly, horizontal, forming an anticlinal axis to the other two.

This elevated tract of the nummulitic limestone extends only three miles to the eastward of Luckput, the ground there descending abruptly into a plain, composed of various clays, a coarse ferruginous stone and sandstone, with quantities of selenite scattered about, the whole presenting a confused appearance, as if it had been the site of an igneous outburst. Patches of ground, every here and there, have also an altered appearance, and are covered with small fragments of igneous rock. The plain is bounded to the south by a low range of basaltic hills. From Luckput southward to the village of Punundrow, the same nummulitic rock continues, but varies in hardness from a compact limestone to a white marl. It is also very well exposed between the villages of Eyeraio and Wagé-ké-Pudda, at the southern limits of the formation. To the S.W. of Eyeraio is a plain, composed of a white calcareous marl, and flanked to the south by a low range of hills of the same material, sending off into the plain numerous small projections, with rounded terminations precisely like headlands. Numerous isolated hillocks, or high banks, with sides worn in the same way, and resembling islands, are scattered about the plain, and the whole surface looks as if it had only lately been deserted by water, or as if a violent flood had swept over it. The banks of the small nullahs, which intersect the plain, are composed of gravel, containing rounded masses of a variety of the calcareous marl. Advancing westward, the ground rises a little, and the surface consists of a hard rock, which contains oysters and other bivalves, whilst in some places large patches are entirely composed of silicified corals. I also found in this place fragments of fossil bone, said by Messrs. Clift and Owen to be parts of rib-bones, like those of the *Manatus*, but flatter. To the north, this plain is bounded by a river, the perpendicular banks of which, 60 or 70 feet in height, consist entirely of nummulitic marl, capped by a thin stratum of gravel. In one part, the bed of the river is subjected to the action of a small stream of water, so strongly impregnated with saline ingredients, that large lumps of salt are formed in the hollows worn in the rock, which here assumes the character of a hard limestone, probably in part due to the quality of the water that passes over it. The beds are horizontal, except where they have been disturbed and shattered.

Characteristic Fossils.—The most characteristic fossils of this formation, next to the Nummulites and Fasciolites, are Echini, Galerites, Clypeasters, and Spatangi. The species of Echini and Galerites are all new. A Clypeaster resembles *C. affinis* of the sandy marl of Brabant; and a Spatangus, the *S. Bucklandii* of the marly chalk of Westphalia; while another species agrees with the *Spatangus acuminatus* of the tertiary deposits of Dusseldorf. The other fossils consist of species of Tellina, Astarte, Cardium, Arca, Pectunculus, Pecten, Nucula, Ostrea, Cerithium, Turbinellus, Globulus, and Seraphe. (See Plate XXIV.) The Turbinella abounds and is often very large. In the bed of the river above described, I found large blocks composed entirely of small oysters, similar to *Ostrea Flabellulum*, but more regularly and finely striated.

6. TERTIARY STRATA.

I have called all that portion of the province *tertiary* which is composed of rocks containing fossils belonging to this period. It consists principally of a hard argillaceous grit, interspersed with fossil shells, and covered by beds of pebbles or conglomerate. Some portions of this conglomerate are very coarse, and constituted of rolled or boulder stones loosely connected; whilst other portions are sufficiently indurated to be used as a building stone. A calcareous grit, which soils the fingers like chalk, also occurs in patches, and contains innumerable small shells. It is used for building, and is burnt for lime. The beds are horizontal, and the surface of the country is generally covered with a fine rich soil.

At the village of Soomrow, about ten miles north-east of the fort and harbour of Juckow, on the south-western coast, (see Map,) the banks of a broad river-bed are composed partly of a loose gravelly soil, and partly of a very hard, compact, calcareous rock, full of shells, and burnt for lime; and below this rock is a coralline limestone. The river-bed, in some places, is nearly a mile across, the banks being cut into ledges or steps, whilst numerous small hillocks, or high banks of gravel and clay, stand isolated in its middle. Only a small stream now winds from shore to shore. One part of the northern bank rises into a small hill, the surface of which is composed of the same hard, compact, shelly rock as that which is found even with the bed of the river. For some distance north of this spot, the ground is also high, and cut into innumerable ravines; and there are breaks in the surface, as well as circular hollows, or large, deep pits. The natives have a tradition, that an earthquake occurred at this spot, some centuries since, during a severe battle between the Sindians and the natives of Cutch. The raised position of the shelly rock, and the peculiarly rent and broken appearance of the ground, indicate some convulsive movement; and it should be noticed, that, as all the beds are horizontal, those forming the hill cannot be an unbroken continuation of those in the banks of the river.

This formation continues a few miles further to the northward, where it abuts against the nummulitic beds.

In many places towards its northern limits, it rises into hills, and considerable tracts of high, undulating country; the loftier portions consisting invariably of hard, shelly rock, including large patches, of one or two acres in extent, of silicified corals; and the lower parts, or intervening spaces, of a loose gravel or clay, equally full of organic remains. Some parts of this district, particularly that near the village of Kotra, have a very remarkable appearance, as if they had been subjected to a violent flood, which had washed away the surface-soil to a depth of 30 or 40 feet, leaving a broad, shallow valley, two or three miles across, with numerous isolated and rounded bluff hills of gravel, scattered about its bed. The banks, or bounding lines, consist of low hills, cut into innumerable small ravines; the whole being composed of the same shelly rock, and gravel, and clay as above described.

The fossil shells found in this district occur often in beds, consisting of a single species. One of the hillocks, above described, is about 60 yards long by 20 broad, and 15 feet in height, and is entirely covered with *Ostrea callifera*, lying loosely on a gravelly soil, or cemented into a solid rock. The highest part of the table-land in one place, near the village of Kotra, is also composed solely of oysters, forming a very hard rock or limestone; other isolated banks are completely covered with what appears to be a species of large Serpula, or else fragments of coral. Numerous other fossils are found, either lying loose or imbedded in the rock, and consist of species of Lucina, Venus, Cardium, Pecten, Ostrea, Turritella, and Clypeaster. The Turritellæ are imperfect, but particularly numerous.

This flat valley or broad river-bed (for a small stream still winds through it,) continues to the hills surrounding the town of Mhurr, spreading, in places, into lake-basins, all of the same description as above detailed; but, a short distance south of the Mhurr hills, its course is cut across by a dyke of very compact basalt, of perfectly columnar structure; each face of the polygons being about two feet in breadth. This basalt forms both banks of the river for 50 or 60 yards, and to the height of 20 or 25 feet; the bed of the river being also formed of sections of the columns. The clay through which the basalt passes is hard, and of a brick red; and quantities of iron ore, of a spongiform texture, are scattered about.

The southern base of the Mhurr hills is now approached, and presents a most confused appearance, the country at their foot being shattered in all directions. It is impossible to conceive ground in a more disturbed state. The

banks and ridges, varying from 20 to 60 feet in height, are partly composed of coarse, calcareous grit, full of the marine shells already enumerated, and partly of a blood-red coloured clay, which has apparently been altered by a trap dyke. One bank exposes a section, 60 to 70 feet high, of horizontal layers of gravel, clay, shelly rock, and iron clay, which in one spot appear to have fallen in bodily, dipping abruptly from both sides to a point.

Fossils.—The principal deposit of fossil shells which came under my inspection, was at the village of Soomrow, just described. The specimens which I collected have been examined by Mr. James Sowerby, and found to consist of 33 known genera. Of the 57 species belonging to these genera, 47 are new, 6 are known, and 4 are doubtful. (Pl. XXV. and XXVI.) The most numerous among the univalves belong to the genera Mitra and Voluta: there are also great quantities of the genera Cerithium and Terebra; some of the latter being very beautifully marked The genera Solarium, Conus, and Strombus also abound. Among the bivalves, the Pectens are most numerous; and among the Radiata are great numbers of Clypeaster. Most of the fossils which I collected, either lay loosely on the gravelly bank, or were cemented into large tabular slabs of rock.

