CHAPTER XXI.

External physiognomy of Etna—Minor cones produced by lateral eruptions—Successive obliteration of these cones—Early eruptions of Etna—Monti Rossi thrown up in 1669—Great fissure of S. Lio—Towns overflowed by lava—Part of Catania destroyed—Mode of the advance of a current of lava—Excavation of a church under lava—Series of subterranean caverns—Linear direction of cones formed in 1811 and 1819—Flood produced in 1755 by the melting of snow during an eruption—A glacier covered by a lava-stream on Etna—Volcanic eruptions in Iceland—New island thrown up in 1783—Two lava-currents of Skaptár Jokul in the same year—Their immense volume—Eruption of Jorullo in Mexico—Humboldt's Theory respecting the convexity of the Plain of Malpais.

As we have entered into a detailed historical account of the changes in the volcanic district round Naples, our limits will only permit us to allude in a cursory manner to some of the circumstances of principal interest in the history of other volcanic mountains. After Vesuvius, our most authentic records relate to Etna, which rises near the sea in solitary grandeur to the height of nearly eleven thousand feet *, the mass being chiefly composed of volcanic matter ejected above the surface of the water. The base of the cone is almost circular, and eighty-seven English miles in circumference; but if we include the whole district over which its lavas extend, the circuit is probably twice that extent. The cone is divided by Nature into three distinct zones, called the *fertile*, the *woody*, and the *desert* regions. The first of these, comprising the delightful country around the skirts of the mountain, is well cultivated, thickly inhabited, and covered with olives, vines, corn, fruit-trees, and aromatic herbs. Higher up, the woody region encircles the mountain—an extensive forest, six or seven miles in width, affording pasturage for numerous flocks. The trees are of various species, the chestnut, oak, and pine, being most luxuriant; while, in some tracts, are groves of cork

* According to Captain Smyth (Sicily and its Islands, p. 145), its height is 10,874 feet.

and beech. Above the forest is the desert region, a waste of black lava and scoriæ; where, on a kind of plain, rises the cone to the height of about eleven hundred feet, from which sulphureous vapours are continually evolved. The most grand and original feature in the physiognomy of Etna are the multitude of minor cones which are distributed over its flanks, and which are most abundant in the woody region. These, although they appear but trifling irregularities when viewed from a distance as subordinate parts of so imposing and colossal a mountain, would, nevertheless, be deemed hills of considerable altitude in almost any other region.

Without enumerating numerous monticules of ashes thrown out at different points, there are about eighty of these secondary volcanos, of considerable dimensions; fifty-two on the west and north, and twenty-seven on the east side of Etna. One of the largest, called Monte Minardo, near Bronte, is upwards of seven hundred feet in height: and a double hill near Nicolosi called Monti Rossi, formed in 1669, is four hundred and fifty feet high, and the base two miles in circumference; so that it somewhat exceeds in size Monte Nuovo, before described. Yet it ranks only as a cone of the second magnitude amongst those produced by the lateral eruptions of Etna. On looking down from the lower borders of the desert region, these volcanos present us with one of the most beautiful and characteristic scenes in Europe. They afford every variety of height and size, and are arranged in beautiful and picturesque groups. However uniform they may appear when seen from the sea, or the plains below, nothing can be more diversified than their shape when we look from above into their craters, one side of which is generally broken down. There are, indeed, few objects in Nature more picturesque than a wooded volcanic crater. The cones situated in the higher parts of the forest zone are chiefly clothed with lofty pines; while those at a lower elevation are adorned with chestnuts, oak, beech, and holm.

The history of the eruptions of Etna, imperfect and interrupted as it is, affords, nevertheless, a full insight into the manner in which the whole mountain has successively attained its present magnitude and internal structure. The principal cone has more than once fallen in, and been reproduced. In 1444 it was three hundred and twenty feet high, and fell in after the

