CHAPTER XIV.

Volcanic rocks of the older Pliocene period—Italy—Volcanic region of Olot in Catalonia—Its extent and geological structure—Map—Number of cones—Scoriæ—Lava currents—Ravines in the latter cut by water—Ancient alluvium underlying lava—Jets of air called 'Bufadors'—Age of the Catalonian volcanos uncertain—Earthquake which destroyed Olot in 1421—Sardinian volcanos—District of the Eifel and Lower Rhine—Map—Geological structure of the country—Peculiar characteristics of the Eifel volcanos—Lake craters—Trass—Crater of the Roderberg—Age of the Eifel volcanic rocks uncertain—Brown coal formation.

VOLCANIC ROCKS OF THE OLDER PLIOCENE PERIOD.

Italy.— It is part of our proposed plan to consider the igneous as well as the aqueous formations of each period, but we are far from being able as yet to assign to each of the numerous groups of volcanic origin scattered over Europe a precise place in the chronological series. We have already stated that the volcanic rocks of Tuscany belong, in great part at least, to the older Pliocene period,—those for example of Radicofani, Viterbo, and Aquapendente, which have been chiefly erupted beneath the sea. The same observation would probably hold true in regard to the igneous rocks of the Campagna di Roma.

But several other districts, of which the dates are still uncertain, may be mentioned in this chapter as being possibly referrible to the period now under consideration. It will at least be useful to explain to the student the points which require elucidation before the exact age of the groups about to be described can be accurately determined.

Volcanos of Olot, in Catalonia.—I shall first direct the reader's attention to a district of extinct volcanos in the north of Spain, which is little known, and which I visited in the summer of 1830.

The whole extent of country occupied by volcanic products in Catalonia is not more than fifteen geographical miles from

north to south, and about six from east to west. The vents of eruption range entirely within a narrow band running north and south, and the branches which we have represented as extending eastward in the map are formed simply of two lava-streams, those of Castell Follit and Cellent.

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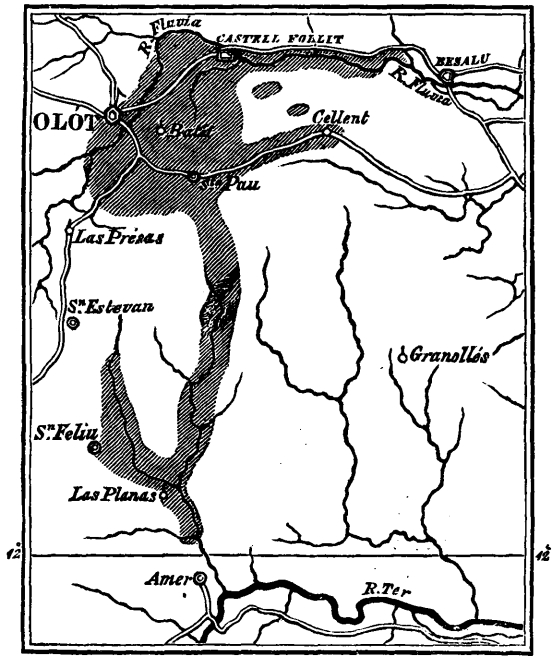

Volcanic district of Catalonia.

Dr. Maclure, the American geologist, was the first who made known the existence of these volcanos * ; and, according to his description, the volcanic region extended over twenty square leagues, from Amer to Massanet. I searched in vain in the environs of Massanet, in the Pyrenees, for traces of a lava-current; and I can say with confidence that the adjoined map gives a correct view of the true area of the volcanic action.

* Maclure, Journ. de Phys., vol. lxvi. p. 219, 1808; cited by Daubeny, Description of Volcanos, p. 24.

Geological structure of the district.—The eruptions have burst entirely through secondary rocks, composed in great part of grey and greenish sandstone and conglomerate, with some thick beds of nummulitic limestone. The conglomerate contains pebbles of quartz, limestone, and Lydian stone. The limestone is not only replete with nummulites, but occasionally includes oysters, pectens, and other shells. This system of rocks is very extensively spread throughout Catalonia, one of its members being a red sandstone, to which the celebrated salt-rock of Cardona is subordinate. It is conjectured that the whole belongs to the age of our green-sand and chalk.

