CHAPTER VI.

Newer Pliocene formations—Reasons for considering in the first place the more modern periods—Geological structure of Sicily—Formations of the Val di Noto of newer Pliocene period—Divisible into three groups—Great limestone—Schistose and arenaceous limestone—Blue marl with shells—Strata subjacent to the above—Volcanic rocks of the Val di Noto—Dikes—Tuffs and Peperinos—Volcanic conglomerates—Proofs of long intervals between volcanic eruptions—Dip and direction of newer Pliocene strata of Sicily.

NEWER PLIOCENE FORMATIONS.

HAVING endeavoured, in the last chapter, to explain the principles on which the different tertiary formations may be arranged in chronological order, we shall now proceed to consider the newest division of formations, or that which we have named the newer Pliocene.

It may appear to some of our readers, that we reverse the natural order of historical research by thus describing, in the first place, the monuments of a period which immediately preceded our own era, and passing afterwards to the events of antecedent ages. But, in the present state of our science, this retrospective order of inquiry is the only one which can conduct us gradually from the known to the unknown, from the simple to the more complex phenomena. We have already explained our reasons for beginning this work with an examination, in the first two volumes, of the events of the *recent* epoch, from which the greater number of rules of interpretation in geology may be derived. The formations of the newer Pliocene period will be considered next in order, because these have undergone the least degree of alteration, both in position and internal structure, subsequently to their origin. They are monuments of which the characters are more easily deciphered than those belonging to more remote periods, for they have been less mutilated by the hand of time. The organic remains, more

especially of this era, are most important, not only as being in a more perfect state of preservation, but also as being chiefly referrible to species now living; so that their habits are known to us by direct comparison, and not merely by inference from analogy, as in the case of extinct species.

Geological structure of Sicily.—We shall first describe an extensive district in Sicily, where the newer Pliocene strata are largely developed, and where they are raised to considerable heights above the level of the sea. After presenting the reader with a view of these formations, we shall endeavour to explain the manner in which they originated, and speculate on the subterranean changes of which their present position affords evidence.

The island of Sicily consists partly of primary and secondary rocks, which occupy, perhaps, about two-thirds of its superficial area *, and the remaining part is covered by tertiary formations, which are of great extent in the southern and central parts of the island, while portions are found bordering nearly the whole of the coasts.

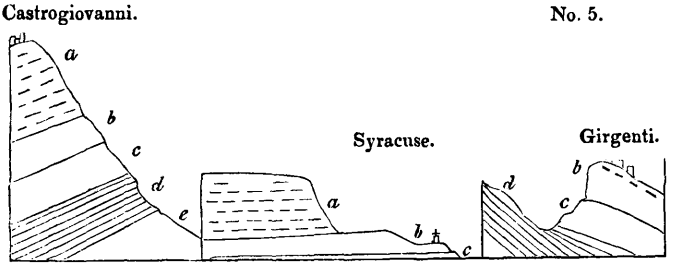
Formations of the Val di Noto.—If we first turn our attention to the Val di Noto, a district which intervenes between Etna and the southern promontory of Sicily, we find a considerable tract, containing within it hills which are from one to two thousand feet in height, entirely composed of limestone, marl, sandstone, and associated volcanic rocks, which belong to the newer Pliocene era. The recent shells of the Mediterranean abound throughout the sedimentary strata, and there are abundant proofs that the igneous rocks were the produce of successive submarine eruptions, repeated at intervals during the time when the subaqueous formations were in progress.

These rising grounds of the Val di Noto are separated from the cone of Etna, and the marine strata whereon it rests, by the low level plain of Catania, just elevated above the level of the sea, and watered by the Simeto. The traveller who passes

* We may shortly expect a full account of the Geology of this island from Professor Hoffmann, who has devoted more than a year to its examination.

from Catania to Syracuse, has an opportunity of observing, on the sides of the valley, many deep sections of the modern formations above described, especially if he makes a slight detour by Sortino and the Valley of Pentalica.

The whole series of strata, in the Val di Noto, is divisible into three principal groups, exclusive of the associated volcanic rocks. The uppermost mass consists of limestone, which sometimes acquires the enormous thickness of seven or eight hundred feet, below which is a series much inferior in thickness, consisting of a calcareous sandstone, conglomerate and schistose limestone, and beneath this again, blue marl. The whole of the above groups contain shells and zoophytes, nearly all of which are referrible to species now inhabiting the contiguous sea.



a, Great limestone of Val di Noto.
b, Schistose and arenaceous limestone of Florida, &c.
c, Blue marl with shells.
d, White laminated marl.
e, Blue clay and gypsum, &c. without shells.