I was informed by the natives, that, about the year 1834, great quantities of large fossil shells, called by the country people *Sonk* or *Conk*, being a species of Turbinella, were found in a land-crack, in a field about two miles from this spot; and so perfect, that they were given to the priests of the different temples in the neighbourhood, who, by inserting a metal tube into the apex of the shell, converted them into horns, to call the devout to prayer. I could not, however, find any when I visited the spot, the crack having been filled up by subsequent floods.

Extent of the Tertiary Formation.—These tertiary beds reach, in one place, to the town of Mhurr, a distance of thirty miles from the sea, and extend in a belt of, perhaps, a third of that breadth, throughout the whole southern coast of the province. A narrow line should also be drawn along the borders of the Runn, and around the islands in it, as the fossils, found on the immediate shores, belong to the tertiary period.

7. ALLUVIAL, OR RECENT DEPOSITS.

The part coloured as alluvial in the Map (see Pl. XX.) consists entirely of plains covered with soil, evidently detritus which has been washed from the hills, or of land recovered from the sea by the blowing up of sand. The whole of the province south of the volcanic range (see Map) might be considered alluvial; the surface being composed of a thick soil, formed by the rapid decomposition of the basaltic or igneous hills; but as the banks of the rivers contain tertiary shells, I have thought it better to colour the district as consisting of rocks of that age. The boundary between the tertiary and

alluvial districts must, therefore, be considered partly imaginary, as I have thought it more correct to give a general outline, than to mark, with apparent minuteness, limits, which my examination of the district, did not enable me to ascertain.

Land gaining on the Sea.—In many places along the coast, where there are ridges of sand, the land gains upon the sea. These dunes are constantly increasing, from the particles blown up by the sea-breezes, or the south-west winds, which prevail during so great a portion of the year; and the ridges frequently occur in double rows, occupying a considerable breadth, and varying from 50 to 100 feet in height. During strong winds the whole appear to be in motion, from the sand drifting along their surfaces.

At Mandavee, the principal seaport in Cutch, is a ruin on a spot called the Old Bunder, or Quay. It is now about three miles inland, and is situated on the bank of the river, which flows into the sea near the present town; but at the time when this old quay was in use, the town must have been some distance from the present shore. A small temple, built upon a rock, now in the middle of the town, is said to have been at that time also in the sea. Even now, a considerable space, composed of loose sand and sand-hills, intervenes between the town and the sea; and the distance is continually increasing, owing to the quantity of sandy detritus brought down by the river during the periodical floods, and washed back by the sea in the dry season. A bar is also thus formed across the mouth of the river, and the position of it varies so much, and so often, as to render the entrance to the river very difficult. Even boatmen belonging to the port, who have been absent a few months, cannot pilot their vessels in. During very dry seasons, this bar increases to so great a degree as almost to block up the entrance entirely; and the laden boats always strand upon it at high water, their cargoes being carried away by carts, when the tide is out.

At Moondrah, Budraseer, and other seaports up the Gulf of Cutch (see Map), the land also gains upon the sea, rendering necessary the frequent removal, further seaward, of the quays or landing-places. Where rivers enter the gulf, this increase of land at their mouths is easily understood, as the sea, for nine months of the year, washes back the sandy detritus accumulated by the river at its delta during the periodical floods. Where rivers flow all the year round, they may be enabled to keep a channel through the deltas constantly free; but when the stream is inert during three fourths of the year, and the wind and sea are continually at work, the case must be very different.

Marine Forests.—The same operation is in progress at places separated from the main waters of the gulf by small creeks.

Some of these inlets penetrate six or seven miles from the coast through a tract covered for miles in extent with shrubs. At low water, these plants are exposed to their roots; but at high tides merely their upper branches are visible, so that the boats sail through a marine forest, the sails and yards frequently brushing against the boughs of the trees. The growth of these shrubs is so rapid, that the sailors have very often to force their boats through the upper branches, particularly at the various angles of the very tortuous creeks, when they wish to save a tack, and the wind is scant. The stems and branches of the trees are covered with Crustacea

and Mollusca, whilst numerous water-fowl occupy the higher branches; the whole presenting a most curious picture. That the land should gain on the sea, in these places also, is very natural, as during the monsoons, when the numerous small streams convey their muddy alluvium into the gulf, the roots and stems of the shrubs act as a filter, and the water passing slowly between them, a great portion of the earthy matter is precipitated; a portion also adhering to the stems.

Effects of Floods.—Considerable damage is frequently done by the periodical floods, which, from the peculiar hilly structure of the country, sometimes rush down with a force, that carries all things before them.

In August 1834, the rains were very violent and long-continued, and did considerable damage. The river, which flows past Nurra, and through the flat, from six to eight miles broad, which extends from the town to the Runn, brought down so much alluvium, as to cover with a fine soil a surface of 150 pragas, or nearly 1000 acres of land. This tract had been sunk by the earthquake of 1819 so nearly to a level with the Runn, as to have remained unfit for cultivation. On the opposite side of the province, at a village called Kundagra, not far from Mandavee, 50 pragas or 300 acres of soil were entirely washed away, leaving a bare sandy surface, similar to the bed of a river; and not far from the same spot, half a small village, with a quantity of land, was swept bodily into the sea; large trees being uprooted and carried down by the flood. At Pheraudee, 12 miles N.E. from Mandavee, at Mandavee, and many other places, great devastations are said to have been produced. A few similar inundations would alter the features of the country, consisting of such abrupt hills and loose surface-soil.

8. VOLCANIC AND TRAPPEAN ROCKS.

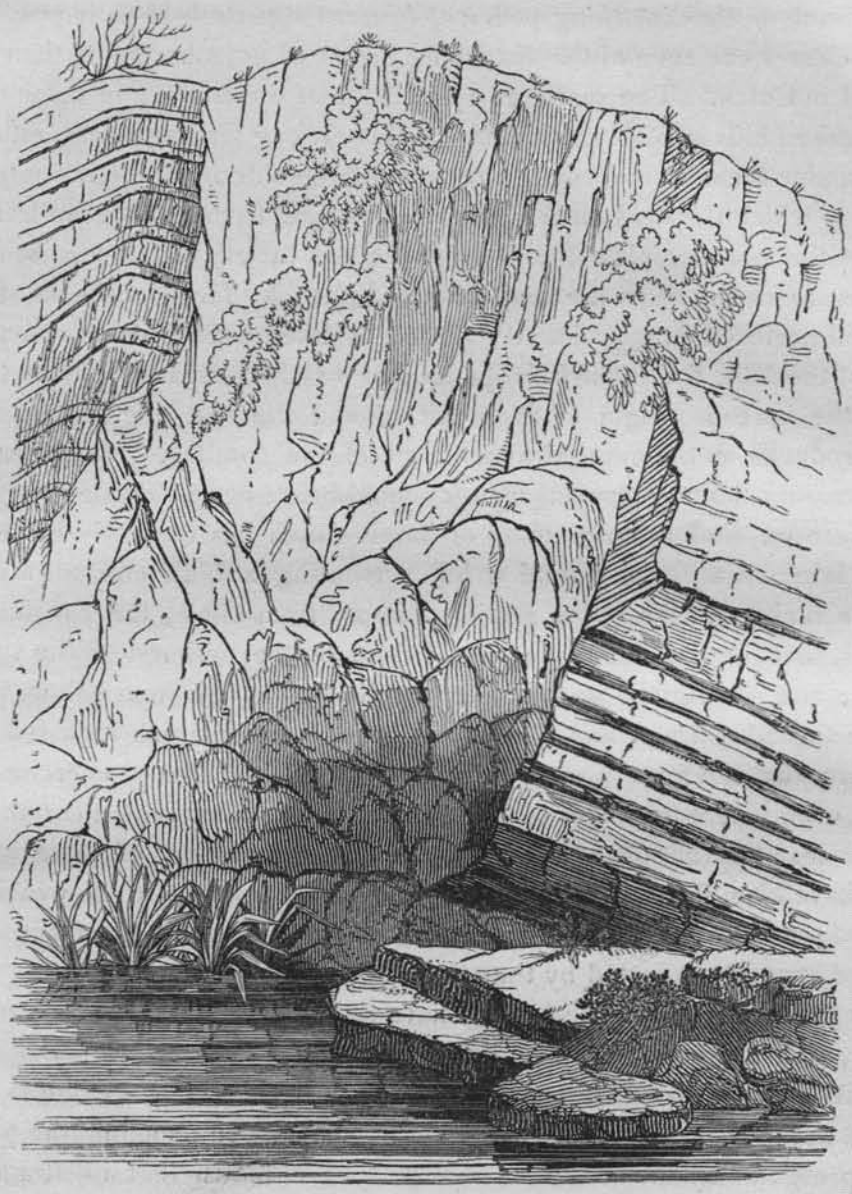
The district coloured in the Map as composed of volcanic and trappean rocks (see Map, Pl. XX.) is one of the principal features in the geology of Cutch, not only from the space it occupies, but from the phænomena which it presents.