Near Amer, in the Valley of the Ter, on the southern borders of the region delineated in the map, primary rocks are seen consisting of gneiss, mica-schist, and clay-slate. They run in a line nearly parallel to the Pyrenees, and throw off the secondary strata from their flanks, causing them to dip to the north and north-west. This dip, which is towards the Pyrenees, is connected with a distinct axis of elevation, and prevails through the whole area described in the map, the inclination of the beds being sometimes at an angle of between 40 and 50 degrees.

It is evident that the physical geography of the country has undergone no material change since the commencement of the era of the volcanic eruptions, except such as has resulted from the introduction of new hills of scoriæ and currents of lava upon the surface. If the lavas could be remelted and poured out again from their respective craters, they would descend the same valleys in which they are now seen, and reoccupy the spaces which they at present fill. The only difference in the external configuration of the fresh lavas would consist in this, that they would nowhere be intersected by ravines, or exhibit marks of erosion by running water.

Volcanic cones and lavas.—There are about fourteen distinct cones with craters in this part of Spain, besides several points whence lavas may have issued; all of them arranged along a narrow line running north and south, as will be seen in the

map. The greatest number of perfect cones are in the immediate neighbourhood of Olot, some of which are represented in the frontispiece, and the level plain on which that town stands has clearly been produced by the flowing down of many lava-streams from those hills into the bottom of a valley, probably once of considerable depth like those of the surrounding country.

In the frontispiece an attempt is made to represent by colours the different geological formations of which the country is composed. The blue line of mountains in the distance are the Pyrenees, which are to the north of the spectator, and consist of primary and ancient secondary rocks. In front of these are the secondary formations described in this chapter, coloured grey. Different shades of this colour are introduced, to express various distances. The flank of the hill, in the foreground, called Costa de Pujou, is composed partly of secondary rocks and partly of volcanic, the red colour expressing lava and scoriæ.

The Fluvia, which passes near the town of Olot, has only cut to the depth of forty feet through the lavas of the plain before mentioned. The bed of the river is hard basalt, and at the bridge of Santa Madalena, are seen two distinct lava-currents, one above the other, separated by a horizontal bed of scoriæ eight feet thick.

In one place, to the south of Olot, the even surface of the plain is broken by a mound of lava, called the 'Bosque de Tosca,' the upper part of which is scoriaceous, and covered with enormous heaps of fragments of basalt more or less porous. Between the numerous hummocks thus formed, are deep cavities, having the appearance of small craters. The whole precisely resembles some of the modern currents of Etna, or that of Côme, near Clermont, the last of which, like the Bosque de Tosca, supports only a scanty vegetation.

Most of the Catalonian volcanos are as entire as those in the neighbourhood of Naples, or on the flanks of Etna. One of these, figured in the frontispiece, called Montsacopa, is of a

very regular form, and has a circular depression or crater at the summit. It is chiefly made up of red scoriæ, undistinguishable from that of the minor cones of Etna. The neighbouring hills of Olivet and Garrinada, also figured in the frontispiece, are of similar composition and shape. The largest crater of the whole district occurs farther to the east of Olot, and is called Santa Margarita. It is 455 feet deep, and about a mile in circumference. Like Astroni, near Naples, it is richly covered with wood, wherein game of various kinds abound.

Although the volcanos of Catalonia have broken out through sandstone, shale, and limestone, as have those of the Eifel, in Germany, to be described in the sequel, there is a remarkable difference in the nature of the ejections composing the cones in these two regions. In the Eifel, the quantity of pieces of sandstone and shale thrown out from the vents, is often so immense as far to exceed in volume the scoriæ, pumice, and lava; but I sought in vain in the cones near Olot for a single fragment of any extraneous rock, and Don Francisco Bolos informs me that he has never been able to detect any. Volcanic sand and ashes are not confined to the cones, but have been sometimes scattered by the wind over the country, and drifted into narrow valleys, as is seen between Olot and Cellent, where the annexed section is exposed. The light cindery volcanic matter rests in thin regular layers, just as it alighted on the slope formed by the solid conglomerate. No flood could have passed through

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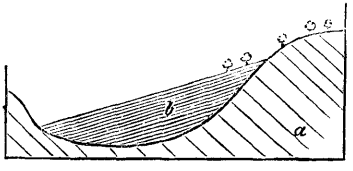

a, Secondary conglomerate. *b*, Thin seams of volcanic sand and scoriæ.

the valley since the scoriæ fell, or these would have been for the most part removed.