earthquakes of 1537. In the year 1693, when a violent earthquake shook the whole of Sicily, and killed sixty thousand persons, the cone lost so much of its height, says Boccone, that it could not be seen from several places in Valdemone, whence it was before visible. The greater number of eruptions happen either from the great crater, or from lateral openings in the desert region. When hills are thrown up in the middle zone, and project beyond the general level, they gradually lose their height during subsequent eruptions; for when lava runs down from the upper parts of the mountain, and encounters any of these hills, the stream is divided, and flows round them so as to elevate the gently-sloping grounds from which they rise. In this manner a deduction is often made at once of twenty or thirty feet, or even more, from their height. Thus, one of the minor cones, called Monte Peluso, was diminished in altitude by a great lava-stream which encircled it in 1444; and another current has recently taken the same course—yet this hill still remains four or five hundred feet high. There is a cone called Monte Nucilla, near Nicolosi, round the base of which several successive currents have flowed and showers of ashes fallen since the time of history, till at last, during an eruption in 1536, the surrounding plain was so raised, that the top of the cone alone was left projecting above the general level. Monte Nero, situated above the Grotta dell' Capre, was in 1766 almost submerged by a current; and Monte Capreolo afforded, in the year 1669, a curious example of one of the last stages of obliteration; for a lava-stream descending on a high ridge which had been built up by the continued superposition of successive lavas, flowed directly into the crater, and nearly filled it. The lava, therefore, of each new lateral cone tends to detract from the relative height of lower cones above their base: so that the flanks of Etna, sloping with a gentle inclination, envelop in succession a great multitude of minor volcanos, while new ones spring up from time to time; and this has given to the older parts of the mountain, as seen in some sections two or three thousand feet perpendicular, a complex and highly interesting internal structure.

Etna appears to have been in activity from the earliest times of tradition; for Diodorus Siculus mentions an eruption which caused a district to be deserted by the Sicani before the Trojan

war. Thucydides informs us *, that between the colonization of Sicily by the Greeks, and the commencement of the Peloponnesian war in the year 431 B.C., three eruptions had occurred. The last of these happened in the year 427 B.C., and ravaged the environs of Catania; and was probably that so poetically described by Pindar in his first Pythian ode.

The great eruption which happened in the year 1669 is the first to which we shall call the reader's attention. An earthquake had levelled to the ground all the houses in Nicolosi, a town situated near the lower margin of the woody region, about twenty miles from the summit of Etna, and ten from the sea at Catania. Two gulphs then opened near that town, from whence sand and scoriæ were thrown up in such quantity, that, in the course of three or four months, a double cone was formed, called Monti Rossi, about four hundred and fifty feet

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Minor cones on the flanks of Etna.

1. Monti Rossi, near Nicolosi, formed in 1669. 2. Vampeluso? †

high. But the most extraordinary phenomenon occurred at the commencement of the convulsion in the neighbouring plain of S. Lio. A fissure six feet broad, and of unknown depth, opened with a loud crash, and ran, in a somewhat tortuous course, to within a mile of the summit of Etna. Its direction was from north to south, and its length twelve miles. It

* Book III., towards the end.

† The hill which I have here introduced was called by my guide Vampolara, but the name given in the text is the nearest to this which I find in Gemmellaro's Catalogue of Minor Cones.

emitted a most vivid light. Five other parallel fissures of considerable length afterwards opened one after the other, and emitted smoke, and gave out bellowing sounds which were heard at the distance of forty miles. This case seems to present the geologist with an illustration of the manner in which those continuous dikes of vertical porphyry were formed which are seen to traverse some of the older lavas of Etna; for the light emitted from the great rent of S. Lio appears to indicate that it was filled to a certain height with incandescent lava, probably to the height of an orifice not far distant from Monti Rossi, which at that time opened and poured out a lava-current. This lava soon reached a minor cone called Mompiliere, at the base of which it entered a subterranean grotto communicating with a suite of caverns which are common in the lavas of Etna. Here it appears to have melted down some of the vaulted foundations of the hill, so that the whole cone became slightly depressed and traversed by numerous open fissures. The lava, after overflowing fourteen towns and villages, some having a population of between three and four thousand inhabitants, arrived at length at the walls of Catania. These had been purposely raised to protect the city; but the burning flood accumulated till it rose to the top of the rampart, which was sixty feet in height, and then it fell in a fiery cascade and overwhelmed part of the city. The wall, however, was not thrown down, but was discovered long afterwards by excavations made in the rock by the Prince of Biscari; so that the traveller may now see the solid lava curling over the top of the rampart as if still in the very act of falling.