Great limestone formation (*a*, diagram No. 5).—In mineral character this rock often corresponds to the yellowish white building-stone of Paris, well known by the name of *Calcaire grossier*, but it often passes into a much more compact stone. In the deep ravine-like valleys of Sortino and Pentalica, it is seen in nearly horizontal strata, as solid and as regularly bedded as the greater part of our ancient secondary formations. It abounds in natural caverns, which, in many places, as in the valley of Pentalica, have been enlarged and multiplied by artificial excavations.

The shells in the limestone are often very indistinct, sometimes nothing but casts remaining, but in many localities, especially where there is a slight intermixture of volcanic sand, they are more entire, and, as we have already stated, can almost all be identified with recent Mediterranean testacea. Several species of the genus Pecten are exceedingly numerous, particularly the large scallop (*P. Jacobæus*), now so common on the coasts of Sicily. The shells which I collected from this limestone at Syracuse, Villasmonde, Militello (V. di Noto), and Girgenti, have been examined by M. Deshayes, and found to be all referrible to species now living, with three or four exceptions*.

The mineral characters of this great calcareous formation vary considerably in different parts of the island. In the south, near the town of Noto, the rock puts on the compactness, together with the spheroidal concretionary structure of some of the Italian travertins. At the same place, also, it contains the leaves of plants and reeds, as if a stream of fresh-water, charged with carbonate of lime and terrestrial vegetable remains, had entered the sea in the neighbourhood. At Spaccaforno, and other places in the south of Sicily, a similar compact variety of the limestone occurs, where it is for the most part pure white, often very thick bedded, and occasionally without any lines of stratification. This hard white rock is often four or five hundred feet in thickness, and appears to contain no fossil shells. It has much the appearance of having been precipitated from the waters of mineral springs, such as frequently rise up at the bottom of the sea in the volcanic regions of the Mediterranean. As these springs give out an equal quantity of mineral matter at all seasons, they are much more likely to give rise to unstratified masses, than a river which is swoln and charged with

* For lists of these see Appendix II. I procured at Villasmonde, seven species; at Militello, ten; in the limestone of Girgenti, of which the ancient temples are built, ten species; from the limestone and subjacent clay at Syracuse, twenty-six species; in the limestone and clay near Palermo, also belonging to the newer Pliocene formation, one hundred shells.

sedimentary matter of different kinds, and in unequal quantities, at particular seasons of the year.

The great limestone above mentioned prevails not only in the Val di Noto, but re-appears in the centre of the island, capping the hill of Castrogiovanni, at the height of three thousand feet above the level of the sea. It is cavernous there, as at Sortino and Syracuse, and contains fossil shells and casts of shells of the same species*.

Schistose and arenaceous limestone, &c. (*b*, diagram No. 5.)—The limestone above-mentioned passes downwards into a white calcareous sand, which has sometimes a tendency to an oolitic and pisolitic structure, analogous to that which we have described when speaking of the travertin of Tivoli†. At Florida, near Syracuse, it contains a sufficient number of small calcareous pebbles to constitute a conglomerate, where also beds of sandy limestone are associated, replete with numerous fragments of shells, and much resembling, in structure, the English cornbrash. A diagonal lamination is often observable in the calcareous sandy beds analogous to that represented in the first volume (chap. xiv. diagram No. 6), and to that exhibited in many sections of the English crag, to which we shall afterwards allude.

In some parts of the island this sandy calcareous division *b*, seems to be represented by yellow sand, exactly resembling that so frequently superimposed on the blue shelly marl of the Subapennines in the Italian peninsula. Thus, near Grammichele, on the road to Caltagirone, beds of incoherent yellow sand, several hundred feet in thickness, with occasional layers of shells, repose upon the blue shelly marl of Caltagirone.

When we consider the arenaceous character of this formation, the disposition of the laminæ, and the broken shells sometimes imbedded in it, it is difficult not to suspect that it was

* Dr. Daubeny correctly identified the Val di Noto limestone of Syracuse with that of the summit of Castrogiovanni.—Jameson, Ed. Phil. Journ., No. xxv. p. 107, July, 1825.