The currents of lava in Catalonia, like those of Auvergne, the Vivarais, Iceland, and all mountainous countries, are of considerable depth in narrow defiles, but spread out into com-

paratively thin sheets in places where the valleys widen. If a river has flowed on nearly level ground, as in the great plain near Olot, the water has only excavated a channel of slight depth; but where the declivity is great, the stream has cut a deep section, sometimes by penetrating directly through the central part of a lava-current, but more frequently by passing between the lava and the secondary rock which bounds the valley. Thus, in the accompanying section, at the bridge of Cellent, six miles east of Olot, we see the lava on one side of

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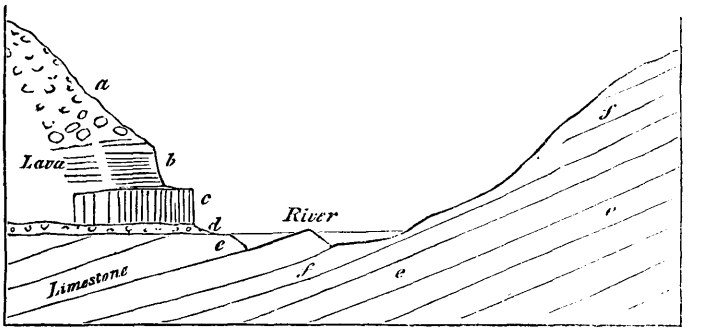


Section above the bridge of Cellent.

a, Scoriaceous lava.
b, Schistose basalt.
c, Columnar basalt.
d, Scoriæ, vegetable soil, and alluvium.
e, Nummulitic limestone.
f, Micaceous grey sandstone.

the small stream, while the inclined stratified rocks constitute the channel and opposite bank. The upper part of the lava at that place is scoriaceous; farther down it becomes less porous, and assumes a spheroidal structure; still lower it divides in horizontal plates, each about two inches in thickness, and is more compact. Lastly, at the bottom is a mass of prismatic basalt about five feet thick. The vertical columns often rest immediately on the subjacent secondary rocks; but there is sometimes an intervention of such sand and scoriæ as cover a country during volcanic eruptions, and which when unprotected, as here, by superincumbent lava, is washed away from the surface of the land. Sometimes the bed *d* contains a few

pebbles and angular fragments of rock; in other places fine earth, which may have constituted an ancient vegetable soil.

In several localities, beds of sand and ashes are interposed between the lava and subjacent stratified rock, as may be seen if we follow the course of the lava-current which descends from Las Planas towards Amer, and stops two miles short of that town. The river there has often cut through the lava, and through eighteen feet of underlying limestone. Occasionally an alluvium, several feet thick, is interposed between the igneous and marine formation; and it is interesting to remark, that in this, as in other beds of pebbles occupying a similar position, there are no rounded fragments of lava, whereas, in the modern gravel beds of rivers in this country, volcanic pebbles are abundant.

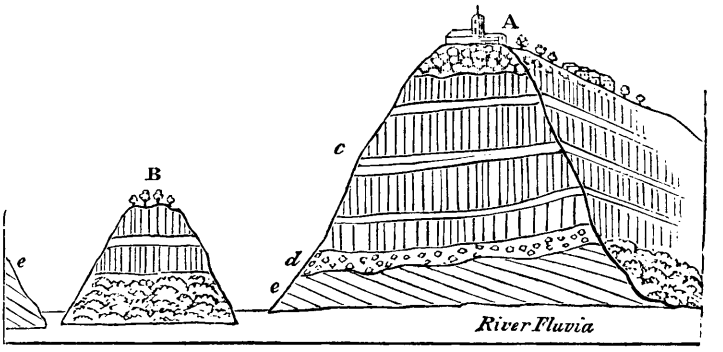
The deepest excavation made by a river through lava, which I observed in this part of Spain, is that seen in the bottom of a valley near San Feliu de Palleróls, opposite the Castell de Stolles. The lava there has filled up the bottom of a valley, and a narrow ravine has been cut through it to the depth of 100 feet. In the lower part the lava has a columnar structure. A great number of ages were probably required for the erosion of so deep a ravine; but we have no reason to infer that this current is of higher antiquity than those of the plain near Olot. The fall of the ground, and consequent velocity of the stream, being in this case greater, a more considerable volume of rock may have been removed in an equal quantity of time.

