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TRAVELS
IN THE
TWO SICILIES,
AND
SOME PARTS OF THE APENNINES.

Translated from the Original Italian of the

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Padua, &c. &c.

IN FOUR VOLUMES.—WITH ELEVEN PLATES.

V O L. III.

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TRAVELS
IN THE
TWO SICILIES, &c.

CHAP. XVI.

LIPARI.

PART THE SECOND.

OBSERVATIONS MADE IN THE INTERIOR
PARTS OF LIPARI, AND SEVERAL OF
ITS MOUNTAINS.

*Extremely irregular appearance of this
island—No characterised crater discover-
able in it—Conjecture that the Monte San
Angelo, and the Monte della Guardia, the*

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B

highest

highest mountains in Lipari, were produced by two distinct volcanos—Efflorescences of muriate of ammoniac (sal ammoniac) in two caverns near the plain called La Valle—Curious volcanic breccia—The volcanic tufa which, on one side, covers the whole mountain of the celebrated Stoves (or vapour baths) of Lipari, has every appearance of having been an earthy current; and is remarkable for containing true ligneous coal—Conjectural enquiries into the origin of this—The road that leads from the town to the stoves formed, in a great measure, of tufa corroded by the rain-water—Various bodies observable within this corroded tufa—Detached pieces of enamel, which include many small bulbous bodies that appear to be garnets—Comparison between these and the garnets of Vesuvius—Enamel of the Liparese garnets, which has for its base the horn-stone—Detached lavas in the road leading to the stoves—Volcanic chrysolites in a lava with a horn-stone base—These chrysolites compared with those of

Etina—Large pieces of red porphyry which do not seem to have suffered fusion—None of these bodies disposed in currents; whence it is probable that they have been thrown into the air by some volcano—A spacious plain of tufa rendered cultivable, situated beyond the Monte della Stufe, which affords numerous pieces of the finest and purest glass found in Lipari—Local origin of this glass—Bed of pumices on the extensive current of tufa before mentioned—Stoves of Lipari described—Remains of conflagrations of sulphur under them, and in their environs—Prodigious number of lavas decomposed by the action of sulphureous acid vapours—Oxyde of pure iron deposited on some of these lavas—Variety of colours which they present to the eye—Their decomposition usually in the inverse proportion of the depth of their masses—When freed from the decomposition which renders it difficult to ascertain their nature, they are usually found of a petrosiliceous base—This decomposition an obstacle to their fusion in the furnace—

Explication of the cause of this change—Sulphates of lime, variously coloured, and adhering to the decomposed lavas—Iron, oxydated, and modified in various manners, the cause of the different colours of the decomposed lavas, and sulphates of lime—Discovery of several amorphous and crystallised zeolites near the stoves—Jelly which they form with mineral acids—Emit bright flashes when on the point of melting, and swell considerably on their actual fusion—Terms of comparison between these zeolites and those of other countries—Their production not by the dry but the humid way—Though the zeolites of several volcanized countries are probably formed within the sea, this does not seem to be the origin of those of Lipari—Instances of zeolites produced in fresh water—Springs of hot water which supply the baths of Lipari—Another prodigious accumulation of decomposed lavas, and sulphures of lime, on the southern side of the island—Perhaps there is no volcanized country in Europe where the sulphureous fumes
issuing

issuing from subterranean conflagrations are so extensive as at Lipari—Vitrifications of Campo Bianco, and the Monte della Castagna, which are found attached to those of the Monte delle Stufe, the Monte San Angelo, and other places—Proofs that almost two-thirds of Lipari, which island is nineteen miles and a half in circumference, are composed of vitrifications—The materials of which this island is composed, principally derived from the petrosilex, felspars in the mass, and horn-stones, in part simply fused by subterraneous combustions, and in a still greater part vitrified—Notwithstanding the immense accumulations of this vitrification, an extraordinary intensity of heat not necessary to be supposed—An exception in the pumices originating from granite—Few notices left us by ancient authors relative to the fires of Lipari; though we know from indubitable authorities, that both the island and the city existed before the Trojan war—No eruption in this island described by History.—Feeble fires, visible by night, alone ob-

served in ancient times—This island, the produce of subterranean conflagration, had arrived at its greatest dimensions, before it was noticed by any writer.

TO acquire a just knowledge of the interior part of a mountainous vulcanized country, the best method, as it appears to me, is first to ascend the highest mountain, and, after having examined the summit, to turn the eye downward, and observe the chain of smaller mountains that surround it. We may thus, at one glance, discover the form of these inferior mountains, their interchangeable connection, and the relations which they bear to each other, and to the primary mountain, with other important objects, which, had we first ascended one of the lower eminences, we should not have been able to ascertain with equal precision and clearness.

After, therefore, having made researches, with the greatest diligence, around the shore of Lipari, when I proceeded, according to
my

my original intention, to explore, likewise, the internal parts of the island ; I, first, ascended to the summit of the Monte San Angelo, situated to the north of the city of Lipari ; this being the highest mountain in the island. Here the whole of the island presented itself, at once, to my view, and I could perceive that, far from having a conical figure, such as is that of Stromboli, and in a certain manner of Vulcano, it is composed of groups of broken and half-destroyed mountains, confusedly heaped together ; which give it a most irregular appearance. It is evident that the volcanic fires have raged in many places, and that, from their too great proximity to each other, they have not been able to form those distinct cones which are so observable in Vesuvius and on Etna. But the matters ejected by the superior volcanos, pouring upon those which issued from the lower, have produced in every part confusion and disorder. From the summit of Etna we may discover a multitude of subjacent craters, well characterised ; but from

that of San Angelo I could not perceive one. There are, indeed, many openings and hollows to be seen, which once, perhaps, were fiery mouths; but none of these cavities have at present the figure of an inverted tunnel, possibly because they have been in part filled up and destroyed by subsequent eruptions, or by time.

M. Dolomieu observed at the summit of this mountain a circular plain, surrounded by eminences shelving towards the inside, which he imagined might be the remains of an ancient crater. This conjecture, after a careful examination of the spot, does not appear to me improbable. The same naturalist likewise supposes that this mountain, the height of which is nearly a mile above the sea, was the first that was formed in the island, through which the volcano burst forth, and which served as a base and support for the other mountains that were thrown up afterwards. This opinion is extremely plausible; but the fact may likewise be, in my opinion, that this mountain,

at

at the time of its production, or very soon afterwards, had for its companion the Monte della Guardia, which looks towards the south, and of which I have before spoken ; both because the latter is separated from the former, and because it is little inferior to it in height. From the ideas suggested by a view of the places themselves, I conceive it not improbable that these two mountains, which rise so much higher than the rest, have been produced by two distinct volcanos, and were the first that emerged from the sea, forming then two small islands, which afterwards, enlarging their base, united into one ; for it is well known that other volcanic islands originally consisted of several parts, which afterwards were joined. To these two mountains subsequent eruptions made new additions, until at length the whole of the island of Lipari was produced, which, from the erosion of the rains and the sea, is now certainly less than it once was.

From Monte San Angelo, I passed to the
Monte

Monte della Guardia, which on the side towards the sea presents only steep and rugged precipices of lava, and, consequently, is deprived of all vegetation and verdure ; but on the land side, which is opposite in one part to the city, it is formed with gentle declivities, and covered with vineyards ; for, as its soil is tufaceous, it less resists cultivation than any other volcanic product. While standing on the summit I was still more confirmed in the opinion, that this mountain is not an accessory to, or prolongation of, that of San Angelo ; but that it forms a whole of itself, and may be called primary equally with the other, from the distance between them, and the wide valley, running from east to west, by which they are separated.

Having visited these two mountains, which are the loftiest in the island, I proceeded next to examine the lesser eminences, and found additional confirmation of what I have already observed ; I mean, that these eminences have entirely lost the
true

true form of volcanic craters, so much have the matters ejected from them intersected each other, and confusedly intermixed. The long and unknown series of years that has elapsed since these eruptions, must, no doubt, have contributed to increase the confusion. Excepting, therefore, some few flat places, and practicable declivities, which the inhabitants have rendered cultivable by great labour, Lipari is a ruinous pile of horrid precipices, rugged cliffs, and enormous masses; and there is no summit, or projecting part of a mountain, which does not exhibit manifest indications of its future fall and destruction. The materials of which these ruins are formed are pumices, enamels, and glasses, which I shall not describe, because they are partly the same, and partly extremely analogous to those of which I have already given the description.

Some of the natives, by the accounts they gave me, excited my curiosity to visit a cavern situated in a small plain called La Valle, about a quarter of a mile to the west
of

of the city. This cavern has its mouth in a rock of decomposed lava, and a man may walk into it to the distance of fifty paces. Its sides are covered with efflorescences of muriate of ammoniac, as were, likewise, those of another smaller cavern in the same rock. This salt must have been formed by sublimation, having been reduced to vapour by subterraneous fires, and thus attached itself to the sides of these two caverns, as it is found attached in many other volcanic places ; but of these fires and ammoniacal vapours no traces whatever now exist.

In this short excursion I found by the way a volcanic breccia, which, on account of the heterogeneous substances it contained, it would be improper to pass without notice. It is found in large isolated pieces, but I was unable to discover from what vein it derived its origin. Its principal substance is an earthy lava, of a blueish grey, a coarse grain, and little hardness. In this were inclosed the following bodies :

First,

First, fragments of two kinds of lava; the one black, of a scaly fracture, and which moved the magnetic needle at the distance of two lines: the other of a grey ground, a very rough surface, an unequal fracture, which gave sparks with steel, and contained small plates of felspar. Both were of the horn-stone base, and emitted a strong argillaceous odour.

Secondly, several pieces of vitreous lava, of a very beautiful colour, between a green and a blue: by its smoothness, clear fracture, its aspect, and want of hardness, it resembles the pitch-stone, or pitch-blende.

Thirdly, numerous small pieces of a cinereous compact pumice.

Fourthly, pieces of a whitish semi-transparent glass.

Fifthly, small pieces of a colourless glass, resembling in transparency factitious glass. The largest piece was fourteen lines in length,

length, and eight in breadth, and was, like the others, buried in the breccia.

These five species of volcanic productions were certainly not natural to the substance of the lava; for their fractures and angles are very visible, and by carefully breaking the lava they may be extracted entire. We must therefore conclude that they were absorbed and inclosed in the lava when it was in motion, and thus were consolidated into one body.

In making these observations a doubt suggested itself. Though to the naked eye, and likewise to the touch, the vitreous lava appears perfectly smooth, yet, when viewed with a lens of a strong magnifying power, its surface appeared full of very minute fissures. At least, if this was not observable in all, it was in several pieces of both these kinds of glass. I therefore conjectured, that when these substances were in an ignited state, a current of water might have passed over them; or that they suddenly came in
contact

contact with the cold air ; unless we rather choose to suppose that these fissures were produced, when these vitreous bodies, in a frigid state, were suddenly enveloped in the fiery torrent.