This great current had performed a course of fifteen miles before it entered the sea, where it was still six hundred yards broad and forty feet deep. It covered some territories in the environs of Catania, which had never before been visited by the lavas of Etna. While moving on, its surface was in general a mass of solid rock; and its mode of advancing, as is usual with lava-streams, was by the occasional fissuring of the solid walls. A gentleman of Catania, named Pappalardo, desiring to secure the city from the approach of the threatening torrent, went out with a party of fifty men whom he had dressed in skins to protect them from the heat, and armed with iron crows and hooks. They broke

open one of the solid walls which flanked the current near Belpasso, and immediately forth issued a rivulet of melted matter which took the direction of Paternò; but the inhabitants of that town, being alarmed for their safety, took up arms and put a stop to farther operations*. As another illustration of the solidity of the walls of an advancing lava-stream, we may mention an adventure related by Recupero, who, in 1766, had ascended a small hill formed of ancient volcanic matter, to behold the slow and gradual approach of a fiery current, two miles and a half broad; when suddenly two small threads of liquid matter issuing from a crevice detached themselves from the main stream, and ran rapidly towards the hill. He and his guide had just time to escape, when they saw the hill, which was fifty feet in height, surrounded, and in a quarter of an hour melted down into the burning mass, so as to flow on with it. But it must not be supposed that this complete fusion of rocky matter coming in contact with lava is of universal, or even common occurrence. It probably happens when fresh portions of incandescent matter come successively in contact with fusible materials. In many of the dikes which intersect the tuffs and lavas of Etna, there is scarcely any perceptible alteration effected by heat on the edges of the horizontal beds, in contact with the vertical and more crystalline mass. On the site of Mompiliere, one of the towns overflowed in the great eruption above described, an excavation was made in 1704; and by immense labour the workmen reached, at the depth of thirty-five feet, the gate of the principal church, where there were three statues, held in high veneration. One of these, together with a bell, some money, and other articles, were extracted in a good state of preservation from beneath a great arch formed by the lava. It seems very extraordinary that any works of art, not encased with tuff, like those in Herculaneum, should have escaped fusion in hollow spaces left open in this lava-current, which was so hot at Catania eight years after it entered the town, that it was impossible to hold the hand in some of the crevices.

We mentioned the entrance of the lava-stream into a subterranean grotto, whereby the foundations of a hill were par-

* Ferrara, Descriz. dell' Etna, p. 108.

tially undermined. Such underground passages are among the most curious features on Etna, and appear to have been produced by the hardening of the lava, during the escape of great volumes of elastic fluids, which are often discharged for many days in succession, after the crisis of the eruption is over. Near Nicolosi, not far from Monti Rossi, one of these great openings may be seen, called the Fossa della Palomba, 625 feet in circumference at its mouth, and 78 deep. After reaching the bottom of this, we enter another dark cavity, and then others in succession, sometimes descending precipices by means of ladders. At length the vaults terminate in a great gallery ninety feet long, and from fifteen to fifty broad, beyond which there is still a passage, never yet explored; so that the extent of these caverns remains unknown*. The walls and roofs of these great vaults are composed of rough and bristling scoriæ, of the most fantastic forms.

We shall now proceed to offer some observations on the two last eruptions in 1811 and 1819. It appears, from the relation of Signor Gemmellaro, who witnessed the phenomena, that the great crater in 1811 testified, by its violent detonations, that the lava had ascended to near the summit of the mountain, by its central duct. A violent shock was then felt, and a stream broke out from the side of the cone, at no great distance from its apex. Shortly after this had ceased to flow, a second stream burst forth at another opening, considerably below the first; then a third still lower, and so on till seven different issues had been thus successively formed, all lying upon the same straight line. It has been supposed that this line was a perpendicular rent in the internal framework of the mountain, which rent was probably not produced at one shock, but prolonged successively downwards, by the lateral pressure and intense heat of the internal column of lava, as it subsided by gradual discharge through each vent†.

In 1819 three large mouths or caverns opened very near those which were formed in the eruptions of 1811, from which flames, red hot cinders, and sand, were thrown up with loud explosions. A few minutes afterwards another mouth opened below, from which flames and smoke issued;

* Ferrara, Descriz. dell' Etna. Palermo, 1818. † Scrope on Volcanos, p. 153.

and finally a fifth, lower still, whence a torrent of lava flowed which spread itself with great velocity over the valley 'del Bove.' This stream flowed two miles in the first twenty-four hours, and nearly as far in the succeeding day and night. The three original mouths at length united into one large crater, and sent forth lava, as did the four inferior apertures, so that an enormous torrent poured down the great valley 'del Bove.' When it arrived at a vast and almost perpendicular precipice, at the head of the valley of Calanna, it poured over in a cascade, and, being hardened in its descent, made an inconceivable crash as it was dashed against the bottom. So immense was the column of dust raised by the abrasion of the tufaceous hill over which the hardened mass descended, that the Catanians were in great alarm, supposing a new eruption to have burst out in the woody region, exceeding in violence that near the summit of Etna.