We shall describe one more section to elucidate the phenomena of this district. A lava-stream, flowing from a ridge of hills to the east of Olot, descends a considerable slope until it reaches the valley of the river Fluvia. Here, for the first time, it comes in contact with running water, which has removed a portion, and laid open its internal structure in a precipice about 130 feet in height, at the edge of which stands the town of Castell Follit.

By the junction of the rivers Fluvia and Teronel the mass of lava has been cut away on two sides; and the insular mass

B (No. 46) has been left, which was probably never so high as the cliff A, as it may have constituted the lower part of the sloping side of the original current.

No. 46.



Section at Castell Follit.

A, Church and town of Castell Follit, overlooking precipices of basalt.

B, Small island, on each side of which branches of the river Teronel flow to meet the Fluvia.

c, Precipice of basaltic lava, chiefly columnar.

d, Ancient alluvium underlying the lava-current.

e, Inclined strata of secondary sandstone.

From an examination of the vertical cliffs, it appears that the upper part of the lava on which the town is built is scoriaceous, passing downwards into a spheroidal basalt; some of the huge spheroids being no less than six feet in diameter. Below this is a more compact basalt with crystals of olivine. There are in all about four distinct ranges of prismatic basalt, separated by thinner beds not columnar, and some of which are schistose. The whole mass rests on alluvium, ten or twelve feet in thickness, composed of pebbles of limestone and quartz, but without any intermixture of igneous rocks; in which circumstance alone it appears to differ from the modern gravel of the Fluvia.

Bufadors.—The volcanic rocks near Olot have often a cavernous structure like some of the lavas of Etna; and in many parts of the hill of Batet, in the environs of the town, the sound returned by the earth, when struck, is like that of an archway. At the base of the same hill are the mouths of

several subterranean caverns, about twelve in number, which are called in the country 'bufadors,' from which a current of cold air issues during summer; but which in winter is said to be scarcely perceptible. I visited one of these bufadors in the beginning of August, 1830, when the heat of the season was unusually intense, and found a cold wind blowing from it, which may easily be explained, for as the external air when rarefied by heat ascends, the cold air from the interior of the mountain rushes in to supply its place.

Age of the Catalonian volcanos uncertain.—It now only remains to offer some remarks on the probable age of these Spanish volcanos. Attempts have been made to prove, that in this country, as well as in Auvergne and the Eifel, the earliest inhabitants were eye-witnesses to the volcanic action. In the year 1421 it is said, when Olot was destroyed by an earthquake, an eruption broke out near Amer, and consumed the town. The researches of Don Francisco Bolos have, I think, shown, in the most satisfactory manner, that there is no good historical foundation for the latter part of this story; and any geologist who has visited Amer must be convinced that there never was any eruption on that spot. It is true that, in the year above-mentioned, the whole of Olot, with the exception of a single house, was cast down by an earthquake; one of those shocks which at distant intervals, during the last five centuries, have shaken the Pyrenees, and particularly the country between Perpignan and Olot, where the movements, at the period alluded to, were most violent.

Some houses are said to have sunk into the earth; and this account has been corroborated by the fact that, within the memory of persons now living, the buried arches of a Benedictine monastery were found at a depth of six feet beneath the surface; and still later, some houses were dug out in the street called Aigua. Don Bolos informed me, that he was present when the latter excavation was made, and when the roof of a buried house, nearly entire, was found six feet beneath the surface, the interior being in a great part empty, so that it was

necessary to fill it up with earth and stones, in order to form a sure foundation for the new edifice.

The annihilation of the ancient Olot may, perhaps, be ascribed, not to the extraordinary violence of the movement on that spot, but to the cavernous nature of the subjacent rocks; for Catalonia is beyond the line of those modern European earthquakes which destroy towns throughout extensive areas.

As we have no historical records, then, to guide us in regard to the extinct volcanos, we must appeal to geological monuments. We have little doubt that some fossil land-shells, and bones of quadrupeds, will hereafter reward the industry of collectors. If such remains are found imbedded in volcanic ejections, the period of the eruptions may be inferred; but at present we have no evidence beyond that afforded by superposition, in regard to which the annexed diagram will present to the reader, in a synoptical form, the results obtained from numerous sections.