But the celebrated Stoves of Lipari appear to be the object which most excites the curiosity of travellers ; I could not, therefore, omit to visit them. I must, however, confess, that the road which led to them afforded me more instructive objects than the stoves themselves.

These stoves lie to the west of the city, at the distance of four miles, and somewhat beyond the summit of a mountain, which, after those of San Angelo and della Guardia, is one of the highest in the island. The road I went was that which leads immediately from the city to the stoves, and the only one which can be travelled without great difficulty. It is in a great degree the work of rain waters, which have made a deep excavation in an immense mass of tufa.

tufa. In more than one place, in this work ; I have spoken of volcanic tufas, but almost always incidentally. The present species of this substance requires to be treated of somewhat more at length.

At the beginning of this work, when speaking of the volcanic tufas of Posilipo, I said, and endeavoured to prove, that it was probable they were formed by slimy eruptions ; though I would not deny that ashes, sand, and other subtile matters ejected by volcanos, and penetrated either by the rain-waters or those of the sea when they covered the bases of the burning mountains, have been consolidated into some tufas*. The tufa of Lipari, of which I now speak, has every appearance of having been an earthy current. It begins at about a hundred paces from the city, and continues, without interruption, to beyond the summit of the Monte della Stufe, or Mountain of the Stoves. This mountain, like most of the others, varies considerably in its dif-

* See Chap. II.

ferent parts, in one place presenting gentle declivities, and in another steep and rugged descents ; here plains nearly level, and there precipices almost perpendicular. The tufa with which it is covered, takes exactly the same course ; and sometimes curves, and, as it were, waves on the surface : nor does it in the least differ in its sinuosities and windings, from the most completely characterised currents of lava, which it likewise resembles by being disposed in beds lying one over the other, as appears in those places which have been most corroded by the rain. I therefore was of opinion, that this tufa had been a stream, if I may use the expression, of slimy substances, that had flowed down the mountain ; as examples are not wanting of similar eruptions, produced in the humid way, in the mountains Vesuvius, Etna, and Hecla.

But here a difficulty presented itself in opposition to this hypothesis. Had this part of the mountain been inundated by a torrent of water issuing from the earth,

when its violence had ceased, the more heavy bodies must have subsided to the bottom in obedience to the law of gravity, the less heavy have remained above them, and the lightest have occupied the highest place; which, however, is not the fact, since, as we shall see, at a small depth within the tufa, are found large masses of lavas, enamels, and glasses. But it does not appear to me improbable that these masses may have been thrown out from some burning mouth, after the hardening of the tufa, within which they have not penetrated deep.

Not only the position and winding course of this tufa over the back and sides of the mountain sufficiently prove that it once flowed: its very nature is a strong confirmation of this fact. It is not an aggregation of ashes and sand; a mixture of fragments of shoerls, felspars, and lavas decomposed, and rendered earthy, and fastened together by the action of the water, becoming so hard as to be cut into pieces proper

per for building, as is the case with many other tufas ; but it is merely an argillaceous earth, resembling, from its softness, the hardened mud of rivers. Its colour is a dull grey, its structure somewhat granular, and so yielding that it may be crumbled and pulverized between the fingers. It is light, adheres slightly to the inside of the lip, emits a feeble argillaceous odour, and, when immersed in water, greedily imbibes it in every part.

In the furnace it first acquired a reddish brown colour, and afterwards the black colour of iron. It became so hard that it gave sparks with steel, without, however, vitrifying, except that its surface assumed a kind of vitreous varnish.

The depth of this tufa is different in different parts of the mountain. In some places it is several feet deep, in others but a few, and in others there is so great a quantity of it that, notwithstanding the excavations made in it by the rains, I was unable

to ascertain its depth. But in every place where I could discover the bottom, I observed that it rested on a bed of pumices, partly pulverized, and partly in detached pieces approaching to the globose form. They belong to the class of the lightest of these substances. It appears, therefore, indubitable that these pumices had been thrown out of the burning mouth of some volcano, before the flowing of the tufaceous current.

This tufa presented a very unexpected phenomenon. On breaking it, its fractures exhibited small black particles, which were distinctly recognized to be true coal, from their blackness, lightness, dryness, the facility with which they broke, and their small degree of hardness. Some of them, likewise, when exposed to fire in the open air, fumed, and became red hot; others emitted a little flame. The latter had not been perfectly reduced to coal, as the fibrous parts of the wood were still to be seen. These coals were small cylinders from two
or

or three lines in length to twelve or fourteen, and of proportional thickness. They appeared to have appertained to branches of trees or shrubs; they are buried in the tufa at various depths, and are found, though thinly scattered, through its whole extent.

This fact, never before, to my knowledge, observed by others in volcanic tufas, might induce us to imagine that the two methods, the humid and the dry, had here been combined; and that the watery slime, when it flowed down the mountain, had been penetrated by the fire in such a manner that it had inflamed, and converted into coal, the vegetables it met with in its way. This explanation is certainly not free from difficulties, as the reader, no doubt, already perceives; it therefore may appear more probable that the earthy inundation had involved, and carried with itself, these carbonaceous substances, which existed previous to its eruption, and which derived their origin from a shower of ignited matter having burned, but not entirely consumed,

the few plants which feebly vegetated on the declivities of the mountain.

It has been already said, that the rapid descent of the rain-waters on that part of the mountain which leads to the faves, has corroded the tufa to a great depth; and it is in the middle of these corrosions that we meet with various volcanic bodies, which, together with others lying in the public road, merit well to be described.

First, we find pieces of enamel of every size, which, though they are smooth without, when broken, have, within, an angular fracture. Their colour is a pale blue, they have no great brilliancy, nor are they very hard, as they fly in pieces when struck against the steel. The cause of the want of hardness in this enamel, may be ascribed to the fissures, of which it is full; and these, perhaps, are to be attributed to the pieces of enamel being red-hot when they fell into the tufa not yet dry. The felspars it contains have the same cracks, and probably from the same cause.

In

In the same places is found another kind of enamel containing a great number of small bodies, which I will not absolutely affirm to be garnets, because I was not able to analyze them in the humid way; but their external characters, together with the proofs furnished by the dry way, almost induce me to conclude them such. In all my volcanic researches I have never met with any similar. In general they have a bulbous figure, and are of a blackish colour, which in some inclines to a red. Their surface is smooth and shining, their recent fractures lamellar, perfectly vitreous, and will cut glass. The largest are about three lines and a half in thickness, and are opaque; the smallest, about the third part of a line, and are semi-transparent. They give sparks with steel, and melt in the furnace into a black and scoriaceous enamel. These characters, taken together, certainly give them a great resemblance to garnets: I shall not therefore hesitate to class them with that species of stone; as their not being crystallized is of little importance, since we know that there are also amorphous garnets.

While employed in the examination of these stones, I resolved to compare them with the Vesuvian garnets ; for, in my excursion to that volcano, I had collected several different species of them on Monte Somma, which is the ancient Vesuvius. I made several experiments on four of these, of which the following is the result.

The first species is found in a lava with a horn-stone base, of a yellowish grey colour, an unequal surface, and of a consistence little different from earthy, from the great alteration it has undergone ; not, as far as appears, from sulphureous exhalations, but from the action of the atmosphere. The garnets it contains have likewise suffered injury, having lost a part of their native lustre, and being easily broken or crumbled to pieces from the multitude of minute fissures and cracks in them. They, however, retain somewhat of the vitreous character. Their colour is between a white and a grey. At first view their figure appears perfectly globular ; but on extracting them from the stone, their matrix, (which may easily be done.)

done,) and attentively examining them, they are found to have facets, though it is not possible to ascertain the number of them, as many of the angles have been defaced by time. I shall only observe, that having broken one of these garnets into two equal parts, the perimeter of each half was octagonal. This fracture at the same time shewed the texture of the garnet, which is composed of very thin circular leaves. These garnets are of different sizes, from four lines and a half to one sixth of a line.

The furnace reduces the matrix-lava to a compact enamel of the colour of pitch; but it leaves the garnets untouched, which only become somewhat whiter, more vitreous, and more hard. The blackness of the enamel being a contrast to the whiteness of the garnets, a great number of the latter become conspicuous, which before were not visible in the lava; and, notwithstanding their extreme minuteness, they remain uninjured by the fire.

The

The garnets of the second species are contained in a lava which has for its base a soft horn-stone. They are larger than the former, and entirely opaque. They are white as snow, and more brilliant in their fractures than the preceding. Many of them are of a round figure, and manifestly shew a crystallization in various facets ; which, however, it is impossible to number, as they break in pieces if we attempt to extract them from the lava. Many others of them are of very irregular forms.

Several of this second species of garnets inclose within them small prismatic shoerls, of the colour and lustre of asphaltum, which probably pre-existed completely formed, and were taken into the moisture from which the garnet derived its origin.

These garnets are, likewise, infusible in the furnace, though the lava is converted into a porous scoria.

The third kind is strongly infixed in a
heavy

heavy lava, which also has for its base the horn-stone, is of an iron-black, compact, but not sufficiently hard to give sparks with steel. The garnets, which are of a yellowish white colour, and some of them four lines in diameter, for the most part have clefts or fissures, but in such a manner that in the recent fractures the surface resembles a round polypetalous flower.

The furnace melted the lava, but not the garnets, which only acquired the red colour of copper.

The garnets of the fourth and last species have four-and-twenty facets, and are semi-transparent, white, and vitreous. Their matrix is a compact lava of a horn-stone base, which emits an argillaceous odour. In the furnace it changes into a black enamellar product, but the garnets remain untouched.

On comparing these results with others before detailed, we shall find that the structure

ture of the Vesuvian garnets, so far as it is vitreous and lamellar, is similar to that of those of Lipari ; but that, when exposed to the fire, a difference is found between these two stones, the one easily melting in the furnace, and the other proving refractory.

Finding, therefore, that these four species of garnets were infusible in the furnace, though continued in it for several days, I had recourse to oxygenous gas (or dephlogisticated air), by the action of which they all melted, though slowly. When the matrix lava flowed like common glass, the small pieces of garnet within it remained unchanged ; but at length fused, though without incorporating with the lava, so as to form a homogeneous whole.

Those chemists and naturalists, who, before me, have made experiments with fire on the Vesuvian garnets, have described results similar to those I observed. Bergmann says these garnets melt with the blow-pipe alone, but a vehement fire is necessary,

fary *. Sauffure tells us, that a spotted lava (*lave à oeil de perdrix*) which he found on Monte Somma, acquired, after fusion, a black vitrified ground, but that the polyhedrous grains of this lava remained unchanged in the most violent fire; and by polyhedrous grains it is evident that he means what I and others have called garnets †. With respect to the action of oxygenous gas upon them, we may refer to Ehrmann, in his work on the Air of Fire. “The white opaque garnet of “Vesuvius,” says this writer, “differs from “garnets properly so called, in this, that it “melts with extreme difficulty (with the “assistance of oxygenous gas is here to be “understood), and at length, after continual “ebullition, becomes a mass perfectly similar to quartz, even in its fracture, and “which crackles in like manner between “the teeth.”