The igneous origin of trap being acknowledged, I shall always speak of it and lava under the comprehensive term of igneous rocks, as in composition they differ only in the proportions of hornblende, felspar, and augite, and as they all appear to have originated in the same cause, and to have equally disturbed or affected the neighbouring strata. But there appears to be a very marked distinction between those rocks which have been in fusion below the surface, and subsequently forced up, and those sedimentary formations, which have an altered appearance, and have been evidently subjected to violent heat since they were deposited in their present position. The latter rocks, however, bear a very small proportion to the former. The part coloured as volcanic shows the principal theatre of the outbursts; but to mark on the Map every spot where traces of igneous action are observable, it would be necessary to dot over the whole of the secondary formations.

Evidence of the disturbing power of Igneous Agents.—It is impossible to desire clearer evidence of the disturbing power of igneous agents than is developed in Cutch. The shattered appearance of the country in some places, the upraised hills in others, with the igneous rock or moving agent, either directly under them, or immediately in front of the outcrop of their strata; the angles to which the beds have been raised varying from a gentle, unfractured slope to the most complete dislocations; the vast variety in the composition of the igneous matter, from the most loose and clay-like form to the most compact and perfect columnar basalt; the crater-like shape and construction of some of the hills, from which large lava or basaltic streams can be traced, prove the igneous origin of these rocks, and the vast effects which they have produced on the general appearance of the country. Moreover, it is not necessary that the igneous matter should be on every occasion apparent; as, where we find a large mass of basalt which has evidently come from below, lying on a plain, behind a hill presenting a bluff cliff towards the igneous rocks, and the strata sloping sharply from them, the conclusion is obvious, that the hill must have been raised by the outburst of the volcanic matter; and it is equally just to infer, that, in its passage from below, it must have disturbed, more or less, the various beds through which it passed; and, therefore, that the form of many hills may be owing to a latent exercise of this power, even where no traces of the igneous matter are visible near the surface, or near the raised strata. That the greater number of these igneous rocks have been forced up, and are not portions of lava streams which have flowed from volcanos, is very evident, from the manner in which the superimposed strata are affected by them.

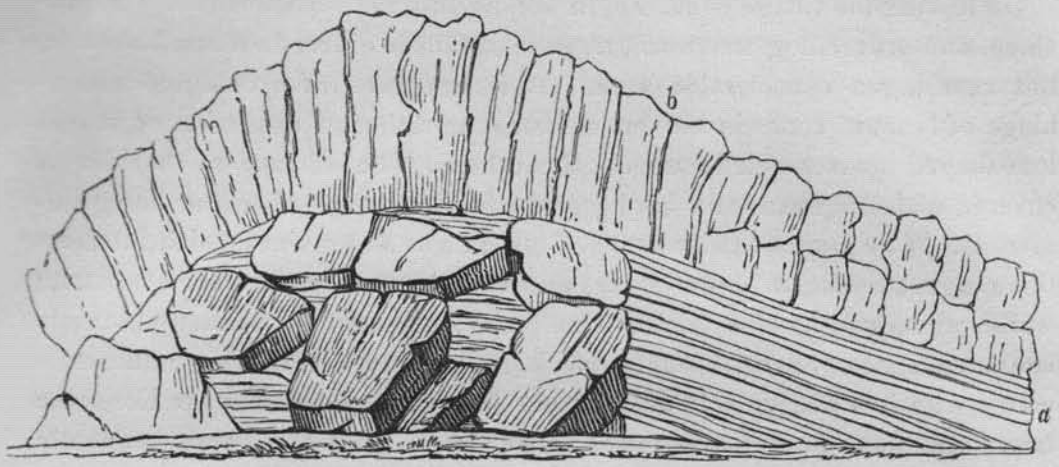
In a preceding part of the paper I have described a hill of quartz rock near Mhurr, and shown that its strata have been violently disturbed; and I have also inferred, from the nature of the rock, that its characters are due to grains of sand having been agglutinated by volcanic heat. In detailing the phænomena presented by the second formation, I have shown that its strata have been also subject to great dislocations.

The following wood-cut presents an example of a large dyke of basalt which has cut through the strata in the river near Jaumtra, and thrown them off in opposite directions.



In describing the upper secondary formation, I have stated, that I conceive the hills owe their outline, presenting to the north an abrupt escarpment resting on a slope, and to the south an inclined plane, to the agency of volcanic forces. In the Karee river, near Bhooj, these beds have been disturbed to an extent which defies representation. Near the village of Jarra, on the borders of the Runn, a bank affords a good example of the manner in which this upheaving power has acted. The laminated beds (upper secondary formation) being of a loose earthy character have yielded to the disturbing agent; whilst the overlying compact stone has broken short off, and pre-

sents a wall of rock, split by such perfectly vertical lines, that at first sight I thought the stone was columnar.



Bank near Jarra :—*a.* laminated series; *b.* compact sandstone.

The range of Roha-ké-Koss, composed of beds of the fourth or upper secondary formation, is a good example of disturbing action. It is situated between the villages of Joorun and Lodye, on the borders of the Runn, and extends nearly east and west for eight miles, presenting, to the north, a perpendicular cliff of sandstone, which rests on a sloping talus of laminated sandstone and slate-clay, and dipping at a high angle to the southward. About three quarters of a mile from this main range, and parallel to it, is a ridge of smaller hills, consisting principally of basalt, intermixed, in some places, with the same sandstone as that of the main hill; and which, in the banks of the nullahs at its base, overlies the laminated strata. The space between the two ridges is composed of large broken masses of sandstone, covered by a thick bed of gravel, evidently the detritus of the hills. In this instance, the strata of the Koss range dip towards the south; and, at a short distance to the north of it, we find a mass of basaltic or igneous matter, which probably raised the hills in its passage up, and established itself at their foot. Large basaltic dykes, disturbing the strata through which they pass, are observable in many of the river banks in the immediate neighbourhood.

The beds of nummulitic limestone, on which Luckput stands, present, as before stated (p. 300), most decided marks of elevatory movements, consisting of a central platform of horizontal strata, with inclined beds on the flanks.

Another most striking example of the effects of igneous action in upraising hills, occurs in the nummulitic limestone, near the village of Punundrow; and

the phænomena are so strongly marked, that they deserve a detailed description.

On leaving the village of Korah, in the north-west department of the province, and proceeding westward, a range of hills is entered, of small altitude, but covering a considerable area. It is composed of a confused assemblage of basaltic cones in broken columns, or rather of a number of sugar-loaf-shaped masses piled one on the other. The surface of the hills is covered with fragments of a hard greenstone, the crystals of felspar being numerous. The perpendicular banks of the nullahs and ravines which intersect this range, present, in some places, entire sections of the columnar basalt; whilst others consist of a friable, sandy clay, disposed in horizontal, thinly laminated strata of every shade of black, red, and yellow, to white; and associated with it is a beautiful purple loam. The basalt sometimes overlies these beds, sometimes forms dykes in them; and one side of the ravine frequently consists of this variegated loam, and the opposite of basaltic pillars. In many places the ground has an altered appearance; the ironstone, of which large quantities are lying about, appearing partially fused, and the clays or variegated marls variously acted on, and always accompanied by dykes of basalt. These hills continue about eight miles from Korah to the village of Ukri, where they gradually decline into a plain, throwing off numerous ridges or forks. About three miles distant, a solitary hill, with a flat but uneven top, called Baboa, rises out of the plain. To this hill I wish to draw particular attention; and the foregoing account of the basaltic range has been given as necessary to a proper understanding of it.