Of the cones thrown up during this eruption, not more than two are of sufficient magnitude to be numbered among those eighty which we before reckoned as adorning the flanks of Etna. The surface of the lava which deluged the valley 'del Bove' consists of rocky and *angular* blocks, tossed together in the utmost disorder. Nothing can be more rugged, or more unlike the smooth and even superficies which those who are unacquainted with volcanic countries may have pictured to themselves, in a mass of matter which had consolidated from a liquid state. Mr. Scrope observed this current in the year 1819, slowly progressing down a considerable slope, at the rate of about a yard an hour, nine months after its first emission. The lower stratum being arrested by the resistance of the ground, the upper or central part gradually protruded itself, and being unsupported fell down. This in its turn was covered by a mass of more liquid lava, which swelled over it from above. The current had all the appearance of a huge heap of rough and large cinders rolling over and over upon itself by the effect of an extremely slow propulsion from behind. The contraction of the crust as it solidified, and the friction of the scoriform cakes against one another, produced a crackling sound. Within the crevices a dull red heat might be seen by night, and vapour issuing in considerable quantity was visible by day *.

* Scrope, on Volcanos, p. 102.

The erosive and transporting power of running water is rarely exerted on Etna with great force, the rain which falls being immediately imbibed by the porous lavas ; so that, vast as is the extent of the mountain, it feeds only a few small rivulets, and these, even, are dry throughout the greater portion of the year. The enormous rounded boulders, therefore, of trachyte and basalt, a line of which can be traced from the sea, from near Giardini, by Mascali, and Zafarana, to the valley 'del Bove,' would offer a perplexing problem to the geologist, if history had not preserved the memorials of a tremendous flood which happened in this district in the year 1755. It appears that two streams of lava flowed in that year, on the 2nd of March, from the highest crater: they were immediately precipitated upon an enormous mass of snow, which then covered the whole mountain, and was extremely deep near the summit. The sudden melting of this frozen mass, by a fiery torrent three miles in length, produced a frightful inundation, which devastated the sides of the mountain for eight miles in length, and afterwards covered the lower flanks of Etna, where they were less steep, together with the plains near the sea, with great deposits of sand, scoriæ, and blocks of lava. Many absurd stories circulated in Sicily respecting this event, such as that the water was boiling, and that it was vomited from the highest crater; that it was as salt as the sea, and full of marine shells; but these were mere inventions, to which Recupero, although he relates them as tales of the mountaineers, seems to have attached rather too much importance. Floods of considerable violence have been sometimes produced on Etna, by the fall of heavy rains, aided, probably, by the melting of snow. By this cause alone, in 1761, sixty of the inhabitants of Acicatena were killed, and many of their houses swept away*.

A remarkable discovery has lately been made on Etna of a great mass of ice, preserved for many years, perhaps for centuries from melting, by the singular event of a current of red hot lava having flowed over it. The following are the facts in attestation of a phenomenon which must at first sight appear of so paradoxical a character. The extraordinary heat experienced in the South of Europe, during the summer

* Ferrara, Descriz. dell' Etna, p. 116.