† Vol. i. chap. xii.

formed in shallower water, and nearer the action of superficial currents, than the superincumbent limestone, which was evidently accumulated in a sea of considerable depth. If we adopt this view, we must suppose a considerable subsidence of the bed of the sea, subsequent to the deposition of the arenaceous beds in the Val di Noto.

Blue marl with shells (*c*, diagram No. 5).—Under the sandy beds last mentioned is found an argillaceous deposit of variable thickness, called *Creta* in Sicily. It resembles the blue marl of the Subapennine hills, and, like it, encloses fossil shells and corals in a beautiful state of preservation. Of these I collected a great abundance from the clay, on the south side of the harbour of Syracuse, and twenty species in the environs of Caltanisetta, all of which, with three exceptions, M. Deshayes was able to identify with recent species*. From similar blue marl, alternating with yellow sand, at Caltagirone, at an elevation of about five hundred feet above the level of the sea, I obtained forty species of shells, of which all but six were recognized as identical with recent species†. The position of this argillaceous formation is well seen at Castrogiovanni and Girgenti, as represented in the sections, diagram No. 5. In both of these localities, the limestone of the Val di Noto re-appears, passing downwards into a calcareous sandstone, below which is a shelly blue clay.

Strata beneath the blue marl.—The clay rests, in both localities, on an older series of white and blue marls, probably belonging to the tertiary period, but of which I was unable to determine the age, having procured from it no organic remains save the skeletons of fish which I found in the white thinly-laminated marls‡.

* See list of these shells, Appendix II.

† See Appendix II.

‡ I found these fossil fish in great abundance on the road, half a mile north-west of Radusa, on the road to Castrogiovanni, where the marls are fetid, and near Castrogiovanni in gypseous marls, at the mile-stone No. 88, and between that and No. 89. Lord Northampton has since presented to the Geological Society

The marls are sometimes gypseous, and belong to a great argillaceous formation which stretches over a considerable part of Sicily, and contains sulphur and salt in great abundance. The strata of this group have been in some places contorted in the most extraordinary manner, their convolutions often resembling those seen in the most disturbed districts of primary clay slate.

But we wish, at present, to direct the reader's exclusive attention to strata decidedly referrible to the newer Pliocene era, and we have yet to mention the igneous rocks associated with the sedimentary formations already alluded to.

Volcanic Rocks of the Val di Noto.—The volcanic rocks occasionally associated with the limestones, sands, and marls already described, constitute a very prominent feature throughout the Val di Noto. Great confusion might have been expected to prevail, where lava and ejected sand and scoriæ are intermixed with the marine strata, and, accordingly, we find it often impossible to recognize the exact part of the series to which the beds thus interfered with belong.

Sometimes there are proofs of the posterior origin of the lava, and sometimes of the newer date of the stratified rock, for we find dikes of lava intersecting both the marl and limestone, while, in other places, calcareous beds repose upon lava, and are unaltered at the point of contact. Thus the shelly limestone of Capo Santa Croce rests in horizontal strata upon a mass of lava, which had evidently been long exposed to the action of the waves, so that the surface has been worn perfectly smooth. The limestone is unchanged at its junction with the igneous rock, and incloses within it pebbles of the lava *.

The volcanic formations of the Val di Noto usually consist of the most ordinary variety of basalt with or without olivine. The rock is sometimes compact, often very vesicular. The

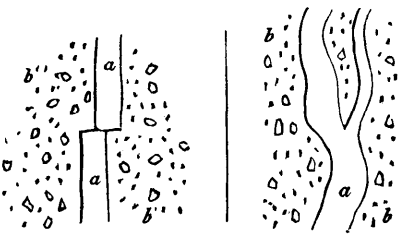
some which he obtained from the same localities, but I have met with no zoologists who could name the species.

* This locality is described by Professor Hoffman, Archiv für Mineralogie, &c. Berlin, 1831.

vesicles are occasionally empty, both in dikes and currents, and are in some localities filled with calcareous spar, arragonite, and zeolites. The structure is, in some places, spheroidal, in others, though rarely, columnar. I found dykes of amygdaloid, wacke, and prismatic basalt, intersecting the limestone at the bottom of the hollow, called Gozzo degli Martiri, below Melilli.

Dikes.—Dikes of vesicular and amygdaloidal lava are also seen traversing peperino, west of Palagonia, near a mill by the road side.

No. 6. No. 7.



Horizontal section of Dikes near Palagonia.

a, Lava.
b, Peperino, consisting of volcanic sand, mixed with fragments of lava and of limestone.