The first part of this plain is composed of thick beds of gravel, but further westward it consists of the nummulitic formation. Out of this soil rises the Baboa hill, composed of hard limestone, full of marine remains. One of the forks projecting from the basaltic range reaches to within half a mile of the hill, the ground near it being strewed with small fragments of igneous rock.

The cause of the elevation of this hill is, in my opinion, distinctly visible in the banks of a river which passes by its western base. They are from 20 to 30 feet in height, and are composed of white calcareous marl, covered by a thin bed of gravel. Immediately opposite the hill, these beds are cut through by a dyke of very compact dark green basalt, forming, towards the river, a wall about eight feet high; its base being hid by a talus of gravel. In several places on each side of this dyke, which is about 50 yards in breadth, independent masses of igneous rock break through the marl. They are principally of a blunt, conical form, capped with portions of the marl, and consist of sphe-

roids of basalt, which desquamate in concentric layers, precisely resembling scales of iron. At a short distance up the river, or northward, this marl is covered by a stratified series, dipping at a high angle to the north, and consisting of a yellowish marl, with small imbedded fragments of lignite, covered by a bed of blue clay, containing also fragments of lignite and quantities of an olive-brown earth, in which small pieces of either amber or mineral resin are inclosed. Above this bed is a stratum of red sandstone; and the whole is covered, at its lower extremity, by a thick bed of gravel. These inclined beds reach the level of the water about 400 yards from the basaltic dyke, beyond which the marl again appears in horizontal beds. Southward of the dyke, the change from the broken part to the undisturbed horizontal strata, is much more abrupt, occurring within a very short distance. On the top of the bank adjoining the south end of the dyke the stratified beds of blue clay, &c. are horizontal.

From the above description it appears, that the only place in which the basalt is exposed, is directly under the hill, no trace of it being discernible either above or below this spot; also, that the most compact and extensive mass of basalt is exactly under the highest part of the hill; and that detached masses of igneous rock present themselves, with large portions of the marl adhering to them. A series of stratified beds is also noticed rising from the north towards the hill, meeting the surface at its foot, and is again found in a horizontal position just south of the hill. All these facts surely prove, that the hill must have been elevated by an outburst of igneous matter, which was probably a branch from the basaltic hills to the eastward; one of its forks reaching within half a mile of the spot.

Quantities, of what I believe to be frothy or foam lava, being a brownish black substance, very vesicular or spongiform, extremely light, and somewhat similar to a very porous cinder, are found adhering to the marl, and in the rubble of the bank.

Large blocks of the shelly limestone, composing the summit of the hill, are scattered about its sides and base; and some of them, my guide informed me, fell during the earthquake of 1819; and the abrupt and steep sides are, no doubt, due to the action of water. Numerous fossils are found lying about, characteristic of the nummulitic limestone.

I have minutely described this hill, in the hopes of impressing others with the same belief as myself, of the cause of its elevation.

Near the village of Nambye, in the Charwar range, a basaltic dyke traverses beds of thinly laminated slate-clay and layers of limestone slate. In the immediate vicinity of the dyke the strata dip in all directions, and form

even anticlinal lines. The basalt is very hard, compact, and of a dark blue colour, and presents irregular masses, without the slightest approach to a columnar structure.

Distinct Periods of Volcanic Eruption.—That the volcanic eruptions have occurred at many distinct periods, is also evident, from the different formations with which the igneous rocks are associated, and from the variations in their characters. Thus, in the same section, the lower part frequently consists of large, rolled, or water-worn masses, whilst the upper portion is columnar: in other places the basalt alternates with a calcareous grit or coarse limestone, having a tabular structure, but always distinctly stratified, and very brittle, so as to present perpendicular banks. This limestone is generally associated with basalt, where the latter is raised into hills; and from the fact of *angular* pieces of basalt or igneous matter being imbedded in it, would incline one to believe that, in such cases, it must be contemporaneous, though it often regularly alternates with it. In other places the basalt is interstratified with a pure crystalline limestone or travertin.

The principal mass of igneous rocks (see Map) lies towards the southern department of the province, and forms a group of hills called the Doura range; the intervening spaces and the ground at their southern base generally assuming a porphyritic structure. The northern parts of the range have, for the greater part, a flat, smooth outline; but in the interior of the group are many clusters of small, conical hills, arranged round a circular space, inclosing a kind of hollow. The sides of these cones are very steep, and invariably present innumerable horizontal lines, forming rings resembling narrow paths. The surface being covered with basalt, in very small pieces, is totally devoid of vegetation, and has precisely the appearance of a newly-laid macadamised road. Their interior, however, has a much more solid construction, as is well seen in numerous deep clefts and ravines with which the hills are in all directions intersected.

One of these ravines, near the village of Doonee, is 50 or 60 yards broad, and nearly 100 feet deep; and its perpendicular sides are composed of compact columnar basalt of a greenish grey colour; the columns being perfect polygons, and of a very large size. This rent must have been formed by some convulsion, as it reaches nearly to the summit of the hill; and the only water that could ever have flowed down it being that which falls on its sides and bed, and must be very little.

Alternations of Basalt with Strata of the Upper Secondary Formation.—Near Nurra, on the borders of the Runn, a hill called Jogé-ki-bit, basalt alternates with slate-clay, limestone slate, slaty limestone, and a laminated loam. The strata dip from 40° to 50° to the north, which being

at a higher angle than that at which the hill itself rises, it causes them to crop out; the surface being also broken into several distinct ridges. The igneous rock alternates three times. In one instance it underlies a stratum of hard slate-clay; in another it occurs between a coarse, soft sandstone, and slate-clay, and sandstone slate; and it also forms the conical summit of the hill, which is not more than ten feet in diameter. The basalt desquamates in flakes, but has a centre of compact rock. The same inclination of the beds is continued through the hill.

Alternations of the Calcareous Grit with Basalt.—At the village of Doonee, above mentioned, the banks of the river present a perfectly perpendicular wall, from 15 to 20 feet high, and are composed of the calcareous grit, or coarse limestone alternating with basalt, in the following order: first, grit; then a horizontal bed of rounded pieces of basalt; and next, another stratum of the grit, 15 feet in thickness; the whole being covered by the basalt forming the hills.

Another good example of this alternation is near the village of Keroee, at the eastern limit of the formation. The banks of a river are here composed, in some places, of the basalt forming the Doura range; and in others, entirely of the limestone grit, which in one place overlies the basalt, but forced up into anticlinal lines, as if the igneous rock had been protruded from below; the broken state of the strata showing that it was not originally deposited in this position. The bed of the river at this place is entirely composed of basaltic columns; their horizontal sections forming a regular pavement; and large masses of the columns, occupying from 200 to 300 square yards, and being about eight feet in height, remain every here and there, similar to a field of corn partially reaped. The columns are very regular, generally four-sided, with smooth, even surfaces, and are composed of a hard, compact, dark blue basalt.