and autumn of 1828, caused the supplies of snow and ice which had been preserved in the spring of that year for the use of Catania and the adjoining parts of Sicily and the island of Malta, to fail entirely. Considerable distress was felt for the want of a commodity regarded in these countries as one of the necessaries of life rather than an article of luxury, and on the abundance of which in some large cities the salubrity of the water and the general health of the community is said in some degree to depend. The magistrates of Catania applied to Signor M. Gemmellaro, in the hope that his local knowledge of Etna might enable him to point out some crevice or natural grotto on the mountain, where drift snow was still preserved. Nor were they disappointed; for he had long suspected that a small mass of perennial ice at the foot of the highest cone was part of a larger and continuous glacier covered by a lava-current. Having procured a large body of workmen, he quarried into this ice, and proved the superposition of the lava for several hundred yards, so as completely to satisfy himself that nothing but the subsequent flowing of the lava over the ice could account for the position of the glacier. Unfortunately for the geologist, the ice was so extremely hard, and the excavation so expensive, that there is no probability of the operations being renewed. On the first of December, 1828, I visited this spot, which is on the south-east side of the cone, and not far above the Casa Inglese, but the fresh snow had already nearly filled up the new opening, so that it had only the appearance of the mouth of a grotto. I do not, however, question the accuracy of the conclusion of Signor Gemmellaro, who being well acquainted with all the appearances of drift snow in the fissures and cavities of Etna, had recognized, even before the late excavations, the peculiarity of the position of the ice in this locality. We may suppose, that, at the commencement of the eruption, a deep mass of drift snow had been covered by volcanic sand showered down upon it before the descent of the lava. A dense stratum of this fine dust mixed with scoriæ is well known to be an excellent non-conductor of heat, and may thus have preserved the snow from complete fusion when the burning flood poured over it. The shepherds in the higher regions of Etna are accustomed to provide an annual store of snow to supply their flocks with water in

the summer months, by simply strewing over the snow in the spring a layer of volcanic sand a few inches thick, which effectually prevents the sun from penetrating. When lava had once consolidated over a glacier at the height of ten thousand feet above the level of the sea, we may readily conceive that the ice would endure as long as the snows of Mont Blanc, unless melted by volcanic heat from below. When I visited the great crater in the beginning of winter, (December 1st, 1828,) I found the crevices in the interior encrusted with thick ice, and in some cases hot vapours were streaming out between masses of ice and the rugged and steep walls of the crater. After the discovery of Signor Gemmellaro, it would not be surprising to find, in the cones of the Icelandic volcanos, repeated alternations of lava streams and glaciers.

Volcanic Eruptions in Iceland.—With the exception of Etna and Vesuvius, the most complete chronological records of a series of eruptions are those of Iceland: for their history reaches as far back as the ninth century of our era; and, from the beginning of the twelfth century, there is clear evidence that, during the whole period, there has never been an interval of more than forty, and very rarely one of twenty years, without either an eruption or a great earthquake. So intense is the energy of the volcanic action in this region, that some eruptions of Hecla have lasted six years without ceasing. Earthquakes have often shaken the whole island at once, causing great changes in the interior, such as the sinking down of hills, the rending of mountains, the desertion by rivers of their channels, and the appearance of new lakes *. New islands have often been thrown up near the coast, some of which still exist, while others have disappeared either by subsidences or the action of the waves.

In the interval between eruptions, innumerable hot springs afford vent to subterranean heat, and solfataras discharge copious streams of inflammable matter. The volcanos in different parts of this island are observed, like those of the Phlegræan Fields, to be in activity by turns, one vent often serving for a time as a safety-valve to the rest. Many cones

* Hoff, vol. ii., p. 393.

are often thrown up in one eruption, and in this case they take a linear direction, running generally from north-east to south-west, from the north-eastern part of the island where the volcano Krabla lies, to the promontory Reykianas.

The convulsions of the year 1783 appear to have been more tremendous than any recorded in the modern annals of Iceland; and the original Danish narrative of the catastrophe, drawn up in great detail, has since been substantiated by several English travellers, particularly in regard to the prodigious extent of country laid waste, and the volume of lava produced *. About a month previous to the eruption on the main land, a submarine volcano burst forth in the sea at the distance of thirty or forty miles in a south-west direction from Cape Reykianas, and ejected so much pumice, that the ocean was covered to the distance of one hundred and fifty miles, and ships were considerably impeded in their course. A new island was thrown up, consisting of high cliffs, within which, fire, smoke, and pumice were emitted from two or three different points. This island was claimed by his Danish Majesty, who denominated it Nyöe, or the new island; but, ere a year had elapsed, the sea resumed her ancient domain, and nothing was left but a rocky reef from five to thirty fathoms under water. Earthquakes, which had long been felt in Iceland, became violent on the 11th of June, when Skaptár Jokul, distant nearly two hundred miles from Nyöe, threw out a torrent of lava which flowed down into the river Skaptâ, and completely dried it up. The channel of the river was between high rocks, in many places from four hundred to six hundred feet in depth, and near two hundred in breadth. Not only did the lava fill up these great defiles to the brink, but it overflowed the adjacent fields to a considerable extent. The burning flood, on issuing from the confined rocky gorge, was then arrested for some