This kind of ebullition I have observed in the four varieties of garnets above men-

* De Productis Vulcanicis.

† Voyage dans les Alpes, Tom. I.

tioned,

tioned, when they were in a state of fusion. The first and third, likewise, produced two small masses resembling quartz, but those of the second and fourth variety were spongy. It is very possible that this author only made his experiments on one species.

Some learned naturalists are of opinion that the garnets of Vesuvius are improperly so denominated; first, because they contain no iron; secondly, because they fuse with difficulty; and, thirdly, because they differ in the proportionate qualities of their constituent parts from those of true garnets. These reasons, however, do not appear to me sufficient to exclude them from being classed with this kind of stones. It is true, that iron is usually contained in garnets; but it is not essential to them; as has been observed by Bergmann, who, in transparent garnets, found only $\frac{4}{100}$ parts of this metal. The absence of iron, probably, therefore, renders them so difficult to fuse. With respect to their constituent parts, the Swedish chemist (Bergmann) has observed, that the
principal

principal of these is filex, the next alumine, and that which is least of all in quantity, lime. This analysis agrees with that made by Achard on some of the purest Bohemian garnets; and such a proportion of the constituent principles is sufficiently suitable to that of the garnets of Vesuvius, in which Bergmann found about 55 parts of filex, 39 of alumine, and 6 of lime. And though the proportion of the filex to the alumine is not entirely the same in both these stones, the difference is not so great, in my opinion, as to induce us to consider them as two distinct species; as will appear by comparing the numbers 55 and 39, which express the quantities of filex and alumine in the Vesuvian garnets, with the numbers 48 and 30, denoting those of the same two earths, in the Bohemian garnets, analyzed by the before-cited chemist of Berlin (Achard).

To return for a moment to the garnets of Lipari: these do not so tenaciously adhere to their base as we almost always find the felspars and shoerls; but, like other garnets, are

implanted in it in such a manner that they may be easily detached without breaking, leaving the exact impresson of their figure in the enamel. This enamel, which is compact, heavy, and of a grey cinereous colour, is found in detached pieces, both in the road and in the tufa; and is the first production which presents itself, after leaving the city to proceed towards the stoves.

Continuing our journey still further along this road, we find in it, and likewise within the tufa, very curious mixtures of a white argillaceous earth, and black enamel; both of which are so mingled and kneaded together, that we can scarcely find a quantity of this earth of the size of a pea, which does not contain several particles of this enamel; and very few, indeed, are the pieces of enamel that contain none of this earth. It has an earthy odour, and adheres to the tongue.

In the same situations where this peculiar mixture is found, we likewise meet with an enamel containing garnets, similar to those
above

above-mentioned, but larger, and more approaching to a globular figure. It is remarkable that this enamel, in some places, forms one whole with some pieces of lava of a horn-stone base, which also contains garnets.

I shall briefly distinguish four species of lava, each of a horn-stone base, which are met with, in detached pieces, on the road to the Stoves.

The first has a fibrous fracture, the colour of iron, some appearance of porosity, sufficient hardness to give sparks with steel, and the power to move the magnetic needle at the distance of a line and a quarter. It emits an earthy odour, and contains felspars.

The second is of a black-grey colour, and, though compact, rather soft. Almost one half of it consists of rhomboidal felspars.

The third only differs from the second by being somewhat more compact, harder, and containing fewer felspars.

The fourth, which in solidity, weight, and hardness, exceeds the three preceding, has a black ferrugineous colour, an earthy fracture, adheres slightly to the tongue, and emits the usual argillaceous odour. It moves the magnetic needle at the distance of half a line.

All these four kinds of lavas are changed, in the furnace, into vitreous scorixæ, but without the fusion of their felspars.

Having mentioned these, it will be necessary to describe, somewhat more at length, another species of lava, which is enriched with a great number of extremely beautiful volcanic chrysolites.

This lava has for its base a soft horn-stone: it is of a dark brown colour, and unequal in its fractures on account of the fissures

which separate its parts. It is found in detached pieces, like the four preceding lavas, but these pieces are rare. It gives but few sparks with steel, emits a slight argillaceous odour, and acts on the magnetic needle at the distance of a full line. In consequence of its numerous fissures it is rather light, and when struck with a hammer is somewhat sonorous. I omit to mention some small scales of felspar incorporated in it, and proceed to the examination of the chrysolites.

These, when situated in the external parts of the lava, which have suffered by the influence of the atmosphere and elements, readily attract the eye, by their lively colour, which is between a green and a yellow; but in the recent fractures they shine with much more brilliant colours. The most conspicuous are the golden-yellow, and the fine grass-green, with which, sometimes, is mixed a fire-red, tempered with a tinge of purple. If these chrysolites are exposed to the immediate light of the sun, and viewed

under certain angles, their colours become much more lively and bright. Many of them are amorphous, but some are quadrangular prisms. Their surface, in the fractures, shines with a glassy brilliancy, and is sometimes smooth, and sometimes rough, according as the plates of which the chrysolites are composed may have been broken. The small fragments of them are angular and semi-transparent. These chrysolites give sparks with steel, and cut glass nearly like rock-crystal. The largest are not less than three lines and a half in length, but the smallest can scarcely be discerned by the naked eye. They are so firmly infixed in the lava, that only fragments of them can be detached.

The fire of the furnace, and that of the blow-pipe, not only will not fuse these minute stones, but are unable to injure them either in their colours or texture. Oxygenous gas (dephlogisticated air) alone discolours them, and melts them into a globule, of a white colour, but without brilliancy.

Though

Though it was not known till the present time that Lipari afforded volcanic chrysolites, they had been before found in other volcanized countries, as in Vivarais and Velay, by M. Faujas, and on Mount Etna by M. Dolomieu. But on comparing their chrysolites with mine, I find certain differences and resemblances, which it will be proper to enumerate.

The chrysolites observed and described by M. Faujas, when examined with the lens, are found to be composed of an aggregate of arenaceous grains, more or less fine, and more or less adherent; scabrous, irregular, and sometimes forming crusts and small sandy scales; but, for the most part, having the appearance of angular fragments united by insertion into each other.

The chrysolites of Lipari have nothing of this nature in their structure. I broke several of them, and examined their fragments with the microscope; but they never appeared to me granular, but always smooth

and glassy. The most minute parts of these chrysolites exhibited the same aspect they presented when whole.

I must not omit to mention another difference of importance, which is, that the chrysolites of Lipari are only a few lines in length, whereas those described by M. Faujas are sometimes several pounds in weight.

They agree, however, with mine in their infusibility in an extremely active fire; for those on which he made his experiments resisted the fire of common furnaces, however violent and continued it might be, and could not be reduced to a state of fusion but by the aid of oxygenous gas.

The colours of both are sometimes the same. I say sometimes, for M. Faujas informs us, that several of his chrysolites were only of one colour; a green, or topaz-yellow.

The traits of resemblance and difference
between

between the Liparese and Etnean chrysolites will be seen by comparing the description I have given of the former with what M. Dolomieu says of the latter, in the work I have frequently cited. He tells us, that some of the chrysolites he found there are amorphous, others crystallized in tetragonal or hexagonal prisms, sometimes with an hexagonal pyramid; that their fracture is partly conchoidal, and partly lamellar; that they are harder than quartz; that they are more or less transparent; that their colour is a greenish yellow, with various tinges, and that they are fusible in a strong fire. He does not give their size, but they cannot be large; both because he calls them *grains*, and because those which I observed in some lavas of Etna were very minute.

I have designedly called the chrysolites of Lipari, *volcanic* chrysolites, not merely because they are found within a lava, but to preserve a distinction between them and the gem of that name; since I know that some respectable authors are of opinion, that the

volcanic stones which, from their greenish yellow colour, and other circumstances, resemble that gem, and therefore are called chrysolites by the Volcanists, differ from them entirely in their component parts, and several of their external characters. To this opinion I can make no objection, though, in describing these stones, I have adopted the name by which they are usually known. It must be observed, however, that some of their properties shew they cannot be classed as shoerls, among which some naturalists generally place the chrysolites of volcanos.

It remains likewise to speak of a stone which was the last of the products that offered themselves to my observation, as I proceeded along the declivity of the mountain leading to the Stoves.

This stone is a porphyry, the base of which is the petrosilex, containing felspars with several faces, and brilliant in the fractures, and blackish irregular shoerls. The
base

base has the red colour of brick. It is found in detached masses, some of which weigh several thousand pounds. It is compact, and scaly in the fractures. The pieces broken from it are irregular; the thinnest are transparent at the edges; and they give sparks moderately with steel. The colour of the base has given the felspars a reddish tinge, as we see in certain oriental porphyries.

But has this porphyry suffered fusion, or is it in its natural state, and, at most, calcined when it was ejected by the volcano? I cannot pretend positively to decide; but I incline to the latter opinion more than to the former, since an alteration is visible, even in the internal parts, which appears to be the effect of a true calcination.

In the furnace, the substance of this rock becomes soft, but does not fuse: the felspars remain unchanged, but the shoerls are vitrified.

The

The spacious and deep excavations made in the tufa by the rain-water, and which extend from the bottom of the mountain to the summit, afforded me an opportunity to discover and examine the stony substances I have described ; for it was only in those excavations that they were visible : in every other part nothing appeared but the naked superficial crust of the tufa. None of these substances are disposed in currents ; they are all detached ; and thus render it probable that they fell into the tufa after having been thrown up into the air in volcanic ejections.

When we have reached the summit of the mountain, an ample plain opens, formed of the same tufa, but become earthy, in which corn is sown, and a few vineyards are planted. Here we find numerous pieces of a shining glass, which is semi-transparent, of a blackish colour, and some of the finest and purest to be found in Lipari. As I wished to discover the origin of this substance, I caused the place where it is
found

found to be dug into. The tufaceous earth is there about three or four feet deep. The pumices lie immediately under it, and among them this glafs is found, in confiderable quantities. It has probably been turned up, and brought to the furface, by the plough, or other fimilar inftruments ufed to prepare the earth for fowing with corn.

Beyond this plain there is a gentle defcent of about two hundred feet in length, at the end of which are the Stoves. Whatever prepossession in their favour the traveller may have conceived from hearing fo much of them, he lofes it the moment he fees them. They form a group of four or five caves, more like to the dens of bears than the habitations of men; and which exhibit much lefs of art than the edifices framed by the beaver. Every cave has an opening at the bottom, through which the warm and humid vapours enter, and another in the top through which they pafs out. I entered one of thefe, but was unable to remain long in it, lefs from the heat, for
the

the thermometer stood at only $48\frac{2}{3}$ degrees, than from I know not what of a suffocating nature which the air had in it. These Stoves now retain little more than their name, and are nearly deserted. In fact, though they still retained their virtue, and were efficacious in the cure of various disorders, how would it be possible to make use of them, when they are destitute of every convenience necessary to that purpose?