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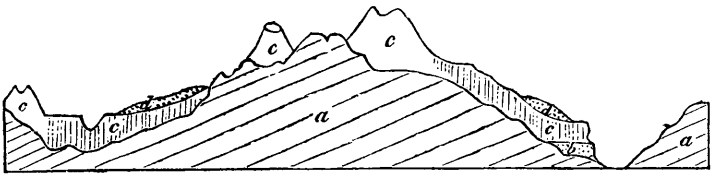

Superposition of rocks in the volcanic district of Catalonia.

a, Sandstone and nummulitic limestone.
b, Older alluvium with volcanic pebbles.
c, Cones of scoriæ and lava.
d, Newer alluvium.

The more modern alluvium *d* is partial, and has been formed by the action of rivers and floods upon the lava; whereas the older gravel, *b*, was strewed over the country before the volcanic eruptions. In neither have any organic remains been discovered, so that we can merely affirm, as yet, that the volcanos broke out after the elevation of some of the newest rocks of the secondary series, and before the formation of an alluvium, *d*, of unknown date. The integrity of the cones merely shows that the country has not been agitated by violent earth-

quakes, nor subjected to the action of any great transient flood since their origin.

East of Olot, on the Catalonian coast, marine tertiary strata occur, which, near Barcelona, attain the height of about 500 feet. It appears probable, from a small number of shells which I collected, that these strata may correspond with the Subapennine beds, so that if the volcanic district had extended thus far, we might be able to determine the age of the igneous products, by observing their relation to these older Pliocene formations *.

Sardinian volcanos.—The line of extinct volcanos in Sardinia, described by Captain Smyth †, is also of uncertain date, as, notwithstanding the freshness of some of the cones and lavas, they may be of high antiquity. They rest, however, on a tertiary formation, supposed by some to correspond to the Subapennine strata, but of which the fossil remains have not been fully described.

VOLCANIC ROCKS OF THE EIFEL.

The volcanos of the Lower Rhine and the Eifel are of no less uncertain date than those of Catalonia; but we are desirous of pointing out some of their peculiar characters, and shall, therefore, treat of them in this chapter, trusting that future investigations will determine their chronological relations more accurately.

For the geographical details of this volcanic region, we refer the reader to the annexed map, for which I am indebted to Mr. Leonard Horner, whose residence in the country has enabled him to verify the maps of MM. Nöeggerath and Von Oyenhausen, from which that now given has been principally compiled.

* For some account of the Olot volcanos see 'Noticia de Los Estinguidos Volcanes de la Villa de Olot,' by Francisco Bolos. Barcelona. No date,—but the observations, I am told, preceded those of Dr. Maclure.

† Present state of Sardinia, &c., pp. 69, 70.

English Miles.
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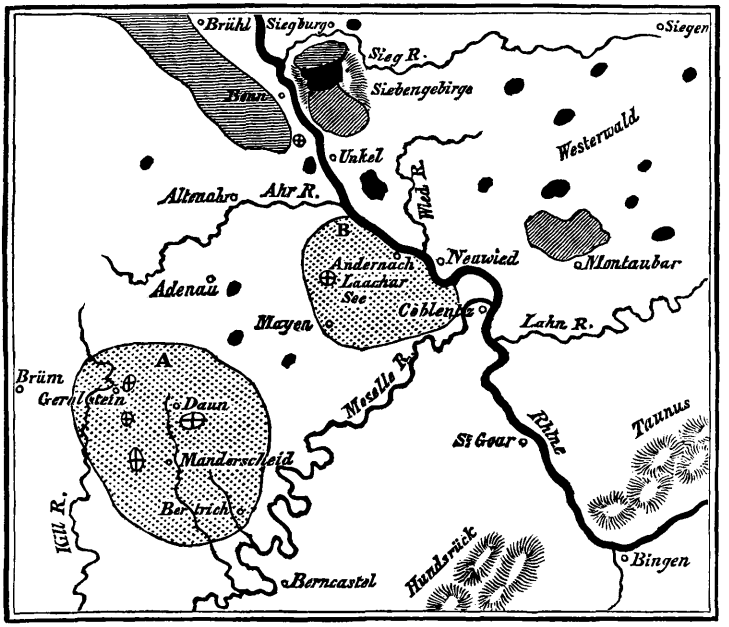

Volcanic District { A, Upper Eifel. B, Lower Eifel.
Trachyte.
Points of eruption, with craters and scoriæ.
Basalt.
Brown coal.