In this case we may suppose the peperino to have resulted from showers of volcanic sand and scoriæ, together with fragments of limestone thrown out by a submarine explosion, similar to that which lately gave rise to the volcanic island off Sciacca. When the mass was, to a certain degree, consolidated, it may have been rent open, so that the lava ascended through fissures, the walls of which were perfectly even and parallel. After the melted matter that filled the rent had cooled down, it must have been fractured and shifted horizontally by a lateral movement.

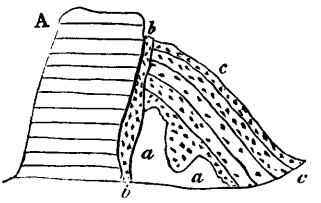
In the second figure, No. 7, the lava has more the appearance of a vein which forced its way through the peperino, availing itself, perhaps, of a slight passage opened by rents caused by earthquakes. Some of the pores of the lava, in these dikes, are empty, while others are filled with carbonate of lime.

The annexed diagrams (Nos. 6 and 7) represent a ground plan of the rocks as they are exposed to view on a horizontal surface. We think it highly probable that similar appearances would be seen, if we could examine the floor of the sea in that part of the Mediterranean where the waves have recently washed away the new volcanic island, for when a superincumbent mass of ejected fragments has been removed by denudation, we may expect to see sections of dikes traversing tuff, or, in other words, sections of the channels of communication by which the subterranean lavas reached the surface.

On the summit of the limestone platform of the Val di Noto, I more than once saw analogous dikes, not only of lava but of volcanic tuff, rising vertically through the horizontal strata, and having no connexion with any igneous masses now apparent on the surface. In regard to the *dikes of tuff or peperino*, we may suppose them to have been open fissures at the bottom of the sea, into which volcanic sand and scoriæ were drifted by a current.

Tuffs and Peperinos.—In the hill of Novera, between Vizzini and Militelli, a mass of limestone, horizontally stratified, comes in contact with inclined strata of tuff (see diagram No. 8),

No. 8.



A, Limestone.
aa, Calcareous breccia with fragments of lava.
b, Black tuff.
c, Tuff.

while a mixed calcareous and volcanic breccia, *a a*, supports the inclined layers of tuff, *c*. The vertical fissure, *b b*, is filled with volcanic sand of a different colour. An inspection of this section will convince the reader that the limestone must have been greatly dislocated during the time that the submarine eruptions were taking place.

At the town of Vizzini, a dike of lava intersects the argillaceous strata, and converts them into siliceous schist, which has

been contorted and shivered into an immense number of fragments.

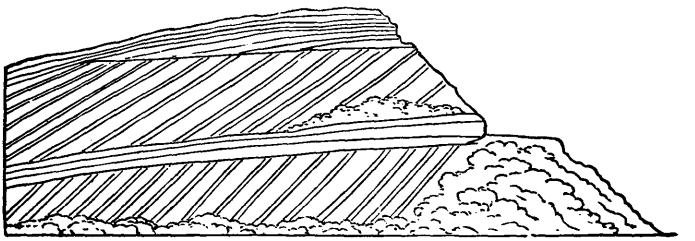
We have stated that the beds of limestone, clay, and sand, in the Val di Noto, are often partially intermixed with volcanic ejections, such as may have been showered down into the sea during eruptions, or may have been swept by rivers from the land. When the volcanic matter predominates, these compound rocks constitute the peperinos of the Italian mineralogists, some of which are highly calcareous, full of shells, and extremely hard, being capable of a high polish like marble. In some parts of the Val di Noto they are variously mottled with spots of red and yellow, and contain small angular fragments, similar to the lapilli thrown from volcanos.

It is recorded that, during the late eruption off the southern coast of Sicily, opposite Sciacca, the sea was in a state of violent ebullition, and filled, for several weeks continuously, with red or chocolate-coloured mud, consisting of finely-comminuted scoriæ. During this period, it is clear that the waves and currents that have since had power to sweep away the island, and disperse its materials far and wide over the bed of the sea, must with still greater ease have carried to vast distances the fine red mud, which was seen boiling up from the bottom, so that it may have entered largely into the composition of modern peperinos.

Professor Hoffman relates that, during the eruption (June, 1831), the surface of the sea was strewed over, at the distance of thirty miles from the new volcano, with so dense a covering of scoriæ, that the fishermen were obliged to part it with their oars, in order to propel their boats through the water. It is, therefore, quite consistent with analogy, that we should find the ancient tuffs and peperinos so much more generally distributed than the submarine lavas.