When M. Dolomieu visited them, the whole ground on which they stand was penetrated with hot vapours, which, under the form of a thick smoke, issued from small apertures of about an inch, or two inches, in diameter. When I was there, circumstances were much changed, as usually happens in volcanos, where the presence of fire manifests itself sometimes more and sometimes less. There was then only one aperture, of about an inch in diameter, from which, from time to time, issued a thin stream of smoke, with a strong sulphureous
 4 smell,

smell. Having enlarged this aperture, I found it surrounded by a small quantity of soft sulphures of iron (pyrites) generated by the union of iron and sulphur. The Abbate Trovatini, whom I have cited in another place, likewise attests, that, at certain times, several streams of smoke ascended round the Stoves; and I shall add, that, besides the strong smell of sulphur, which I perceived on approaching the place, the ground became hot, and the feter increased, on digging to about the depth of a foot: from which it may be concluded, that under the Stoves and the ground adjacent, some remains of sulphureous conflagration still continue*. The Stoves, and the warm
baths,

* It has been shewn, in Chap. XIII, that the decompositions of different products of Stromboli and Vulcano do not derive their origin from the muriatic acid, to which, according to M. Sage, the principal alterations of volcanic substances are to be ascribed, but to sulphureous-acid exhalations. The decompositions in the environs of the Stoves of Lipari, I am of opinion, with M. Dolomieu, are to be attributed to the same cause, the existence of which is sufficiently proved by the re-
mains

baths, of which we shall speak below, are the only places in the whole island where any signs are to be found of as yet unextinguished volcanos.

M. Dolomieu, after having described the Stoves of Lipari, proceeds to speak of the alterations caused by the sulphureous-acid vapours on the lavas of this place, remarking that all of them, besides having become softer and lighter, have lost their primitive colour, and assumed a white tinge, mixed with yellow, red, violet, and other colours, which the oxides of iron usually produce. He observes likewise, that they are coated with a thick crust of sulphates of lime (sele-nite or gypsum), which sulphates penetrate likewise to the internal parts, and that some lavas are covered with that kind of iron ore which is called slimy (*fangosa*) or bog ore. He then very ingeniously explains in what manner, by means of a combination of the mains of sulphureous fumes, and the quantity of sulphates of lime, which I shall presently have occasion to describe.

fulphuric

fulphuric acid with different earths, the lavas have become lighter and variously coloured.

As I visited the Stoves three several times, and examined with great attention the lavas that had suffered alteration by the action of the sulphureous acid, I am enabled to add, to the observations already given, some others which I believe to be new, and which I shall here briefly state.

It was an object equally important and curious to ascertain to what kinds of lavas still remaining in the state in which they were left by the fire, those belong which we now see decomposed by acids; and as the observations I had made at Solfatara di Pozzuolo and other places, had taught me that the decomposition diminishes, the deeper it enters into the substance, I conceived that the most proper means to obtain this knowledge would be, to break fragments of the lava, and examine the internal parts, to find how far the decomposition had penetrated.

The

The greater part of the decomposed lavas of the Monte delle Stufe are, externally, of a reddish white; and some are of a blackish colour. I first examined the latter; and presenting their surface to the full light of the sun, I discovered something of a brilliant appearance which invited me to examine it with the lens. It proved an aggregate of innumerable globules of hæmatitic iron, which beautifully cover the surface of these lavas.

I detached a considerable number of these globules, and found that on trituration they assumed a red colour, which is the property of the dark hæmatites. This was, therefore, a pure martial oxide, deposited here, and formed into globules; and under that aggregate lay another oxide of red, but earthy iron. The lava still deeper was of a white colour, intersected with parallel streaks of a reddish black, or lightly shaded with a yellowish tinge.

These lavas are soft, light, and compact :
they

they adhere to the tongue, have the consistence of clay, but do not emit its odour. They seem to be simple lavas, no extraneous bodies appearing in them. It is observable that every fracture is conchoidal; and that, when struck, they cause a sound similar to that of some kinds of petrosilex; which has induced me to suspect they belong to that species of stone: a suspicion which is confirmed by examining deeper within the fractures; since at the depth of two feet, or thereabouts, a grey colour takes place of the white, and the other external appearances diminish; the lavas begin to assume a siliaceous aspect, and give a few sparks with steel. Still deeper we perceive without the least doubt that these lavas have a petrosiliceous base, and contain a few shorls, which do not appear in the decomposed parts, probably because they are themselves decomposed.

These observations, which were made on some lavas of a black colour on the surface, are likewise true of several others, which, externally, are of a reddish white. The ap-

pearances in them are, essentially, the same. The red colour in the internal parts insensibly vanishes ; the grey by degrees succeeds the white, which, still deeper, acquires a lustre, the lava at the same time becoming harder, and at length distinctly exhibiting all the characters of the petrosilex.

One of these lavas, streaked with white and a clear red like that of the peach-flower, is spotted on the surface with points almost pulverulent. These are decomposed felspars, though they still retain a residue of crystallization. This lava has been more changed by the acids than the others, being softer, and even pulverable ; though at the depth of two feet it is hard, heavy, of a black-grey colour, evidently has a petrosiliceous base, and contains felspars which are perfectly entire.

In describing the variously decomposed lavas of Solfatara, we have seen that felspars are a kind of stones which strongly resist the action of acids. It frequently happens,

happens, that their base is completely decomposed, while they are scarcely in the least changed. As, therefore, in the present lava, the felspars are decomposed equally with their base, we must be convinced that the strength of these acids must have been very great. In general, these lavas at their surface are soft, like dough, and almost saponaceous; characters that usually accompany these decompositions.

We must not omit to notice a lava of the breccia kind, the base of which is likewise petrosilex, and in which the action of the acids has extended only to the depth of a few inches. This base, even near the surface, has not entirely lost its natural colour, resembling that of iron, and in it are incorporated irregular small masses of whitened and pulverulent lava. These, therefore, have yielded more to the decomposition than the base that contains them. At a greater depth we find them unaltered; and they are then only fragments of lava of a horn-stone base.

Though many of the lavas of the Stoves of Lipari have suffered by the sulphureous-acid vapours, there are some that are entirely unchanged. I shall only describe one, which is so well preserved that it appears to have been produced but yesterday by the volcanic gulph. If we scale the surface of it, where it projects in large masses from the earth, it appears of a dark iron colour, has an extremely compact grain, and a conchoidal fracture. The scales at the edges are sharp and cutting, and give very lively sparks with steel. It is one of the heaviest and hardest among the lavas, and puts the magnetic needle in motion at two lines distance. It has for its base the petrosilex, containing very brilliant felspar needles.

This lava, therefore, has not been in the least affected by these acids, not, probably, because it was able to resist their strength, but because it was not exposed to their action. The places under which the conflagrations of a volcano burn, have numerous apertures and fissures through which issue
sulphureous

sulphureous fumes; and when lavas are situated around or within these, they will be more or less affected by them. But in the same tracts of ground there are more places than one impenetrable to these fumes, and there, in consequence, the lavas suffer no other alterations than those produced by time. These interrupted exhalations of sulphureous vapours I have observed at Vesuvius, Etna, and Stromboli, and have noticed them before in my accounts of these volcanos. It is only to be remarked that, at the Stoves of Lipari, the quantity of decomposed lavas being very great, and extending for the most part to a great depth, the sulphureous-acid vapours must have there issued in extraordinary abundance, and at the same time have been of long duration. The intensity of them, and their consequently greater efficacy, might, indeed, have supplied the place of long continuance; for I have observed, that when the lava of Vesuvius flowed before my eyes, and several of its lateral branches had ceased to move, two of these, which had been penetrated

by a thick cloud of the fumes usual there, were already half decomposed, though they were evidently parts of that current which, but a few months before, had been disgorged by the side of the mountain. Lastly, according to the different qualities of the lavas, and as they may be composed more or less of calcareous, argillaceous, or martial principles, all combinable with sulphureous acids, a greater or less decomposition will be produced.

The different degrees of decomposition in lavas render them sometimes more, and sometimes less susceptible of fusion in the furnace. The parts not decomposed will fuse. A beginning decomposition renders them stubborn, and, when it is complete, they entirely resist the fire. The cause of these differences appears to me sufficiently evident. The more earths are pure the more they resist fusion. All those hitherto known are infusible, except in very violent fires. Their mixture facilitates their fusion, as they thus become a reciprocal flux ; and

we

we know that fusion readily follows, when flint, alumine, and lime are mixed in the proportion of 3, 1 and 1. There was no lava on which I made experiments, in which I did not find these three kinds of earth; and though they might not be combined exactly in this proportion, their combination was yet such as to render almost every lava fusible in the furnace. The lime, which, in the dry way, acts as a flux to the flint, is in a great degree diminished in the decomposition of lavas, forming sulphate of lime by its intimate union with the sulphuric acid; and hence we have one impediment to the fusibility of these lavas. The diminution of the alumine, arising from its combination with the abovementioned acid forming sulphate of alumine, which is afterwards detached and carried away by the rains *, will likewise be another obstacle;

* To prevent any ambiguity, it may be proper to repeat what I have said in Chap. II, that the pretended transmutation of flint, or any other earth, into argillaceous earth, in the decomposition of lavas, has no existence; since, in this case, that earth likewise is diminished, from the causes alleged above.

to which we may add a third, which is the loss of the iron, likewise an aid to fusion.

These sulphates, which for the most part accompany lavas, present a pleasing spectacle to the naturalist. Their colours are infinitely varied. Those which are most prominent to the eye, are the rose colour, violet, and orange, and they are the more conspicuous because they are generally placed on a white ground.

I have observed three kinds of sulphate of lime, independent of several varieties which I omit. The first is composed of thin plates, parallel to each other, closely united, brilliant, compact, and opaque. They form strata or beds of different thickness, sometimes more than a foot, and these strata are easily detached from the lavas to which they adhere.

The second species is filamentous, having either parallel or stellated filaments, in which latter case the filaments form a kind of pyramids, which have their apices in one

common centre, and their bases at the circumference. We find some very large pieces of this kind, formed by the aggregation of these pyramids.

The third species is composed of thin and shining plates, somewhat elastic, transparent, very soft, and forms the indeterminate crystallization of sulphate of lime called specular stone; but this species is rare, and its crystals are always very small. In these cases the determinate and primitive crystallization of this neutral earthy salt is always wanting.

It is therefore evident that this variety of colours, such as yellow, red, or violet, exhibited by the decomposed lavas, is a consequence of the iron pre-existing in them; which being, if not decomposed, at least greatly altered, by the sulphureous acids, is variously modified, and assumes this diversity of hues. The same cause operates, in like manner, on the sulphates of lime, formed by the combination of the sulphuric acid
with

with the lime, which is laid open by the destruction of the adhesion of the constituent principles of the lavas, and variously coloured by the oxydated metal. The white colour of the decomposed lavas, then, it is evident, is produced by the loss of their iron; which agrees perfectly with experience, since, where the decomposition has taken place, the lavas are incapable of moving the magnetic needle, whereas they constantly produce motion in it, some at the distance of two lines, and some at more or less, in the parts not decomposed.