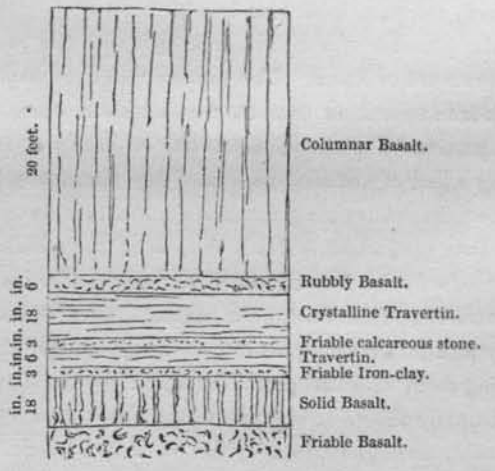
Another instance of the junction of the limestone grit with the basalt is near the village of Choolree, a little to the westward of Kaira. The basaltic range is completely divided by a narrow ravine, in which the two rocks appear in contact, the limestone being broken in all directions. One side of the ravine presents a perpendicular cliff, of nearly 80 feet in height, of irregular columnar basalt, overlying a bed of rounded masses of the same, though the opposite bank is composed of the limestone grit. Advancing through the Pass, the basalt terminates abruptly, and is succeeded by the limestone grit, which forms both sides of the ravine. Further on, the basalt again appears in the form of a dyke; beyond which is the grit, once more succeeded by a dyke of basalt, forming, at this extremity of the Pass, both banks. Where the dykes of basalt occur the limestone lies in immense masses, evidently broken off at the time of the projection of the upper bed of igneous rock; being itself of subsequent formation to the lower basaltic bed of rolled masses. This is very distinctly shown at one part of the Pass; and it should be mentioned, that the bed of the ravine consists throughout of irregular or broken basalt.

The intervening spaces and the ground at the base of these hills are composed, for the most part, of a red clay much resembling brick, a variety of it being amygdaloidal, of a darker colour, extremely hard and tough, and containing quantities of calcareous spar, chalcedony, rock crystal, &c.

In some places it forms low ranges of hills of a hard rock, of a dingy red colour, thickly interspersed with cylindrical kernels of zeolite, with a light green coating, some of them dividing into two parts. Other specimens contain numerous crystals of felspar; and, in many instances, all the mineral substances have disappeared, leaving a vesicular mass. Occasionally, thin beds or layers of calcareous spar, of a leek-green colour, are met with, also of rock

crystal and chalcedony in all its varieties. The surface of the plains is covered with fragments of these minerals, derived from the disintegration of the amygdaloids, which are rapidly affected by exposure to air and water. Some of the sides of the hills are covered with heaps of rock crystal, as if cart-loads had been purposely thrown down.

Alternation of Basalt with Travertin.—A very good example of successive eruptions of basalt occurs near the small village of Wurrowsow, on the south-western flanks of the Charwar range. This point must at one period have been a lake, it being now a dead flat, about 4½ miles in diameter, and surrounded by low but steep hills, whose surfaces are covered with small fragments of basalt; its general level is about 20 feet above the ground to the east of it. The soil consists of alluvial matter and fine gravel, totally different from the sandy plain by which it is bounded; but its most interesting feature is the basalt at the eastern outlet or break in the low surrounding hills. This mass of trap consists of perfectly polygonal columns about 25 feet in height, but broken into lengths, forming a series of regular steps, cut into a horse-shoe shape by a small stream, which discharges itself during the rainy season. The hills that flank it on each side are composed of a base of coarse sandstone capped by an earthy basalt, a dyke of which, 8 or 9 inches wide, has, in one spot, penetrated the subjacent sandstone. The following is the section exposed in the horse-shoe part of the fall.



The friable basalt forms the base of the fall. Above the columns the bed of the small stream consists of a loose, calcareous calc-tuff.

This section presents several interesting facts; as, from the alternation of basalt with the limestone or travertin, it is evident, that a considerable time must have elapsed between the igneous eruptions. The variety in the texture of the limestone or travertin may be accounted for by supposing, that the waters under which it was deposited were sometimes perturbed, or rendered muddy by a flood; but at other seasons clear, when a pure calcareous precipitate would take place. The basalt forming the columns is very hard, compact, of a dark blue colour, and smooth surface; and it may be traced to some small hills northward of the spot.

Near this place the surface has been affected in a manner worthy of observation. Every here and there, a small spot, varying in size from 3 to 20

yards in diameter, has been raised into a convex form; the pavement, that covers it, consisting of tabular plates of slaty sandstone, broken into small masses; and the fractured lines generally radiating, though in an irregular manner, from a centre. In some places the tops of these little globular elevations have been removed, leaving a regular circle of stones, whose bounding lines are disposed like the stones of an arch. In other instances they assume a more conical shape, resembling small hillocks, from the upper part of which the outer coating or tabular masses have generally fallen away. When they are of a larger character, the whole presents a heap of broken masses of rock.

Denodur Hill, an extinct Volcano.—Of the detached hills, the elevation of which I conceive to be due to volcanic influence, the principal is that called Denodur, and is situated near the shores of the Runn. It is the largest and highest hill in the country, and is evidently the remains of an extinct volcano, an irregular crater being still visible. In the north side is a large gap, reaching nearly to the foot of the hill, but partially blocked up by a lower ridge, or a kind of traverse. Its western flanks are composed of a series of ridges of laminated clay and loam, interspersed with flat, angular fragments of slaty sandstone and slate-clay. The surface of some of these ridges is smooth, consisting either of thin slabs of slate-clay, or of thicker slabs of a very compact, crystalline, and slightly calcareous stone, the same as that which overlies the laminated series, and forms the walls on the Runn, &c. Near the base of the hill and for more than two-thirds up its side the construction alters, being composed partly of a loose sandstone, and partly of the calcareous grit, containing imbedded, angular fragments of basalt; the uppermost part is a perpendicular wall of basalt, which, apparently, continues all round the top. A stream of very compact basalt runs past its north-western flank, and in other places. Numerous small conical hills, composed of horizontal layers of limestone grit, or of basalt, are scattered over its sides, and its base is covered with a thick mould, formed of decayed vegetables, with earthy matter. Nowhere did I find any traces of recent disturbance, although the people of the neighbourhood, particularly the Jogees, or religious devotees, who inhabit a temple on its northern flank, asserted that fire issued from it during the earthquake of 1819. If it did, there would, of course, be some signs of it remaining; but I was unable to penetrate into the interior of the hill, owing to the dense Bauble Jungle, or crooked thorn tree with which it is covered.

Not far from this place, and adjoining the village of Nuckutrana, is a hill of some size, called Ungia-soorud, the elevation of which has also been effected by volcanic agency. The flanks and base are composed of a very loose, friable, calcareous sandstone and grit, apparently stratified, but inclined

at all angles; and the remainder consists of very compact basalt. The hill is divided into two parts by a narrow, tortuous cleft, the sides of which are nearly perpendicular, and composed of irregularly triangular prisms of basalt. The cleft is not more than four feet wide at the bottom, though it is somewhat broader at the top; and as it passes completely through the hill, we must suppose the whole to be similarly composed.

All the other numerous isolated hills scattered over this part of the province, including that called the Nunnaw, next to Denodur, appear to be similarly constructed.

The hill called Lecka, deserves particular notice. It forms one of a group of hills on the borders of the Runn, at the north-western extremity of the province, and is composed of two portions; one consisting of stratified beds of sandstone; and the other wholly of basalt, in irregular, triangular columns. The beds of sandstone are horizontally disposed, and of various colours and textures; the lowest stratum being a coarse, brown, quartzose grit. The igneous rocks crop out in various places near this spot, forming a cluster of small hills between it and the Jooria range; the intervening spaces being broken in the most confused manner.

Recent Outbursts.—Having given as many examples of the elevatory effects of volcanic action as my space will admit, I shall conclude my account of their phænomena with a description of some igneous outbursts of, apparently, a very recent epoch. The principal one occurs at the village of Wagé-ké-Pudda. The spot which has been acted on is a rather high table-land, composed of the nummulitic marl, and is flanked by low, irregular hills of ironstone and gravel, called by the natives Kara Rurraw. The first view of it, is very striking. Conceive a space of about two square miles, blown out into a flat basin, the sides being broken into fissures, with craters, ravines, and hollows; and the interior, or bed of the basin, interspersed with hillocks and cones of every variety of colour, black, red, yellow, and white, and with patches of cinders, similar to the refuse of a furnace; the whole looking as fresh as if the igneous agents were still in operation.