* The first narrative of the eruption was drawn up by Stephensen, then Chief Justice in Iceland, appointed Commissioner by the King of Denmark, for estimating the damage done to the country, that relief might be afforded to the sufferers. Henderson was enabled to correct some of the measurements given by Stephensen, of the depth, width, and length, of the lava currents, by reference to the MS. of Mr. Paulson, who visited the tract in 1794, and examined the lava with attention. (Journal of a Residence in Iceland, &c., p. 229.) Some of the principal facts are also corroborated by Dr. Hooker in his "Tour in Iceland," vol. ii., p. 128.

time by a deep lake, which formerly existed in the course of the river between Skaptardal and Aa, which it entirely filled. The current then proceeded again, and reaching some ancient lava full of subterraneous caverns, penetrated and melted down part of it; and in some places where the steam could not gain vent, it blew up the rock, throwing fragments to the height of more than one hundred and fifty feet. On the 18th of June, another ejection of liquid lava rushed from the volcano, which flowed down with amazing velocity over the surface of the first stream. By the damming up of the mouths of some of the tributaries of the Skaptâ, many villages were completely overflowed with water, and thus great destruction of property was caused. The lava, after flowing for several days, was precipitated down a tremendous cataract called Stapafoss, where it filled a profound abyss, which that great waterfall had been hollowing out for ages, and then the fiery current continued its course.

On the 3rd of August, fresh floods of lava still pouring from the volcano, a new branch was sent off in a different direction; for the channel of the Skaptâ was now so entirely choked up, and every opening to the west and north so obstructed, that the melted matter was forced to take a new course, and, running in a south-east direction, it discharged itself into the bed of the river Hverfisfliot, where a scene of destruction scarcely inferior to the former was occasioned. These Icelandic lavas, like the ancient streams which are met with in Auvergne, and other provinces of Central France, are stated by Stephensen to have accumulated to a prodigious depth in narrow rocky gorges, but when they came to wide alluvial plains, they spread themselves out into broad lakes of fire, sometimes from twelve to fifteen miles wide, and one hundred feet deep. When the "fiery lake" which filled up the lower portion of the valley of the Skaptâ had been augmented by new supplies, the lava flowed up the course of the river to the foot of the hills, from whence the Skaptâ takes its rise. This affords a parallel case to one which can be shewn to have happened at a remote era in the volcanic region of the Vivarais in France, when lava issued from the cone of Thueyts, and while one branch ran down, another more powerful stream flowed up the river Ardêche. The sides of the valley of the Skaptâ present superb ranges of basaltic

columns of older lavas, resembling those which are laid open in the valleys descending from Mont Dor in Auvergne, where more modern lava-currents, on a scale very inferior in magnitude to those of Iceland, have also usurped the beds of the existing rivers. The eruption of Skaptár Jokul did not entirely cease till the end of two years; and when Mr. Paulson visited the tract eleven years afterwards, in 1794, he found columns of smoke still rising from parts of the lava, and several rents filled with hot water*.

Although the population of Iceland did not exceed fifty thousand, no less than twenty villages were destroyed, besides those inundated by water, and an immense number of cattle, and more than nine thousand human beings perished, partly by the depredations of the lava, partly by the noxious vapours which impregnated the air, and, in part, by the famine caused by showers of ashes throughout the island, and the desertion of the coasts by the fish.

We must now call the reader's particular attention to the extraordinary volume of melted matter produced in this eruption. Of the two branches, which flowed in nearly opposite directions, the greatest was fifty, and the lesser forty miles in length. The extreme breadth which the Skaptâ branch attained in the low countries was from twelve to fifteen miles, that of the other about seven. The ordinary height of both currents was one hundred feet, but in narrow defiles it sometimes amounted to six hundred feet. A more correct idea will be formed of the dimensions of the two streams, if we consider how striking a feature they would now form in the geology of England, had they been poured out on the bottom of the sea after the deposition, and before the elevation of our secondary and tertiary rocks. The same causes which have excavated valleys through parts of our marine strata, once continuous, might have acted with equal force on the igneous rocks, leaving, at the same time, a sufficient portion undestroyed, to enable us to discover their former extent. Let us then imagine the termination of the Skaptâ branch of lava to rest on the escarpment of the inferior and middle oolite, where it commands the vale of Gloucester. The great plateau might be one hundred feet