I shall conclude my observations on the productions of the Stoves of Lipari, with some interesting remarks relative to several different species of zeolites, which I discovered in their vicinity. I shall describe them separately with their matrices.

First species. The matrix containing this zeolite is a lava of a horn-stone base, of a dark-brown colour, granular in the fractures, and which scarcely gives sparks with steel.

steel. It shews no indication of having suffered by the sulphureous acids. It is full of small long cavities, all in one direction, and which probably were produced when the lava was in a fluid state. It is in these cavities that this species of zeolite is found. At first view it appears rather to be a stalactical calcedony, having the form of a cluster of grapes. It is of a white pearl colour, inclining to a light blue, and gives some sparks with steel. It has a filiceous fracture, and a degree of transparency. Three properties, however, especially characterise it : first, that it forms a jelly with mineral acids; secondly, that it flashes or blazes at the moment of fusion ; and, thirdly, that it bubbles, and as it were boils, when in fusion : and though neither of these characters exclusively appertain to the zeolite, all the three together sufficiently fix the nature of this stone, which must be referred to the class of amorphous zeolites. The clustering grains may be extracted entire, as they attach to the lava but in a few points. The largest extend to five lines in length, by two
or

or three in breadth. The figure which I have called clustering, is the most usual in this species of zeolite; though some are only oblong globules, of the same size with that of the small cavities which contain them. They are, however, by no means found in every cavity; for, out of a hundred of these cavities, ninety contained no zeolite. This species is contaminated with a pulverulent, orange-coloured oxyde of iron.

The blow-pipe with difficulty melted it; and several seconds were required for its complete liquefaction, even with the aid of oxygenous gas. It then changed into a snowy-white enamel, full of bubbles. It has a lucid brightness when it begins to melt, and boils and bubbles up when in actual fusion.

Second species. This is found in some pieces of the former lava, but its characters are different from those of the preceding species. It coats over many of the cavities
before

before mentioned with a thin crust, thus forming geodes, which, however, are not crystallized internally. This zeolite, which inclines to a white colour, is more transparent than the other, and, from its hardness, cuts glass, almost like rock crystal. The mineral acids have no effect upon it, not even when pulverised, though they convert the former species into a kind of jelly. When melted with the aid of oxygenous gas, it emits a thin brilliant blaze, and is changed, with ebullition, into a vitreous and white globule.

It is not unusual to find within these zeolitic geodes, plates of very transparent sulphate of lime. A hundred grains of this, pulverised, were put into six hundred of distilled boiling water. A solution was obtained, and the oxalic acid precipitated the lime.

Third species. This consists of ovoid globules, externally dirty, from an earthy coating, but which internally are extremely white.

white. In the fractures we perceive that they consist of a number of opaque groups of fibres, striated, silky, and shining, which diverge from the centre to the circumference of the globules, and thus form so many inverted cones. These globules, some of which are more than four lines in diameter, perfectly fill the cavities of an argillaceous, light, extremely friable lava of a deep grey colour. Every cavity, however, does not contain a zeolite of this conformation: in some we find zeolitic stones with several facets, but so confused that the precise configuration of the crystals cannot be distinguished. On attentive examination, they evidently appear to be formed of the same zeolitic substance, which, when it occupied the whole space of the cavity, took the conformation of those fibrous groups that have externally a globose figure; but when a part of this space remained empty, it crystallized more or less. These zeolitic stones always have in the middle a small empty space, where they are crystallized, forming a number of very minute geodes.

The

The blow-pipe presently melts this third species, and with ebullition ; a phosphorescence precedes the fusion, and the pearly globule which is the result, is a semitransparent glass, abounding in bubbles. If this globule be broken, which requires rather a smart blow, the sharp angles of the fragments will cut deep into glass.

This zeolite, soon after it has been put into acids, attaches to the sides of the containing vessel in the form of a crust, which crust presently resolves itself into a transparent tremulous jelly, similar to that of hartshorn.

Fourth species. The lava which contains this zeolite is of a horn-stone base, and forms two species, at least two varieties ; the one of which is granular, rough to the touch, and extremely friable ; the other has a kind of softness, a fine grain, and greater solidity. In colour, however, which is a grey, and in their argillaceous odour, both these varieties agree.

agree. This lava contains a multitude of zeolitic globules, from half a line to an inch in diameter. On breaking them, a vacuity is found within them, thus forming geodes of a crystallization more or less perfect. Wherever the zeolitic substance has been too confined in the cavity of the lava, the crystallization is extremely imperfect, in consequence of the prisms being half-formed and confusedly intermingled; but where that substance had a larger space to develop itself in, the prisms are no longer so indistinct; many of them, at least, are found to incline to a tetrahedral figure; and where the cavities of the lava have afforded a still greater space to the zeolitic matter, it has crystallized in tetrahedral prisms, of a distinct conformation. Every prism has therefore four faces distinctly separated. In some few places these prisms are terminated by a tetrahedral pyramid. Many of them are of a milky whiteness, and these are semi-transparent; but others have a transparency almost equal to that of quartzose crystals.

A single

A single cavity sometimes contains several scores of such prisms, while another shall contain but very few.

The blow-pipe easily melts these geodes with the usual phenomena of ebullition and phosphorescence, and the glass which is the result of the fusion is similar to that of the zeolite of the third species. A similar jelly is likewise produced from it, and with equal promptness, in acids, except that it has a less degree of viscosity.

Fifth and sixth species. These two species of zeolites are contained within an argillaceous lava, of a dark-grey colour, light, and of an earthy consistence: they both merit to be distinctly described. The first species consists of a great number of small spheres, white as snow, each occupying a cavity in the lava, and varying in size, the smallest being scarcely one third of a line in diameter, and the largest more than three lines. The surface of these small spheres is not smooth, but somewhat rough, from an in-

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finity of points which, viewed through the lens, are discovered to be so many minute tetrahedral prisms, distinctly defined. On breaking the spheres we perceive that the prisms are continued within them, and, becoming thinner, proceed to the centre; or, to speak more properly, we find that the spheres are only the result of a number of prisms joined together lengthwise. The portion of the prisms that is immersed within the spheres is opaque; but that part which projects out has a degree of transparency. It is to be observed, that though the greater number of these minute spheres are perfectly solid, many of them have a round vacuity at the centre, sometimes extending to one tenth part of the whole sphere.

This zeolite is the softest of all the species hitherto enumerated, and may be scraped or cut with a knife.

The sixth, and last, species is one of the most beautiful zeolites hitherto discovered
by

by naturalists. It consists of minute crystals, extremely clear and bright, which, having facets in every part, vividly reflect the light, and sparkle like so many diamonds. These are very numerous in the cavities of the same lava; but are unequally distributed, as some cavities contain but one of these crystals, while others have two, and others three, though the latter are rare. The largest do not exceed a line, and the most minute are scarcely a quarter of a line. While they remain in the lava, it is not easy to examine them as might be wished; but many of them may be extracted without injury, and viewed, in every part, with the lens, at leisure. We then perceive that these zeolites, where they rest on the lava, are flat; but in their upper part incline to a globose figure; and that, there, their crystallization is apparent: that the *isolated* crystals, I mean those which in their formation grew without attaching to the other crystals, have eighteen facets, for the most part pentagonal, or tetragonal, but never triangular: that these isolated crystals are extremely rare; the greater number being *aggregated*, that

is, confusedly heaped upon each other in their formation: that, lastly, though many of them may compare in clearness with the purest rock crystal, they are yet inferior in hardness, as they with difficulty cut glass.

I at first suspected that these zeolites were a simple modification of the fifth species, which, wherever it had a free space, had formed itself into these brilliant crystals, either isolated or aggregate. But this conjecture was not confirmed by observation. It frequently happens that the white minute spheres which form the fifth species, occupy only one half, or even less, of the containing cavities, without ever taking the form of the sixth species; but it is constantly to be observed that the tetrahedral prisms project farther beyond the convexity of the spheres, and have a greater transparency. They must therefore be considered as two distinct species.

This difference is still more confirmed by the action of fire and acids. The latter do not act, at least sensibly, on the sixth species, though

though they reduce the fifth to gelatinous flakes or tufts. The fire of the furnace, in half an hour, converts the crystals of the sixth species into globules of extremely transparent glass; whereas it only softens, in that time, the minute spheres of the fifth, which require a fire of much longer continuance for their complete liquefaction; and the globule, which then results, is an opaque glass, of the colour of milk. Both, however, have the property which is usually common to zeolites; I mean that of phosphorescence at the moment of fusion; as may be seen by employing oxygenous gas.

After having made these experiments on the zeolites of Lipari, I was induced to examine one of those of Iceland, which have the character of being the most excellent for forming a gelatinous body. I certainly obtained from it, very readily, an extremely beautiful jelly; but not in the least superior to that produced by the third

and fourth species. This foreign zeolite is very white, and forms a group of small conical bundles, closely conglutinated, and intersecting each other in various directions; terminating, at their diverging extremities, in a multitude of irregular cylindrical needles. In the furnace it becomes inflated and considerably lighter, but does not fuse. With oxygenous gas, a hard, milk-white enamel, full of bubbles, is produced.

If we compare these observations with the descriptions of other naturalists, we shall find that the zeolites of Lipari have a great resemblance to those of other countries; and it may be observed that the first species is very similar to that of the island of Ferro, which Born has described in his *Lithophylacium*, and which he has compared to the stalactical calcedony.

The second species, from its hardness, resembles some crystallized zeolites of the Isles of the Cyclops of Etna, which, as M. Dolomieu

mieu has observed, and as I have since found by experiment, are little inferior, in that quality, to rock crystal.

The three other species do not essentially differ from several described by Wallerius, Born, Bergmann, Faujas, and others, and which are found in the island of Ferro, the Vivarais, and other volcanized countries. But the sixth species appears to me new ; at least, I have found no writer who mentions a zeolite, constantly crystallized with eighteen facets, as often as its crystals are detached ; nor do I know that any zeolite has hitherto been discovered which is equally clear and brilliant.

It appears that the true figure of the zeolite is a cube ; at least, that it always affects that form where its crystallizations meet with no obstacles. According to circumstances it is more or less modified ; and the tetrahedral prisms of the fourth or fifth species are probably one of these modifications. The first and second are amorphous ;

but in the third we discern a beginning crystallization. One of these modifications may be seen in the sixth species; and we know that there are zeolites of other configurations; as some with twenty-four facets, and others with thirty.

Some naturalists have affirmed that the whitest and purest zeolite of Ferro is the only one from which a transparent and white glass can be obtained. I find, however, the glass of the sixth species preferable to it; for it has an aqueous colour, and its transparency is almost equal to that of quartzose crystal. I have found no zeolitic crystals, but those of the isles of the Cyclops, which have furnished a glass equal to this.

No mineralogist is ignorant that Cronstedt was the first who distinguished this stone from the carbonates of lime with which it was confounded, and made us acquainted with several of its qualities. He observed that mineral acids caused no effervescence with it, but slowly dissolved it into a gelatinous

tinous body: and this slow dissolution, and conversion of the zeolite into jelly, was afterwards confirmed by others; though experiments made on newly discovered species of this stone have shewn that more than one are not, in any manner, affected by acids, even when highly concentrated. From among six species of the zeolites of Lipari, we have seen that the third and fourth presently form, with acids, a transparent gelatinous body; which is less completely characterized in the first and fifth; and not produced at all in the second and sixth species.