The surface of the table-land immediately surrounding the blown-out space, is covered with a burnt ironstone, divided into irregular cells, similar to Septaria; below which are steep banks, 40 to 50 feet high, consisting of comminuted particles of clay, sand, gravel, scoriæ, and small angular pieces of basalt; the whole being loose, and having a dry and brittle feel.

Within the centre are several small craters, or circular spaces, surrounded by walls of basalt. None of them are perfect circles, being broken through by watercourses; but one has about two thirds of its circumference com-

plete, the sides of which, about forty feet high, are in the upper part quite perpendicular, and consist of very compact basalt, of a columnar structure; while the lower ten feet present a talus, composed of volcanic sand, and scoriæ in very thin laminæ. Below the columnar basalt is a bed of a friable variety, three feet in thickness. In some parts the columns are capped with a thin band of ironstone. The interior of this crater is about 80 yards in diameter, and consists of volcanic sand, with imbedded angular fragments of basalt. The most perfect of these craters, or circular spaces, are generally hid from view, being approachable only by the narrow ravine forming the outlet of the watercourse which cuts through them. The basalt varies greatly in texture and general appearance: in some places it is columnar, exceedingly hard and compact, in others it contains imbedded crystals of felspar, and it occasionally presents the structure and texture of an amygdaloidal clay. Some varieties also consist of concentric layers of a kind of brittle, clayey substance, inclosing a nucleus of hard rock; the whole being imbedded in a mass of clay, which looks as if a number of small roots were entwined about it. All the varieties are frequently found in the same bank or hillock.

Several other small basins have been blown out in the surrounding tableland, forming inverted cones, about 15 or 20 feet in depth; and are composed of the same materials as those just described. Many of them consist entirely of small, brittle particles, of a pale yellow colour, evidently sulphuric. The clay has, in various places, been burnt into a perfect brick; and the marls, or sandy clays, are frequently of a beautiful bright purple. Quantities of talc, or mica, lie scattered about, twisted and contorted into a variety of shapes; and some of the iron ore which covers the surface, appears to have been partially fused, consisting of a spongy, vesicular mass. The whole has the appearance of having been for some time subjected to considerable heat, and then suddenly blown up. The cones and banks of loose volcanic scoriæ must be yearly washing away; and it is difficult to conceive, that the walls of solid basalt forming the sides of the craters, can belong to a similar period, having all the appearance and texture of very old basalt; but it is possible that a recent eruption may have taken place in the site of one of a more ancient date, thus presenting a mixture of old and recent volcanic products. If it is true, that basalt owes its columnar structure to its cooling slowly under a great pressure, it is impossible that these masses of columnar basalt and the loose cones of scoriæ can be contemporaneous.

In the nummulitic marl forming the banks of a river which flows past this patch of blown-up ground, is a stratum of earth containing small nodules or

rounded masses, of a pale yellow colour, translucent and brittle, and which burn with a bright flame, giving out a strong aromatic odour. It is contained in a dry, olive-brown earth, so light as to float in water.

Numerous *Echinodermata,* and other fossils, are found on the table-land, and some of the fields are thickly strewed with casts of a Turbinella of a very large size, the external shell being always wanting. On breaking them, small fragments of igneous matter are found in their interior.

In the table-land just south of the outburst, is a large fissure, about a quarter of a mile in length, 40 yards broad, and 40 or 50 feet deep. One extremity communicates with the river, and the other is rounded, or formed into a basin shape. The sides are perfectly perpendicular; and it is clearly an opening in the ground, there not being the slightest indication of anything of the kind, until directly at its brink. I was informed by a native of the village, (the only present inhabitant,) that smoke issued from the outburst about twenty-two years since; but little dependence can be placed on the statements of these people.

Another similar, but smaller, outburst occurs about three miles south of Mhurr, near the spot in which, in my account of the tertiary deposits, I mentioned that a large basaltic dyke crosses the river. The space here blown out, does not exceed 100 yards in diameter, and 15 feet deep, consisting of similar cones of volcanic scoriæ, and comminuted particles, as above described; but there is no trace of any basalt nearer than the dyke in the river.

From what I have now detailed, it appears, that igneous action has affected all the formations of which the province is composed; and it will also appear, by the following details, that the Grand Runn, the most remarkable feature of the country, owes its peculiar characters to volcanic action.

THE GRAND RUNN.

With a short account of this large and singular tract, I shall conclude the paper. It has been described by Captain Burnes, in a memoir in the library of the Royal Asiatic Society; and referred to, at considerable length, by Mr. Lyell, in his "Principles of Geology*."

This tract, containing an area of upwards of 7000 square miles, exclusive of the space occupied by the Bunnee, and the islands of Puchum, Khureer, &c., is, perhaps, unparalleled in any known part of the globe, as it may be said to be placed on a level between land and water. It is dry during the greater part

* 5th Edit., vol. ii. p. 183 *et seq.*

of the year, when its surface consists of a sandy flat, totally devoid of vegetation; but, perhaps, on account of its saline nature, always sufficiently moist to prevent its particles being drifted. During the prevalence of the south-west winds, however, so much water is blown up its eastern inlet by the Gulf of Cutch, and, at its western extremity, by the eastern branch of the Indus, as to cover its whole surface; augmented by the freshes, which, at the same time, come down the Loonee and Bunass rivers, and the numerous small streams which intersect the northern coast of Cutch. At those seasons, the Runn has all the appearance of a sea, and is passable only on camels, and, in some seasons, with difficulty. It has been described as the dried-up bed of a sea; but it is not easy to account for its drying up, unless we suppose a general depression of the ocean. We must, therefore, look to other causes.

In several parts of the world, particularly in the Baltic, there are undeniable proofs of a gradual rising of the land; and, in time, parts of that sea might be converted into a tract similar to that of the Runn*. It does not become me to inquire whether this gradual elevation is due to a series of so minute elevatory movements as to be unnoticeable, except from the effects which subsequent measurement proves them to have produced, or from a gradual expansion by volcanic heat. But in Cutch we have evidence of movements within a very late date, and every reason to believe that similar ones have occurred at various periods. The earthquake of 1819 is known to have produced a remarkable change on the western extremity of the Runn, by throwing up a mound 50 miles in length, 16 in breadth, and 18 feet high; and by depressing an adjoining tract, so as to convert it, from a cultivated district, into a large salt lagoon. As the changes in level, thus effected, have, however, been detailed in other papers, I shall merely observe, that when I was at Luckput in January, 1834, very little if any change had occurred since Captain Burnes' visit, in 1828; except that the Sindians had repaired all the bunds across the river, and thus, by preventing further supplies of fresh water, the lagoon had assumed much the same appearance as previous to the freshes of 1828.

I was also informed by a boatman, who constantly plied up and down from Ullah-Bund to the sea, that between Sindoo and Sindree (see Map), there is a bank, six miles broad, covered by only one foot of water; and as there is no channel through it, the boatmen are obliged to get out and haul the boats across the bank, after which they follow the windings of the channel to Ullah-

* See Mr. Lyell's Memoir, on the proofs of gradual rising of the land in Sweden. Phil. Trans. 1835, p. 1 *et seq.*

Bund. It would therefore appear that this portion could not have been so much sunk as that around Sindree, and between it and Luckput.

I was also assured that pieces of iron and ship-nails have been thrown up from fissures in the Runn; and Capt. McMurdo* mentions a boat which had been buried under 15 feet of alluvium, having become exposed in a mud-bank, near the village of Wuwania, on the Kattywar side of the Runn, or where it joins the Gulf of Cutch.

The number of places still pointed out as Bunders, or quays, together with the large stones formerly used as anchors, one of which still lies on a small elevation on the Runn, not far from the Puchum Island, and the confident assertion of all the inhabitants on its coast, tend to confirm the opinion that the district must once have been covered by a navigable body of water.