N.B. The country in that part of the map which is left blank is almost entirely composed of graywacke.

There has been a long succession of eruptions in this country, and some of them must have occurred when its physical geography was in a very different state, while others have happened when the whole district had nearly assumed its present configuration.

The fundamental rock of the Eifel is an ancient secondary sandstone and shale, to which the obscure and vague appellation of 'graywacke' has been given. The formation has precisely the characters of a great part of those grey and red sandstones and shales which are called 'old red sandstone' in

England and Scotland, where they constitute the inferior member of the carboniferous series. In the Eifel they occupy the same geological position, and in some parts alternate with a limestone, containing trilobites and other fossils of our mountain and transition limestones. The strata are inclined at all angles from the horizontal to the vertical, and must have undergone reiterated convulsions before the country was moulded into its present form.

Lake-Craters.—The volcanos have broken out sometimes at the bottom of deep valleys, sometimes on the summit of hills, and frequently on intervening platforms. The traveller often falls upon them unexpectedly in a district otherwise extremely barren of geological interest. Thus, for example, he might arrive at the village of Gemunden, immediately south of Daun, without suspecting that he was in the immediate vicinity of some of the most remarkable vents of eruption. Leaving a stream which flows at the bottom of a deep valley in a sandstone country, he climbs the steep acclivity of a hill where he observes the edges of strata of sandstone and shale dipping inwards towards the mountain. When he has ascended to a considerable height he sees fragments of scoriæ sparingly scattered over the surface, till at length on reaching the summit he finds himself suddenly on the edge of a *tarn*, or deep circular lake-basin.

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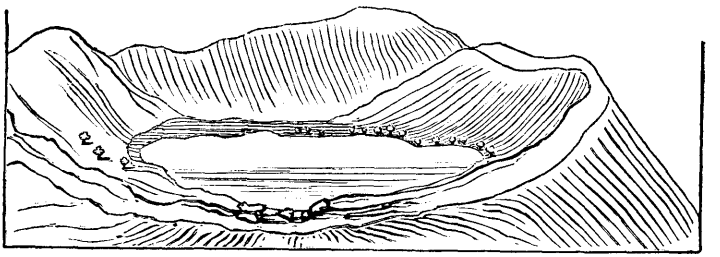

The Gemunden Maar.

This, which is called the Gemunden Maar, is the first of three lakes which are in immediate contact, the same ridge forming the barrier of two neighbouring cavities (see diag. No. 50). On

viewing the first of these we recognize the ordinary form of a crater, for which we have been prepared by the occurrence of

No. 50.

a, Village of Gemunden. *c*, Weinfelder Maar.
b, Gemunden Maar. *d*, Schalkenmehren Maar.

scoriæ scattered over the surface of the soil. But on examining the walls of the crater, we find precipices of sandstone and shale which exhibit no signs of the action of heat, and we look in vain for those beds of lava and scoriæ, dipping in opposite directions on every side, which we have been accustomed to consider as characteristic of volcanic craters. As we proceed, however, to the opposite side of the lake, and afterwards visit the craters *c* and *d*, we find a considerable quantity of scoriæ and some lava, and see the whole surface of the soil sparkling with volcanic sand and ejected fragments of half-fused shale, which preserves its laminated texture in the interior, while it has a vitrified or scoriform coating.

We cannot, therefore, doubt that these great hollows have been formed by gaseous explosions; in other words, that parts of the summits of hills composed of sandstone and shale were blown up during a copious discharge of gas or steam, accompanied by the escape of a small quantity of lava. It is a peculiar feature of the Eifel volcanos that aëriform discharges have been violent, and the quantity of melted matter poured out from the vents proportionably insignificant. In this respect they differ, as a group, from any assemblage of extinct volcanos which I have seen in France, Italy, or Spain.

In some of the Eifel lavas, as in Auvergne and the Vivarais, fragments of granite, gneiss, and clay-slate are found inclosed; pieces of these rocks having probably been torn off by the melted matter and gases as they rose from below.