M. Pelletier has analysed the zeolite of Ferro, and found that it is composed of 20 parts of alumine, 8 of lime, 50 of filix, and 22 of phlegm (or impure water). Other analyses have been made, of other zeolites, by the chemists Bergmann, Meyer, and Klaproth. The minute size of mine, and, still more, the small quantity I obtained of them, prevented me from making a similar analysis of them with the requisite accuracy.

I was,

I was, however, able to ascertain that the second and sixth species contained filix in a greater proportion than it was found in the zeolite analysed by Pelletier; which perhaps was the cause that these two species do not form a gelatinous sediment; the superabundance of quartzose earth not permitting the acids to extract the lime and alumine, and thus dissolve the union of the constituent principles of the zeolite.

The gelatinous dissolution of the zeolite is neither a quality found in every species, nor is it peculiar to it, since experience has shewn that it is common to other stones, the constituent principles of which are the same with those of the zeolite, and combined in a certain proportion. This identity of principles, which, in some species of stones, affords, by means of the action of acids, the same gelatinous product, induced me to make an experiment, of which I shall here give the result.

The colourless garnets of Vesuvius contain,

tain, according to Bergmann, 55 parts of filix, 39 of alumine, and 6 of lime. As, therefore, I had collected a considerable quantity of these at Vesuvius; I determined to make experiments on them with acids, in the same manner I had done on the zeolites. But in the three first varieties which I possess, though I had first reduced them to powder, no gelatinous substance was produced. With the fourth I succeeded; though I did not make the experiment on the same garnets, for the attempt would have been in vain, but on others, of the same species, which I have not mentioned, and which had been greatly softened by the sulphureous acids, though they retained their four-and-twenty facets. These the nitric acid, after thirteen hours, reduced to a jelly, though not one so beautiful as that obtained from the zeolites. We may therefore conclude, that this aptitude to dissolution was produced in the garnets by the alterations they had suffered; in consequence of which the nitric acid, penetrating their internal parts, had acted on them as it acts in many zeolites.

It

It has been believed that zeolites appertain exclusively to volcanized countries, since they are most frequently found there ; and my observations may appear to confirm this opinion. It however admits of no doubt that they are likewise often found in countries that exhibit no signs of volcanization ; this having been incontestably proved by Cronstedt, Linnæus, Bergmann and others.

It appears equally certain that the zeolites of volcanos do not derive their origin from fire, but are adventitious to those places ; not that they were pre-existent to the volcanic eruptions, and taken up by, and incorporated with, the currents of lava, as a celebrated volcanist has supposed. They were, no doubt, generated after the extinction of the conflagrations ; when their constituent parts being deposited by water in the cavities of the lava, and there combining by affinity, formed these stony substances, according to circumstances, sometimes amorphous, and sometimes crystallized ; in the same manner that we have
supposed,

supposed, and, indeed, proved, the beautiful quartzose stones to be formed in certain lavas on the shores of Lipari, not far from Vulcano. The zeolites now described, likewise, afford a proof in favour of this opinion, those, especially, the prismatic crystals of which have for their base the sides of cavities in the lavas.

I shall conclude these observations relative to zeolites, with the following enquiry concerning an hypothesis adopted by M. Dolomieu.

That naturalist was of opinion that the zeolites of volcanized countries are only found in those situations which have been covered by the waters of the sea; and the arguments he adduces to prove this, appear to me sufficiently convincing with respect to the multiform zeolites observed by him. But what shall we say of those we have now described? I certainly did not neglect to make the most accurate researches on the spot. It has been already said that these
stones

stones are found in the vicinity of the Stoves. The first species is met with about two hundred feet before we arrive at them, on the road from the city of Lipari; the others are scattered at a greater distance, in the steep side of the mountain towards the south. One certain proof that these places had anciently been washed by the sea, would be the finding of the remains or impressions of sea animals. Thus the above-mentioned French naturalist remarks that, at Etna, the lavas of the isles of the Cyclops, and those of the mountains of Trezza, which abound in zeolites, have certainly been covered by the waters of the sea, since, at the height of more than two hundred perches above these zeolitic lavas, immense quantities of sea-shells are found. The same may, in like manner, be observed of the Vicentine volcanic mountains, which afford beautiful zeolites, and also copious stores of marine remains. It is, however, certain that neither Lipari, nor any of the Eolian isles, present us with any vestiges of sea animals or plants. I do not mean to say that this is a physical demonstration

demonstration that these places have never been covered by the sea, since it is possible that the marine bodies its waters had left, may have been afterwards destroyed by causes which are not wanting in countries that, at various epochs, have suffered the action of fire; I shall only observe that we are thus deprived of one of the most convincing proofs of this supposed inundation; and I know not on what other we can rely, with respect to a country entirely volcanic.

That zeolites derive their origin from water and not from fire, is proved by the water of crystallization which is more or less abundant in them, and the numbers of them found in some provinces of Sweden, which have never been subjected to the action of fire. That this water has sometimes been that of the sea, the above-cited observations of M. Dolomieu will not permit us to doubt; but it has been proved that there are likewise instances of their having originated from fresh water; of which an observation by Bergmann may furnish an example.

ample. He has remarked that a spring of warm water at Laugarnes, in Iceland, when it issues bubbling from the earth, leaves no sediment of any kind, but deposits it at the bottom of a channel by flowing through which it becomes cooler: and this sediment is truly zeolitic, as has been proved by chemical examination*. The nature of this fact he satisfactorily explains as follows: "While the water is very warm, it holds the zeolitic matter in dissolution; but, afterwards, becoming cold, can no longer support it, so that it precipitates and forms this stalactical concretion. This excellent observation will account for the frequency of zeolites in many volcanos, since the water, whether salt or fresh, being strongly heated by the subterraneous fires, dissolves the zeolitic substances, which it afterwards deposits within the lava, where they crystallize, or remain amorphous, according to circumstances.

When the traveller has arrived at the summit of the Monte della Stufe, he has

* Opusc. Vol. III.

reached,

reached, in that part, the confines of the island; for he suddenly perceives the sea, about four hundred and sixty feet below him, as near as the eye can measure. Taking his way to the south, he, then, discovers several warm springs, which supply the Baths of Lipari, of equal antiquity with the Stoves, but, like them, now almost forsaken; and, proceeding in the same direction, meets again with a prodigious quantity of decomposed lavas, similar to those of the Stoves, exhibiting the same varying colours, and coated in different places with crusts of sulphate of lime.

When the naturalist considers, and unites in his mind, these prodigious aggregations of decomposed lavas, which occupy an area of several miles, he will no doubt be astonished to find there is any volcanized country in Europe, in which the sulphureous vapours, issuing from subterranean conflagrations, have acted through such an extensive space. Those of Solfatara di Pozzuolo, which have whitened its crater, and which

are mentioned with a degree of wonder by every writer on that volcano, are certainly inconsiderable indeed, with respect to their extent, when compared to these. Yet of all the sulphureous exhalations which must have spread themselves so widely over the island, not one now remains in action, except a few very thin fumes that rise from the ground near the Stoves.

I visited the Stoves three times : the two first I returned to the city by the same road I went, which is hollowed in the tufa; but the third I took my way back by Campo Bianco, and the Monte della Castagna, whence I proceeded to the high mountain of San Angelo. We have already seen that Campo Bianco and the Monte della Castagna are two mountains formed entirely of pumices and glasses, that is to say, of vitrified substances * : but how extensive must be the roots of these substances ! The declivity of the Monte delle Stufe, and its ample plain covered with tufa, form, as has been ob-

* See Chap. XV.

served, a bed of pumices, mixed with a great quantity of glasses and enamels. At about the distance of a quarter of a mile from the Stoves, towards Campo Bianco, the tufa disappears, and the pumices remain uncovered, forming a continuation with those of Campo Bianco. I have also found them in the road near Mount San Angelo, which contains great quantities, and every where they are accompanied with glasses. If to these we add the other parts of Lipari in which the same substances abound, I shall not exaggerate if I say that almost two thirds of this island, which is nineteen miles and a half in circuit, are vitrified.

This immense, and almost incredible, quantity of vitrifications may, probably, suggest to the reader the same idea which arose in my mind when I first viewed these places: that the fire which has acted on them must have been extremely powerful. This idea certainly appears very natural. But subsequent experience has taught me that this intense heat is not necessary for the

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production

production of this great accumulation of vitreous bodies by subterranean fires. It is certain that the production of pumices, enamels, and glasses requires a greater heat than the simple fusion of lavas, when these substances derive their origin from the same base; but we shall not find it necessary that this greater heat should be extremely violent, if we consider the kinds of stones from which these vitrified mountains have been produced. The greater part are felspars, and petrosilex, with some small quantities of horn-stone. As to the latter, it has already been shewn that it easily vitrifies in a glass furnace with no very vehement fire; in which, likewise, many petrosilices and some felspars are vitrifiable*. It has also been seen that the glasses, pumices, and enamels of Lipari are all completely refused in the furnace. It appears to me, likewise, that we have positive proofs that the volcanic fire was less violent than that of the furnace, in the substances, as well

* See Chap. V. and Chap. XI.

crystallized as amorphous, which, without having suffered the least fusion, are found incorporated in the pumices, glasses, and enamels of Lipari, and which may be perfectly liquefied in the furnace.

It cannot, however, be denied that the generative fires of Lipari must, at some time, have been extremely vehement; since, according to the observations of M. Dalmieu, they have even fused granite, composed of quartz, felspar, and mica, and converted it into pumice.

The ancient writers have left us very interesting and instructive accounts relative to the state of the conflagrations which in, and prior to, their times had been observed in Stromboli and Vulcano; and we have made use of them when treating of those two islands. But we can say nothing of the ancient fires of Saline, and that chain of rocks, which once, probably, made a part of the island Euonimos, since with respect to these antiquity is totally silent; and we can

only infer that the volcanization of these two islands was known to the ancients, from a passage in Diodorus, who informs us, that all the Eolian isles were subject to great eruptions of fire, and that their craters and mouths were still visible in his time *. With respect to Lipari, very few memorials have been preserved of its ancient conflagrations. We are indeed certain of the great antiquity of this island, and that it existed before the Trojan war; since we learn from Homer that, after the taking of Troy, Ulysses landed there, and was treated with the utmost urbanity and courtesy by king Eolus during a whole month, which he continued there †; and though we allow to

* Αυται δε πασαι πυρος εσχηκασιν αναφυσηματα μεγαλα, ων κρατηρες οι γεγεννημενοι και τα σομαλα μεχρι τε νυν εις φανερα. Lib. V.

† Αιολιν δ' ες νησον αφικομεθ', ενθα δ' εναιεν
Αιολος Ίπποταδης, φιλος αθανατοισι θεοισι,
Πλωτη εν νησω. Hom. Odyss. Lib. X.