Some parts of the shores have precisely the appearance of having been recently deserted by the sea. This is particularly the case near the village of Charee, which is separated from the Runn by a low range of hills. To the northward of this range is an inlet, about one mile and a half in breadth, and it looks precisely like a small creek or bay from which the tide has just ebbed. Its surface is composed of smooth, whitish clay, with numerous scattered gravel banks, the ends of which have been worn round, and the sides present perpendicular or overhanging banks. Several masses of crystalline sandstone also rise suddenly out of the bed; and some of them consist of immense fragments, which look as if they had been piled one on the other, and have a strange effect from a short distance. Beyond the inlet is another range of hills of the same description, but it is more broken and confused than any other in the country. In some places, the upper stratum of hard rock has been thrown into a position like the roof of a house; in others, it precisely resembles a ruined fort with towers on a hill; but the greater part of the stratum is a confused assemblage of huge fragments of rock. Northward of this range, and separated from it by a narrow belt of the Runn, is a steep conical hill, called Keera, 600 or 700 feet in height, consisting partly of the same materials as the others, and partly of basalt; and it appears to have been formed in a similar manner to the hill called Ungur-soorud, before described, and others of that class. It is also more than probable, that the peculiar, fractured appearance of all the ranges is due to the same cause acting at the same period.

Supposing the bed of the Runn to have been raised by a series of violent movements, such as must have upheaved the Keera, and its surface to have

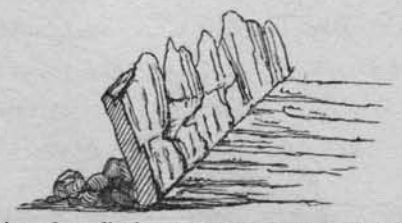
* Extract from Captain McMurdo's MS. memoir on Kattywar, in Captain Burnes' Travels in Bokhara, vol. iii. p. 329, *note*.

been broken, and covered with fragments of rock, its present level outline may be ascribed to subsequent operations. The Runn is bounded to the north, as already stated, by the Thur or Little Desert, a district composed entirely of sand. The Loonee and Bunass rivers also flow through a sandy soil, as do many other streams which enter from the Cutch side. Now, during the periodical floods, vast quantities of sandy alluvium must have been brought down by these rivers, deposited at their mouths, and washed thence and spread over the surface of the Runn by the sea-water annually blown up at its eastern and western extremities. This operation, repeated yearly, would fill up all inequalities, and produce in time a level surface. It is probable, however, that the present state of the district may also be, in some measure, owing to a gradual rising of its bed, as it is only to such operations that some of its shores, as those of the inlet above mentioned, can be ascribed.

There are also many facts to prove, that this tract has been elevated at very different periods. The high hills bordering its southern shore are, as before stated, composed principally of the laminated series, and their surfaces are covered with Ammonites, Nautilites, Belemnites, and other fossils of that geological period; whereas along its immediate line of shore, there are generally low ridges, composed of rocks full of marine remains of a totally different character, many of them belonging to existing species. Numerous small rocky islets, consisting of shells agglutinated into a solid mass, occur in various parts of the Runn, and are barely raised above its present level. They are probably merely the higher portions of large tracts, the lower parts of which are covered by sediment.

Natural Walls on the Runn how formed.—Still more striking instances of the effects of upheavement, since the Runn assumed its present characters, are exhibited in the detached, elevated masses of rock which I have called the *Natural Walls* on the Runn.

They consist (see woodcuts) of disconnected portions of rock rising abruptly from the surface of the Runn, and presenting a smooth, vertical wall, occasionally upwards of thirty feet in height, and in one instance upwards of two

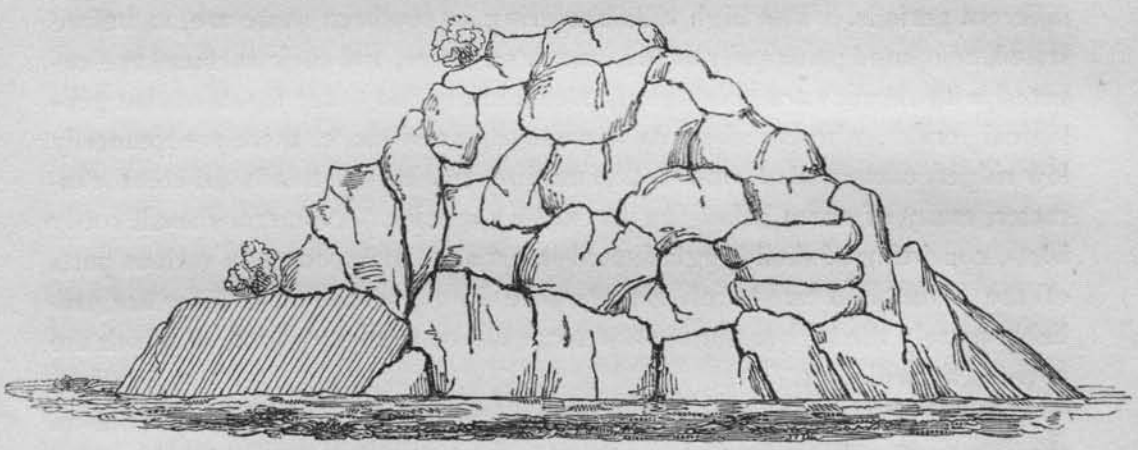


End view of a wall, about 15 feet high, and two miles long.

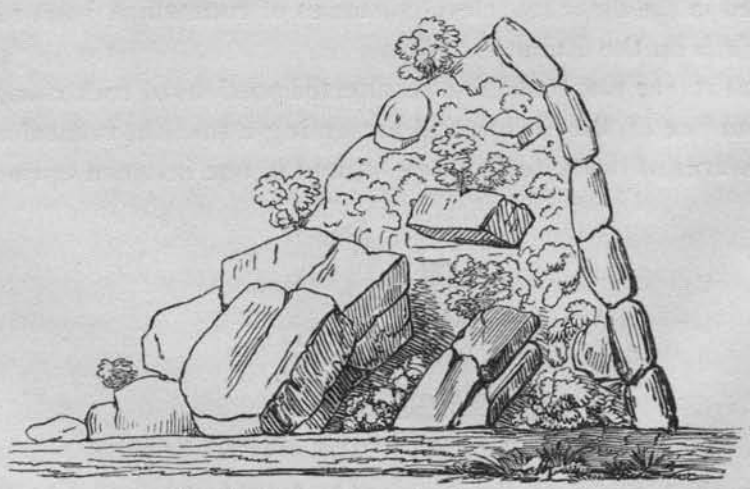
miles in length. Some of them resemble domed or vaulted buildings, the

Dome-shaped wall.

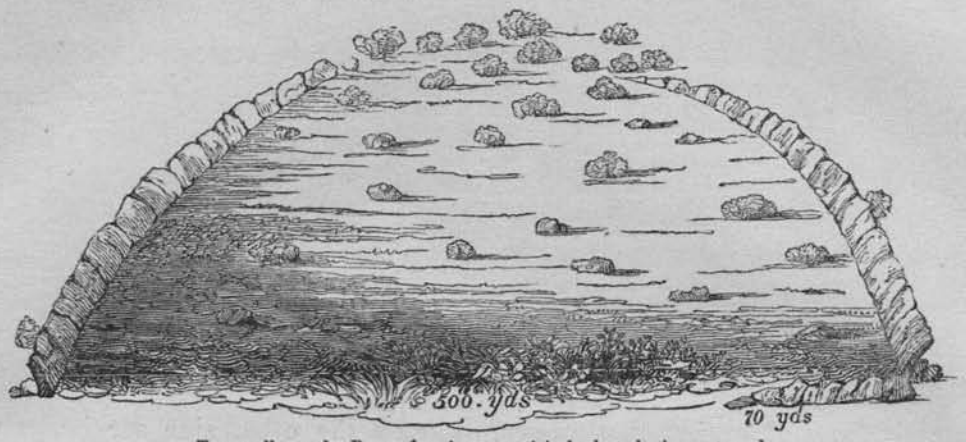
reversed side consisting of a talus of broken fragments of rock and soil.