A few miles to the south of the lakes above-mentioned

occurs the Pulvermaar of Gillenfeld, an oval lake of very regular form, and surrounded by an unbroken ridge of fragmentary materials, consisting of ejected shale and sandstone, and preserving an uniform height of about one hundred and fifty feet above the water. The side slope in the interior is at an angle of about 45°; on the exterior, of 35°. Volcanic substances are intermixed very sparingly with the ejections which in this place entirely conceal from view the stratified rocks of the country *.

The Meerfelder Maar is a cavity of far greater size and depth, hollowed out of similar strata; the sides presenting some abrupt sections of inclined secondary rocks, which in other places are buried under vast heaps of pulverised shale. I could discover no scoriæ amongst the ejected materials, but balls of olivine, and other volcanic substances are mentioned as having been found †. This cavity, which we must suppose to have discharged an immense volume of gas, is nearly a mile in diameter, and is said to be more than one hundred fathoms deep. In the neighbourhood is a mountain called the Moseberg, which consists of red sandstone and shale in its lower parts, but supports on its summit a triple volcanic cone, while a distinct current of lava is seen descending the flanks of the mountain. The edge of the crater of the largest cone reminded me much of the form and characters of that of Vesuvius.

If we pass from the Upper to the Lower Eifel we find the celebrated lake-crater of Laach, which has a greater resemblance than any of those before-mentioned to the Lago di Bolsena, and others in Italy—being surrounded by a ridge of gently sloping hills, composed of loose tuffs, scoriæ, and blocks of a variety of lavas.

Trass and its origin.—It appears that in the Lower Eifel eruptions of trachytic lava preceded the emission of currents of basalt, and that immense quantities of pumice were thrown out wherever trachyte issued. In this district, also, we find

* Scrope, Edin. Journ. of Sci., June 1826, p. 145.

† Hibbert, Extinct Volcanos of the Rhine, p. 24.

the tufaceous alluvium of the Rhine volcanos called *trass*, which has covered large areas, and choked up some valleys now partially re-excavated. This trass is, like the loess, unstratified. The base is composed almost entirely of pumice, in which are included fragments of basalt and other lavas, pieces of burnt shale, slate, and sandstone, and numerous trunks and branches of trees.

If an eruption, attended by a copious evolution of gases, should now happen in one of the lake basins, we might suppose the water to remain for weeks in a state of violent ebullition, until it became of the consistency of mud, just as the sea became charged with red mud round the new island of Sciacca, in the Mediterranean, in the year 1831. If a breach should then be made in the side of the cone, the flood would sweep away great heaps of ejected fragments of shale and sandstone, which would be borne down into the adjoining valleys. Forests would be torn up by such a flood, which would explain the occurrence of the numerous trunks of trees dispersed irregularly through the trass.

Crater of the Roderberg.—One of the most interesting volcanos on the left bank of the Rhine is called the Roderberg. It forms a circular crater nearly a quarter of a mile in diameter, and one hundred feet deep, now covered with fields of corn. The highly inclined graywacke strata rise even to the rim of one side of the crater, but they are overspread by quartzose gravel, and this again is covered by volcanic scoriæ and tufaceous sand. The opposite wall of the crater is a scoriaceous rock, like that at the summit of Vesuvius. It is quite evident that the eruption in this case burst through the graywacke and alluvium which immediately overlies it; and I observed some of the quartz pebbles mixed with scoriæ on the flanks of the mountain, so placed as if they had been cast up into the air, and had fallen again with the volcanic ashes.

On the opposite, or right bank of the Rhine, are the Siebengebirge, a group of mountains wherein analogous phenomena are exhibited. There also trachytic lavas have flowed out and

covered the graywacke; and basaltic currents of a somewhat later date have followed.

There is, however, such a connexion between these rocks that a suite might be procured from the Siebengebirge, showing an insensible gradation from highly crystalline trachyte into compact basalt, with the accompanying passage of the hornblende in the former, into augite in the latter.