Και μεν των ικομεσθα πολιν και δωματα καλα.
Μηνα δε παντα φιλει με, και εξερεεινεν εκασα,
Ιλιον, Αργειων τε νεας, και νοσον Αχαιων.

Ibid.
the

the poet the usual licence of poetry, it is still most certain that he could not have named this island, and the city it contained, unless they existed at the time he wrote his poem, since which nearly three thousand years have now elapsed. But if we consult other ancient and credible writers, we shall find that before Eolus, Liparus reigned in this island, which from him took its name, being before called *Melogonis*, or, according to others, *Meligunis*.

Another observation, likewise, here naturally presents itself. An island formed by depositions, and the subsequent retiring of waters, may, in a short time, be cultivated and inhabited; but it is not so with one that is produced by subterraneous eruptions, where the decomposition of volcanized matters is necessary; that is to say, a far longer time. If, therefore, Lipari had inhabitants and cities, and was a cultivated country before the destruction of Troy; it is evident that it must have existed many ages prior to that event.

From the time, however, that mention is first made of this island in history to the present day, we may consider it as certain that no true eruption, or current of lava, has taken place in it; as, otherwise, it is probable some memorial would have been preserved of it, as well as of those of Stromboli and Vulcano. Aristotle, indeed, mentions the fires burning in Lipari, but adds they were only visible by night*; and the writers who followed him say nothing more. I hence infer that this island had attained its full formation and size, before it was known to men, which was not the case with Stromboli and Vulcano. I must not omit another observation. Many of the lavas of Lipari still scarcely exhibit the least sign of alteration, especially the vitreous, the enamels, and the glasses; though it is evident, from what has been said above, that these bodies must have existed above three thousand years. We hence perceive what

* Και το εν τη Λιπαρά δε πυρ φανερον και φλογωδες, ου μεν ημερας, αλλα νυχλος μονον καιεσθαι λεγεται.

In Mirandis.

an

an adamantine temperament, if I may use the expression, the fire can bestow on various substances, since they can thus resist the influence of the seasons and of time.

When I prove the antiquity of Lipari by the authority of Homer, I do not mean to consider the other neighbouring islands as of posterior date. I am likewise well convinced, by the testimony of history, that, except Vulcanello, they were all in existence in the time of that poet, who probably does not mention the other Eolian isles because Lipari was the largest, the most fruitful, and most generally known, as being the residence and seat of government of king Eolus.

C H A P. XVII.

FELICUDA.

Two bays in this island capable of receiving small vessels—The products found there by the author, sufficiently prove it volcanic—Circuit of it by sea—Prismatic lavas falling into the sea—Spacious cavern hollowed in one of these lavas—Enquiries relative to its origin—Curious alternation of stratas of tufa and lava—Other prismatic lavas along the shore—Observations relative to them—Excursion into the interior part of the island—A mountain, near the centre, higher than the rest, on which is discoverable the crater of an ancient volcano, to which, probably, Felicuda owes its origin—Conjectures that another smaller volcano existed at the summit of a lower mountain—No other perceivable signs of volcanic mouths throughout the whole island—Qualities of the lavas forming the interior

rior part of Felicuda—Glasses, pumices, tufas, and puzzolanas scattered over the island—Puzzolanas and pumices employed by the inhabitants of Felicuda in building—The substances of which the island is composed entirely volcanic, except a piece of granite, which appears to be natural—Reflections on this rock.

IT yet remains to speak of Felicuda and Alicuda, the two extreme islands of those of Lipari towards the west; and I shall the more willingly undertake the description of them, as they have not, to my knowledge, been visited, at least described, by any other naturalist; M. Dolomieu, who was most capable of examining them, having only seen them at a distance, as to have touched at them would have led him too far from his intended route.

On the 7th of October, in the morning, I set sail from Lipari for Felicuda, distant from the former island twenty-three miles,
and

and arrived there in four hours. This island is not provided with a port; but it has two bays, one on the south, and the other on the north-east side, sufficient for the reception of small vessels, and so situated, that though the wind should render the entrance into one of them difficult, it will be easy to get into the other: both of them are likewise sufficiently sheltered by a mountain.

I landed in the bay on the north-east side, and, in the first place, applied myself to discover of what materials the island was formed; and soon discovered incontestable proofs that it is truly volcanic. Not only is the shore of this bay lined with lava; but, having in the course of the day proceeded farther up on the south-east side of the island, I found among the earth of some fields a considerable quantity of pumices, glasses, and enamels, which products I shall separately describe when I come to treat of the internal part of the island.

Being thus fully convinced of the ancient
existence

existence of fire in this island, I determined, the next day, to make the circuit and examine the shores of it, in the same manner as I had proceeded in the other islands.

Felicuda is nine miles in circumference. I began the circuit of it by examining the lavas that border the small bay which I entered. These have for their base the felspar, which is of a scaly consistence, a light grey colour, not very compact, but giving a few sparks with steel and attracting the magnetic needle. Within its substance are included needles of black and fibrous shoerl, and small pieces of felspar, which are easily distinguishable from the base by their whiteness, semitransparence and lustre. A part of the shores of the bay are composed of this lava with deep fissures running lengthwise, as we see in many other lavas. A number of round vacuities are likewise observable in it. They are of considerable depth, and give it the appearance of a honey-comb. I rather incline to ascribe them to the action of elastic gaseous substances,

stances, when the lava was in a state of fusion, than to corrosions produced by the influence of the atmosphere or any external agent. It is certain that the air of the sea will greatly corrode many fossil substances situated in its vicinity; and I have witnessed extraordinary effects from its action on many low rocks, on the shore of the Mediterranean, near Genoa, and especially at Porto Venere, the Golfo della Spezia, and at Lerici. I have also frequently observed the external part of many towers and maritime buildings very much injured on that side which fronts the water. The city of Commachio in the territory of Ferrara, perhaps, furnishes some of the most complete examples of such effects. It is situated in the midst of salt lakes; and its porticos and edifices are so much corroded and damaged by the air, that they are obliged to undergo periodical repairs at the end of no very long time, as I observed with surprise during a short stay which I made there in October 1792. The sea air, however, does not act thus on every fossil substance

indif-

indifferently, but, with respect to stones, seems principally to attack the carbonates of lime; though not all of these, as appears from the hard Istrian marble with which the superb palaces and sumptuous edifices of Venice are built, and which remains uninjured for a long series of years. I likewise observe that volcanic stony substances are little, or not at all, injured by the air of the sea; and I am the more confirmed in my opinion that the incavations in the litoral lava of which I am now speaking must be attributed to the action of aëriform gases, and not to that of the sea air, from observing the same, likewise, in the felspar, a stone much less liable to this kind of alteration than many others.

After having made these observations, I left the bay, and began to coast the island towards the left, on the northern side. I had scarcely proceeded one hundred and fifty paces when I met with a rock of lava, about thirty feet high, and equally broad, rising almost perpendicularly from the water.

This

This rock presented a novelty I had not before observed in the Eolian isles. This was a number of prisms into which the lava divided before it plunged into the sea. The importance of this object induced me to bring my boat close under the rock, that I might make the necessary observations with more certainty and security.

About twelve feet above the level of the sea, the rock is smooth, and presents an equal surface; but, somewhat lower, it begins to be furrowed with narrow longitudinal excavations, which descend to the edge of the water, and form prisms with three unequal sides, the side behind remaining attached to the rock, or, to speak more properly, forming one continued whole with it. These prisms continue to preserve their form under the water, of which I had indubitable proof. The sea, though then calm, had a slight roughness towards the rock, to allay which I poured into it some olive oil, which I always carried with me in these excursions to calm the lesser waves of
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the sea, and thus enable myself to perceive subaqueous bodies at a certain depth as circumstances might require. By these means I discovered that the prisms were immersed in the sea to the depth of some feet. The breadth of some of the prisms was a foot and a half, but that of others less.

This prismatic lava merits to be very accurately described, since, in prosecuting my voyage along the shore of Felicuda, I met with it in several other places, and shall again have occasion to mention it. Its base is a horn-stone of the black colour of iron, and so compact that the smallest bubble is not perceivable in it; it must, therefore, be classed among the heavy lavas. The edges of the thinnest flakes of it are transparent, and give sparks with steel. Its fragments are amorphous, and receive a polish, but without lustre. It attracts the magnetic needle at about the distance of three lines. The powder of this lava is cineritious, and impalpable, and attaches to the finger. In

it are contained various grains of amorphous felspar, and a greater number of small, long, rhomboidal spherls.

The product of this lava in the furnace is a hard enamel, of the colour of pitch, and full of bubbles. The felspars it contains remain refractory. It is to be remarked, that this enamel does not lose the magnetic virtue.

The place where this rock hangs over the sea is called *Fila di Sacca*. Beyond it the shore of the island, which continues to have a steep descent into the sea, offers only common lavas, except one species which has some rude appearance of prisms, that assume a more distinct form near the surface of the water.

Still farther, at a place called *Saccagne*, a number of small rocks rise above the surface of the water; one of which is called *Il Perciato*, because it is perforated in the middle, and the opening is wide enough to admit

admit small vessels to pass through. The forms of prisms are distinctly discernible in these rocks.

At the distance of fifty paces farther, a spacious cavern opens in the lava of the shore; an object highly interesting and beautiful in the eyes of the volcanist. It is called the *Grotta del Bove Marino* (or Grotto of the Sea-ox), perhaps because it was once the retreat of some *phoca* or seal, as in the Lipari islands, and many other places, the phocæ are called sea-calves. The mouth of this cavern, in the upper part, is oval, and is sixty feet in breadth, and above forty in height. The mouth opens into a kind of porch, which leads into a spacious hall two hundred feet long, or nearly, one hundred and twenty broad, and sixty-five high. This hall terminates the cavern. The sea enters it; and as its force is broken by the narrowness of the entrance, small barks when surprised by a storm may there find shelter.

Some may perhaps wish to enquire, whether the roof of this cavern presents any of those stalactical concretions which are observable in many other excavations in mountainous countries. No such concretions are to be seen; the stone of which it is formed being evidently not of an aqueous but an igneous origin, that is, a lava distinguished by the following characters.

Its base is shoerl in the mass; it is moderately porous, and therefore rather light; but gives sparks with steel. It is unequal in the fractures, has a somewhat argillaceous odour, and attracts the magnetic needle at the distance of half a line. It is of a grey colour; but interspersed with white, shining, rhomboidal felspars. Their splendour is diminished in the furnace; but their whiteness appears heightened from the black colour acquired by the enamel produced by the fusion of the lava, which is opaque and extremely full of bubbles. The fusion, instead of diminishing or destroying, rather increases its magnetism.

This

This lava, which forms the large cavern, descends almost perpendicularly into the sea, and there assumes the form of prisms, but larger than those before described. It is worthy of remark, that these prisms, though in their lower part they sink deep into the water, do not rise above it, in their upper, more than eight or nine feet.