One of the walls on the Runn, about 30 feet high, the stones divided into masses, but not broken.



Side view of the same, showing the stones on end.

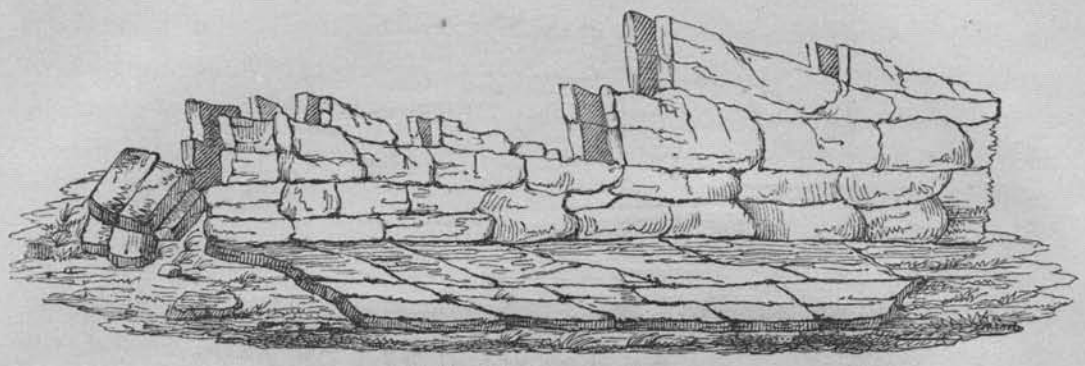


Two walls on the Runn, forming a semicircle, but sloping outwards.

In one place these walls form a semicircle about 500 yards in diameter, both walls sloping outwards. That the walls have been uplifted into their present form is quite evident, first, from the stones being all on end, that is, with the grain in the direction of their present position, and peeling off in scales down the face of the wall; and secondly, from my having met with the same phenomena on a smaller scale, in other parts of the country, where the slabs of rock are at all angles, and even, as those before mentioned, turned over. It should be noticed, also, that the borders of the Runn, near these walls, are composed of friable beds of the laminated series, covered with thick tabular masses of hard sandstone, precisely similar to those forming the walls.

Had they been uplifted during the permanent prevalence of the waters, the sloping talus of earth and fragments of rock, with which they are all backed, must have been washed away. It should be stated, that these examples are situated on ground now almost recovered from a state of Runn; some parts having been sufficiently augmented by means of the sandy alluvium, washed down from the neighbouring hills to support vegetation; whereas the isolated rocks, several of which rise out of that part of the Runn, and are still subjected to inundation, have no detritus or talus, but present smooth walls of perpendicular rocks. I could never perceive any water-marks on them, nor any remains of marine testacea, which might occur, had the sea ever washed the present level of their foot. It is probable that their origina base lines have become obliterated by the sediment which must have accumulated round them in course of time, and which forms the existing surface.

A very good example of a similar wall occurs in the centre of the province, near the village of Rampoora; it is a ridge of coarse sandstone about 300 yards in length, and from 10 to 15 feet in height, the stones being evidently placed edgeways, and in so regular a manner as to resemble precisely an artificial wall. It rises from a base of the same sandstone, and on one side it



Wall of sandstone near Rampoora.

is nearly flat, but broken into masses, while on the other side are heaps of stone, broken and confused, and the interstices are filled with sand and small trees. At the extremity of the wall the stones slope up like the end of a roof. In the immediate vicinity of this wall is a small range of basaltic hills, striking however at right angles to the direction of the sandstone ridge.

Some of the rivers which flow towards the Runn from the Cutch side are lost in the sand at their mouths; though at a short distance up the bed of the river, the stream runs freely. It would thus appear, that at these spots, the bed of the Runn has been increased, by the sediment, probably, brought down by the stream; but so loose is the soil, that the water soaks into it and even flows under it, instead of wearing channels. This phenomenon is observable in the sandy beds of many of the rivers in the province. The stream may be noticed running with some rapidity and of a sudden to cease, the bottom of the river presenting a smooth sandy surface; but a mile lower down the water again issues and continues its course; the intervening parts being sometimes quite hard and dry; in others forming very dangerous quicksands.

The natives have various traditions that the drying up of this sea was sudden, and that boats were tossed on the land and wrecked; they pretend also to assign a date to this event, but their accounts differ so materially and are so vague, that not the slightest reliance can be placed upon them, except to the general fact.

It is evident that the Runn could not have been drained by the bursting of its boundaries, at least since it was deep enough to be navigable; because its present surface, notwithstanding the sediment which yearly accumulates on it, is even now so little raised above the sea's level as to be flooded by the mere effects of the wind; but the most probable supposition is, not that it was ever a detached inland sea or lake, but that it communicated with the ocean by its present outlets, and that its bed has been raised, partly perhaps by a gradual movement, and partly by violent upheavements during

earthquakes. Even such marked changes of level as the raising of Ullah Bund, and the sinking of the ground near the large town of Luckput, would have passed unrecorded but for the accidental circumstance of the district having been visited by a British officer. Other portions of this vast area, the greater part of which is never traversed by man, may have been similarly affected at that time, and yet the changes remain unknown.

Successive Marine and Freshwater Beds.—The submerged tract near Luckput, or Lake of Sindree, may, I think, illustrate the manner in which successive marine and freshwater deposits may be produced. This tract was at one period a richly cultivated district, periodically flooded by a branch of a great river, and produced large quantities of rice. In this state numerous land testacea no doubt occupied it, and were mixed with the remains of fluviatile species brought down by the floods. The bones of animals used in agriculture, and those of various domestic species, also the remains of broken pottery, perhaps coins, and other proofs of civilized life, might likewise have been imbedded. Suddenly, owing to the damming up of the river by the Sindians, the supply of fresh water ceased, and the tract was no longer cultivated or inhabited. Some time after this an earthquake occurred, uplifting one part and depressing below the level of the ocean another, which was immediately converted into a salt lake. A perfectly new description of deposit and organic remains must then have been accumulated, consisting wholly of marine animals, principally such as inhabit shallows and tide-ways. Again, owing to the sudden melting of the snow on far distant mountains (the Himalayahs) the waters of the river came down with such force as to burst all the bunds built across it, as well as that thrown up by the earthquake, and covered the tract with fresh water, or perhaps with fresh at its upper or northern extremity, and brackish at its southern near the sea. Supposing this state of things to have remained for some time, the river continuing to pour its water into this lagoon, another change would take place in the description of the sedimentary deposit. Once more the bunds were erected across the river, the supply of fresh water ceased, and as that on the lagoon evaporated, the sea again flowed in and converted it into a salt lake, which is its present state. All the above changes are known to have occurred ; and it is easy to suppose that if the shallow part at Sindoo were slightly raised above its present level, thus shutting out the sea, the part around the Fort of Sindree would be converted once more into dry land. If, therefore, at any future period, the river should again cut a channel, the banks might present various, regular beds alternately enclosing marine and freshwater exuviæ, the latter being also associated with land productions.

The ruins of one of the towers of the Fort of Sindree remained, when I visited Luckput in 1834, and in all probability now stand as a monument of the changes, which are daily taking place on the earth's surface.

Conclusion:—In concluding this paper, I have only to observe, that I have throughout endeavoured to describe facts as they appeared to me at the time I examined them, without regard to any particular theory; and if I have failed in making my descriptions intelligible, I have only to plead the difficulty of having had a great deal to describe in a limited space. As the country to which this memoir relates is, however, unfortunately from its geographical position, beyond the reach of general observers, I am induced to hope, that this sketch, however imperfect, may be found to possess some interest.

For the arranged list of fossil shells, given in the Appendix, as well as for all my information on that subject, I am entirely indebted to Mr. James De Carl Sowerby, who had my specimens (now in the cabinets of the Geological Society) for some time in his possession for examination.

The woodcuts are copied from drawings taken by myself on the spot, for the express purpose of geological illustration, and are unexaggerated views of what they are intended to represent.

December 31st, 1836.