* Henderson's Journal, &c., p. 228.

thick, and from ten to fifteen miles broad, exceeding any which can be found in Central France. We may also suppose great tabular masses to occur at intervals, capping the summit of the Cotswold Hills between Gloucester and Oxford, by Northleach, Burford, and other towns. The wide valley of the Oxford clay would then occasion an interruption for many miles; but the same rocks might recur on the summit of Cumnor and Shotover Hills, and all the other oolitic eminences of that district. On the chalk of Berkshire, extensive plateaus, six or seven miles wide, would again be formed; and lastly, crowning the highest sands of Highgate and Hampstead, we might behold some remnants of the deepest parts of the current five or six hundred feet in thickness, rivalling or even surpassing in height Salisbury Craigs and Arthur's Seat.

The distance between the extreme points here indicated, would not exceed ninety miles in a direct line; and we might then add, at the distance of nearly two hundred miles from London, along the coast of Dorsetshire and Devonshire for example, a great mass of igneous rocks, to represent those of contemporary origin, which were produced beneath the level of the sea, where the island of Nyöe rose up. Yet, gigantic as must appear the scale of these modern volcanic operations, they are perfectly insignificant in comparison to currents of the primeval ages, if we embrace the theoretical views of some geologists of great celebrity. We are informed by Professor Brongniart, in his last work, that "aux époques géognostiques anciennes, tous les phénomènes géologiques se passoient dans des dimensions *centuples* de celles qu'ils présentent aujourd'hui*." Had Skaptár Jokul therefore been a volcano of the olden time, it would have poured forth lavas at a single eruption, a hundred times more voluminous than those which have been witnessed by the present generation. If we multiply the current before described, by a hundred, and first assume that its height and breadth remain the same, it would stretch out to the length of nine thousand miles, or about half as far again as from the pole to the equator. If, on the other hand, we suppose its length and breadth to remain the same, and multiply its height in an equal proportion, its ordinary elevation becomes

* Tableau des Terrains qui composent l'écorce du Globe, p. 52. Paris, 1829.

ten thousand feet, and its greatest more than double that of the Himalaya mountains. Amongst the ancient strata, no igneous rock of such colossal magnitude has yet been met with, nay it would be most difficult to point out a mass of igneous origin of ancient date distinctly referrible to a single eruption, which would rival in volume the matter poured out from Skaptár Jokul in 1783. It is, however, a received principle in geological reasoning, not only in France, but in England and other countries, that we ought always to assume that the energies of natural forces have been impaired and enfeebled, until the contrary can be shewn; and as we have hitherto investigated but a small part of the globe, evidence may hereafter be brought to light of the superior violence of single volcanic eruptions in remote ages. If the proofs be deficient at present in favour of the general decline of the agents of decay and renovation, we must be content with the argument of the geologist in one of Voltaire's novels, *Monsieur, on en découvrira!* *

Eruption of Jorullo in 1759.—As another example of the stupendous scale of modern volcanic eruptions, we may mention that of Jorullo in Mexico in 1759. We have already described the great region to which this mountain belongs. The plain of Malpais forms part of an elevated plateau, between two and three thousand feet above the level of the sea, and is bounded by hills composed of basalt, trachyte, and volcanic tuff, clearly indicating that the country had previously, though probably at a remote period, been the theatre of igneous action. From the era of the discovery of the New World to the middle of the last century, the district had remained undisturbed, and the space, now the site of the volcano, which is thirty-six leagues distant from the nearest sea, was occupied by fertile fields of sugar-cane and indigo, and watered by the two brooks Cuitimba and San Pedro. In the month of June, 1759, hollow sounds of an alarming nature were heard, and earthquakes succeeded each other for two months, until, in September, flames issued from the ground, and fragments of burning rocks were thrown to prodigious heights. Six volcanic cones, composed of scoriæ and fragmentary lava, were

* L'Homme aux quarante écus.