Age of the volcanic rocks of the Eifel uncertain.—Besides the ancient inclined graywacke, we have in the immediate vicinity of the valley of the Rhine, a nearly horizontal tertiary formation, called brown coal, from the association with it of beds of lignite worked for coal. The great mass of the igneous rocks are seen to be newer than this formation; and thus we obtain a relative date of much local importance for the volcanos of the whole region. This brown coal consists of beds of sand and sandstone, with nodules of clay-ironstone, and siliceous conglomerate. Beds of lignite of various thickness are interstratified with the clays and sands, and often irregularly diffused through them. This deposit was classed with the plastic clay at a time when every group of tertiary strata was referred to the age of some one of the subdivisions of the Paris basin, but as no shells, either marine, fresh-water, or land have yet been found imbedded, it is not easy to decide the age of the formation. Near Marienforst, in the vicinity of Bonn, large blocks are found on the surface of a white opaque quartz rock, containing numerous casts of fresh-water shells which appear to belong to *Planorbis rotundatus* and *Limnea longiscatus*, two well-known Eocene species*; but this rock is not in situ, and may possibly have been a local deposit in some small lake, fed by a spring holding silica in solution. Yet, as there are beds of the brown coal at Marienforst, and this formation contains in other places subordinate beds of silex, it seems to me most probable that the quartzose blocks alluded to were derived from some member of that tertiary group.

* M. Deshayes, to whom I showed the specimens, said he felt as confident of the above identifications as *mere casts* would warrant.

The other organic remains of the brown coal are principally fishes; they are found in a bituminous shale, called paper-coal, from being divisible into extremely thin leaves. The individuals are extremely numerous, but they appear to belong to about five species, which M. Agassiz informs me are all extinct, and hitherto peculiar to the brown coal. They belong to the fresh-water genera Leuciscus, Aspius, and Perca. The remains of frogs also, of an extinct species, have been discovered in the paper coal, and a perfect series may be seen in the museum at Bonn, from the most imperfect state of the tadpole to that of the full-grown animal. With these a salamander, scarcely distinguishable from the recent species, has been found.

All the distinguishable remains of plants in the lignite and associated beds are said to belong to dicotyledonous trees and shrubs, bearing a close resemblance to those now existing in the country. The same is declared to be the case with the remains found in the trachytic tuffs and in the trass; but the absolute identification of species on which some geologists have insisted must be received with great caution.

As trachytic tuff has been observed at several places interstratified with the clay beds of the brown coal formation, and containing the same impressions of plants, there can be no doubt that the oldest eruptions began when the fresh-water deposits were still in progress, and when the geographical features of the country must have been extremely different from those which it has now assumed.

We have stated that the volcanic ejections of the Roderberg repose upon a bed of gravel. This gravel forms part of an ancient alluvium which is quite distinct in character from that now found in the plains of the valley of the Rhine. It consists chiefly of quartz pebbles, and is found at considerable elevations both on the graywacke and brown coal beds. It forms indeed a general capping to the latter, varying from ten to thirty-five feet in thickness, and was probably an alluvium formed at that period when the ancient lake, in which the

brown coal strata were deposited, was drained; for the disappearance of that great body of fresh water may naturally be supposed to have taken place when the country was undergoing great changes in its physical geography.

Beds and large veins of quartz are found in the Hundsruck, Taunus, and Eifel, the nearest mountain-chains which border this part of the Rhine, and their degradation may have supplied the quartz found in this gravel called *Kiesel gerolle* by the Germans.

It has been supposed by some writers that the *latest* volcanic eruptions of the Eifel and Rhine coincided in epoch with the deposition of the Loess before described (chap. xi.). Such an association, if established, would give a comparatively recent date to the most modern igneous eruptions; but I looked in vain for any clear indications of such a connexion, and all the sections which I saw appeared to indicate the posteriority of the Loess. The integrity of the volcanic cones is, for reasons before explained, a character to which we attach no value.

We have, therefore, in this region, graywacke covered by brown coal, and some volcanic formations so blended with the latter as to prove the igneous eruptions to have been contemporaneous. Yet when we endeavour to assign a chronological position to any one part of the series by reference to organic remains, we discover that the evidence is vague and inconclusive. I have as yet been unable to obtain satisfactory proof that any one species of fossil animal or plant has been found in the brown coal, or superimposed formations which was common to a tertiary group of known date in any other part of Europe; whereas the reader will bear in mind that the relative age of different tertiary formations, of which we have before spoken, was usually determined by reference to a comparison of several hundred, often more than a thousand, species of testacea*.

* A memoir has lately been communicated to the Geological Society of London, by Mr. Horner, on the geology of this district. For fuller details consult Noeggerath's Rheinland Westphalen, and the works of Von Dechen, Oyenhausen, Von Buch, Steininger, Van der Wyck, Scrope, Daubeny, Leonhard, and Hibbert.