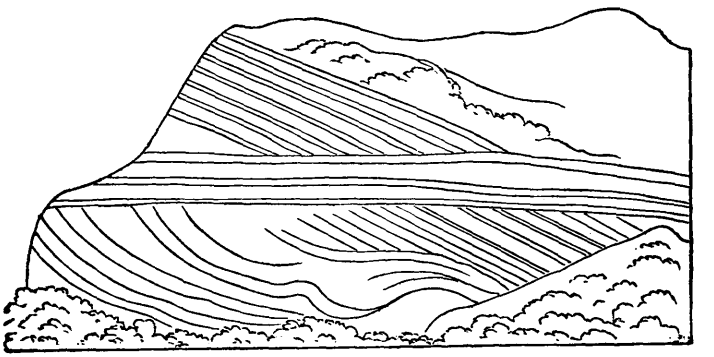
In the road which leads from Palagonia to Lago Naftia, and at the distance of about a mile and a half from the former place, there is a small pass where the hills, on both sides, consist of a calcareous grit, intermixed with some grains of volcanic sand.

No. 9.



Section of calcareous grit and peperino, east of Palagonia. South side of pass. Vertical height about thirty feet

No. 10.



Section of the same beds on the north side of the pass.

The disposition of the strata, on both sides of the pass, is most singular, and remarkably well exposed, as the harder layers have resisted the weathering of the atmosphere and project in relief. The sections exhibited on both sides of the pass are nearly vertical, and do not exactly correspond, as will be seen in the annexed diagrams (Nos. 9 and 10). It is somewhat difficult to conceive in what manner this arrangement of the layers was occasioned, but we may, perhaps, suppose it to have arisen from the throwing down of calcareous sand and volcanic matter, upon steep slanting banks at the bottom of the sea, in which case they might have accumulated at various angles of between thirty and fifty degrees, as may be frequently seen in the sections of volcanic cones in Ischia and elsewhere. The denuding power of the waves may, then, have cut off the upper

portion of these banks, so that nearly horizontal layers may have been superimposed unconformably, after which another bank may have been formed in a similar manner to the first.

Volcanic conglomerates.—In the Val di Noto we sometimes meet with conglomerates entirely composed of volcanic pebbles. They usually occur in the neighbourhood of masses of lava, and may, perhaps, have been the shingle produced by the wasting cliffs of small islands in a volcanic archipelago. The formation of similar beds of volcanic pebbles may now be seen in progress on the beach north of Catania, where the waves are undermining one of the modern lavas of Etna; and the same may also be seen on the shores of Ischia.

Proofs of gradual accumulation.—In one part of the great limestone formation near Lentini, I found some imbedded volcanic pebbles, covered with full-grown serpulæ, supplying a beautiful proof of a considerable interval of time having elapsed between the rounding of these pebbles and their inclosure in a solid stratum. I also observed, not far from Vizzini, a very striking illustration of the length of the intervals which occasionally separated the flows of distinct lava-currents. A bed of oysters, perfectly identifiable with our common eatable species, no less than *twenty feet in thickness*, is there seen resting upon a current of basaltic lava; upon the oyster-bed again is superimposed a second mass of lava, together with tuff or peperino. Near Galieri, not far from the same locality, a horizontal bed, about a foot and a half in thickness, composed entirely of a common Mediterranean coral (*Caryophyllia cespitosa*, Lam.), is also seen in the midst of the same series of alternating igneous and aqueous formations. These corals stand erect as they grew, and after being traced for hundreds of yards, are again found at a corresponding height on the opposite side of the valley.

Dip and direction.—The disturbance which the newer Pliocene strata have undergone in Sicily, subsequent to their deposition, differs greatly in different places; in general, however, the beds are nearly horizontal, and are not often highly

inclined. The calcareous schists, on which part of the town of Lentini is built, are much fractured, and dip at an angle of twenty-five degrees to the north-west. In some of the valleys in the neighbourhood an anticlinal dip is seen, the beds on one side being inclined to the north-west, and on the other to the south-east.

Throughout a considerable part of Sicily which I examined, the dips of the tertiary strata were north-east and south-west; as, for example, in the district included between Terranuova, Girgenti, Caltanisetta, and Piazza, where there are several parallel lines, or ridges of elevation, which run north-west and south-east.