formed on the line of a chasm which ran in the direction from N.N.E. to S.S.W. The least of these cones was three hundred feet in height, and Jorullo, the central volcano, was elevated one thousand six hundred feet above the level of the plain. It sent forth great streams of basaltic lava, containing included fragments of primitive rocks, and its ejections did not cease till the month of February, 1760. Humboldt visited the country twenty years after the occurrence, and was informed by the Indians, that when they returned long after the catastrophe to the plain, they found the ground uninhabitable from the excessive heat. When the Prussian traveller himself visited the locality, there appeared, round the base of the cones, and spreading from them as from a centre over an extent of four square miles, a mass of matter five hundred and fifty feet in height in a convex form, gradually sloping in all directions towards the plain. This mass was still in a heated state, the temperature in the fissures being sufficient to light a cigar at the depth of a few inches. On this convex protuberance were thousands of flattish conical mounds, from six to nine feet high, which, as well as large fissures traversing the plain, acted as fumeroles, giving out clouds of sulphuric acid and hot aqueous vapour. The two small rivers before mentioned disappeared during the eruption, losing themselves below the eastern extremity of the plain, and reappearing as hot springs at its western limit. Humboldt attributed the convexity of the plain to inflation from below, supposing the ground, for four square miles in extent, to have risen up in the shape of a bladder, to the elevation of five hundred and fifty feet above the plain in the highest part. But this theory, which is entirely unsupported by analogy, is by no means borne out by the facts described; and it is the more necessary to scrutinize closely the proofs relied on, because the opinion of Humboldt appears to have been received as if founded on direct observation, and has been made the groundwork of other bold and extraordinary theories. Mr. Scrope has suggested that the phenomena may be accounted for far more naturally, by supposing that lava flowing simultaneously from the different orifices, and principally from Jorullo, united into a sort of pool or lake. As they were poured forth on a surface previously flat, they would, if their liquidity was not very great,

remain thickest and deepest near their source, and diminish in bulk from thence towards the limits of the space which they covered. Fresh supplies were probably emitted successively during the course of an eruption which lasted a year, and some of these resting on those first emitted, might only spread to a small distance from the foot of the cone, where they would necessarily accumulate to a great height.

The showers, also, of loose and pulverulent matter from the six craters, and principally from Jorullo, would be composed of heavier and more bulky particles near the cones, and would raise the ground at their base, where, mixing with rain, they might have given rise to the stratum of black clay which is described as covering the lava. The small conical mounds (called "hornitos" or ovens) may resemble those five or six small hillocks which existed in 1823, on the Vesuvian lava, and sent forth columns of vapour, having been produced by the disengagement of elastic fluids heaving up small dome-shaped masses of lava. The fissures mentioned by Humboldt as of frequent occurrence, are such as might naturally accompany the consolidation of a thick bed of lava, contracting as it congeals; and the disappearance of rivers is the usual result of the occupation of the lower part of a valley or plain by lava, of which there are many beautiful examples in the old lava-currents of Auvergne. The heat of the "hornitos" is stated to have diminished from the first, and Mr. Bullock, who visited the spot many years after Humboldt, found the temperature of the hot spring very low, a fact which seems clearly to indicate the gradual congelation of a subjacent bed of lava, which from its immense thickness may have been enabled to retain its heat for half a century.

Another argument adduced in support of the theory of inflation from below was the hollow sound made by the steps of a horse upon the plain, which, however, proves nothing more than that the materials of which the convex mass is composed are light and porous. The sound called "rimbombo" by the Italians is very commonly returned by *made ground* when struck sharply, and has been observed not only on the sides of Vesuvius and other volcanic cones where there is a cavity below, but in plains such as the Campagna di Roma, composed in great measure of tuff and porous volcanic rocks. The reverberation, however, may, perhaps, be assisted by

grottos and caverns, for these may be as numerous in the lavas of Jorullo, as in many of those of Etna; but their existence would lend no countenance to the hypothesis of a great arched cavity, or bubble, four square miles in extent, and in the centre five hundred and fifty feet high *. A subsequent eruption of Jorullo happened in 1819, accompanied by an earthquake; but unfortunately no European travellers have since visited the spot, and the only facts hitherto known are that ashes fell at the city of Guanaxuato, which is distant about one hundred and forty English miles from Jorullo, in such quantities as to lie six inches deep in the streets, and the tower of the cathedral of Guadalaxara was thrown down †.

* See Scrope on Volcanos, p. 267.

† For this information I am indebted to Captain Vetch, F.R.S.