But in what manner are we to explain the origin of this cavern? How great must have been the violence of the waves of the sea, to form by slow corrosion so vast an excavation within this mass of lava! To this cause I cannot consent to ascribe it; principally for this reason, among others that might be adduced, but which I omit for brevity, that no sooner has the water entered the mouth of the cavern but it loses all its force; besides that the hardness of this lava is such, that it does not easily yield to the stroke of the waves. I incline rather to think it the effect of the action of the gases in the lava at the time it was in a state of fluidity; as we have examples at Etna of

caverns incomparably deeper produced by a similar cause.

Immediately beyond the Grotta del Bove Marino, we meet with a mixture of tufa and lava, which merits some attention from the curious alternation of its strata. They are found on a high precipice which descends into the sea, the surface of which is covered with a tufaceous soil, resting on a bed of lava, above another of tufa, and so successively, that in a rent made in the precipice by the waters we may number eleven strata or beds of tufa, and as many of interposed lava. It appears, therefore, that the fire and water, by their repeated action, have produced this mixture of lavas and tufas.

The lava of the eleven beds is of the same kind, that is, of a horn-stone base, and containing, as usual, shoerls and felspars. It has an earthy aspect, a blackish colour, and a strong argillaceous odour. It moves the magnetic needle at the distance of two lines,

lines, and the enamel into which it is changed in the furnace has the opacity and blackness of pitch, and its magnetism is greater than that of the lava before fusion.

The beds of tufa, likewise, do not essentially differ from each other. They are an ill-kneaded mixture of lumps of argillaceous earth, more or less tinged with yellow oxyde of iron, which earth is easily pulverable. With it are mixed numerous shorls, that from the softness of the base may be separated entire, which they scarcely ever can be in the lava. Notwithstanding, however, the facility with which they may be detached, it is difficult to determine their crystallization, not merely from their extreme minuteness, for some of them are two lines in length, but from their being scarcely ever found single, almost every one being a group of aggregated shorls. When one, however, is found single and detached, it appears to be an hexagonal prism terminated by two trihedral pyramids. They are black, shining in the recent fractures, and are some-

what fibrous : in fine, they perfectly resemble in their structure the shoerls incorporated in lavas.

The tufa, after remaining two or three hours in the furnace, assumes a red colour, and becomes hard ; its magnetism is likewise strong, though before it was scarcely perceptible. A longer continuance in the same fire reduces it to a porous scoria, which does not lose its magnetism, and the black colour it acquires renders more conspicuous a number of white felspars which before were not discernible in the tufa. The shoerls are semi-vitrified, and assume a yellowish tinge.

In the remainder of my circuit round the island, till I returned to the place whence I set out, I observed no other interesting objects, excepting a long tract of prismatic lavas, similar to those I have already described.

I shall conclude what I have to say on
these

these prismatic lavas, which occupy a considerable part of the shore of the island, with the following remarks :

First. These prisms have never more than three faces, one of which always remains adherent to the lava.

Secondly. Their direction is never oblique, or transverse ; but, without exception, perpendicular to the sea.

Thirdly. They are not articulated, as they have been observed to be in some volcanic countries, especially on Mount Etna, but form one continued line.

Fourthly. In their lower extremity they descend within the water, and, in their upper, rise some feet above the level of the sea.

Fifthly. These prismatic lavas have for their base, either the horn-stone or shoerl in the mass.

I shall

I shall now proceed to describe the objects which appeared to merit notice in the interior part of Felicuda. This island, when seen from the sea, at a little distance, has the appearance of a number of mountains heaped together; one of which, situated in the centre, is much higher than the rest, rising, perhaps, half a mile above the level of the sea. After having examined the base or shore of the island, I proceeded, therefore, to the summit of this mountain, taking my way towards the east, as, on that side, the road is least difficult. The ascent is not one of the most fatiguing; for though we meet with steep precipices in some parts of it, they are presently succeeded by gentle declivities, which relieve weariness and restore strength.

When I had reached the summit of the central mountain, I perceived that it inclosed a capacious hollow called *Fossa delle Felci* (the ditch of fern) because it formerly was overgrown with that plant; though when I was there it had been all rooted up, with
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the intention of sowing corn the next spring. This hollow is about half a mile in circuit, the sides approach as they descend, and its depth is not more than forty feet. These circumstances sufficiently prove that this was the ancient crater of the volcano ; and that, perhaps, or rather without doubt, this was the first, which, by its eruptions, contributed to the formation of Felicuda.

It is likewise to be observed, that the external part of this crater corresponds to the internal ; that it is a truncated cone ; that its lavas, parting as from a centre, have diverged like rays down the sides of the mountain, while those on the side towards the north-west have poured rapidly into the sea. The proposal to sow corn in this hollow argues that it must be earthy, as it really is. It is formed of a half pulverulent tufa, under which, however, the lava is discoverable.

Three ridges rise on this mountain, one
of

of which descends to the south; and, at about half way up, joins another mountain. The second of these ridges has its direction to the east, and the third to the west. From this summit I had a complete view of Felicuda, and looked round me with attention to see if I could discover the signs of any other crater. I thought I could discern the vestiges of one to the south-east, and, afterwards, repairing to the spot, was more confirmed in my opinion. I found a hill, about half as high as the mountain already described, and about two miles in circuit. It is isolated on every side, and has the figure of a broken cone, truncated at the top, where it sinks into a cavity growing narrower towards the bottom, which appears to be the relics of an ancient crater. Scattered pieces of various lavas, half-buried in an earthy tufa, occupy the cavity of this hill, and its external sides are formed of a number of currents of lavas.

Except these two craters, of the last of which I have expressed myself with some doubt,

doubt, I know not of any throughout the whole island ; as I shall not venture positively to consider as such a number of cavities, hollows and caverns which we meet with in various places, such appearances not being sufficient to characterise a volcanic mouth.

The principal lavas of the shore of Felicuda have already been described singly : it is now necessary to specify those which form the internal and more elevated parts of the island. These, as far as I was able to discover, during the stay of five days which I made there, may be reduced to three kinds, if we omit those which are merely varieties.

The base of the first is a horn-stone of a colour between a black and a grey, of a fracture evidently brilliant, without any appearance of pores, and which gives sparks copiously with steel. The pieces into which it breaks have no determinate form, do not refuse a tolerable polish, and move the magnetic

netic needle at the distance of a line and three-fourths. Minute grains of quartz, numerous scales of felspar, and extremely small and brilliant needles of shoerl are incorporated in this lava.

The furnace fuses the shoerls, but not the quartz, and the felspars; and the lava is changed into a black, frothy, and opaque enamel.

This lava extremely resembles the prismatic lava described above; though it has not that regular configuration.

The lava of the second species is likewise of the horn-stone base; not very hard nor heavy; of a cinereous and earthy aspect, without pores, attaches slightly to the inside of the lip, and emits an argillaceous odour. The shoerls it contains are rhomboidal, scaly, and of a violet colour.

In the furnace it is only softened; and the shoerls remain entire.

The third species has for its base, shoerl in the mafs. It is black, without pores, rather heavy, and of a granular fracture.

The heterogeneous ftones, which are mixed with the fubftance of this lava, are of three kinds: fmall irregular quartzofe particles, which, from their whitenefs, are moft conspicuous; a few minute feltfpars; and numerous rhomboidal shoerls, of a dark violet colour, and remarkable for their fize, fome of them extending to feven lines.

The feltfpars and quartzofe grains are refractory in the furnace; though their bafe is eafily fufible, and produces a fhining, opake, and porous enamel.

The internal part of the ifland, as far, at leaft, as appears from the furface, is compofed of thefe three lavas and their varieties; which lavas form currents, that, from their great antiquity, do not exhibit thofe tumours, wavings, and inequalities, which are obfervable in recent lavas, or thofe of a moderate

derate age. The same antiquity is, likewise, probably the reason, why in Felicuda we do not find scoriæ, or scoriaceous lavas; these, usually, from their slight and feeble texture, and from their lying on the surface of the current, being the first which are altered and destroyed.

When treating of Lipari, I remarked the great effects which have been produced on the products of that island by the sulphureous-acid exhalations. The contrary is to be observed of Felicuda, there not being a single lava which exhibits the least sign of their influence; though they all bear the marks of the injuries of time and of the atmosphere. So much have I found them changed, especially near the surface, that had I not broken up the lavas to the depth of some feet, a practice to which I had accustomed myself in these researches, I should frequently have taken the same lava for others specifically different.

Having thus described the different kinds
of

of lavas of this island, it will now be proper to proceed to treat of the other volcanic substances it contains. Among these are the tufas, which are found in great abundance in other parts of the island beside those above described. In general they are pulverulent, light, spongy, of an argillaceous nature, and greedily imbibe water. The places in which they are found, are the only parts of the island which the inhabitants can render productive by cultivation.

It is among the tufas that we discover glasses and pumices. We will treat of these two substances separately, beginning with the first.

I have already said, that I had scarcely landed in Felicuda before I discovered several pieces of volcanic glass. In my subsequent researches, I afterwards discovered that this glass was not found among the lavas, but in the cultivated earth of the fields. The peasants of those parts confirmed the truth of this observation, and, finding I was

in search of this substance, brought me more of it than was necessary, which they collected in the fields where they worked. As I was not, however, perfectly satisfied with this first observation, I directed them to dig a deep trench in one of the fields which most abounded in specimens of this substance, with a view to try if I could discover a vein, these being only detached pieces. The trench they dug was eight feet deep, and five in breadth. For the depth of two feet I found only a tufaceous earth, containing some of these vitreous pieces. At a greater depth the virgin tufa appeared, untouched by the ploughshare, or any rustic instrument. This tufa likewise furnished a similar glass, but always in detached pieces; nor was any difference perceivable in the nature of these products, on continuing the research to the bottom of the trench, where the tufa was still found.

It appears, therefore, that the glass in the ploughed fields had its seat in the tufa; though it cannot be affirmed with certainty, that

that it was thrown out from the mouth of the volcano in the same state in which it is now seen ; since it is only found in plates or flakes, and with those points and sharp angles, those cutting edges and waving streaks, which we observe in glass, whether volcanic or factitious, when it has been broken and divided into fragments by a hammer, or other heavy body. We must therefore conclude, that after the subterranean conflagrations had reduced the stony substance to glass, this glass has been thus broken and shivered by some convulsion of the earth, or by some violent and tumultuary agent.

The larger pieces are about five inches and a half over, and two in thickness. Many of them are not inferior in clearness and brilliancy to the finest and brightest glasses of Lipari ; others are less transparent, and of a cineritious, or grey, colour ; while others are almost entirely opaque ; and these approach nearer to the nature of enamels than to that of glasses. They are all, how-

ever, extremely compact, and will readily give sparks with steel, and cut common artificial glass. Several of these pieces contain within them small white particles, which have been observed and described in many of the glasses of Lipari, which particles indicate that the glass containing them is not so perfectly vitrified as the rest. We also find pieces, though they are rare, the one half of which is a very black glass, and the other a simple lava. The lava, which thus forms a whole with the glass, is of a cineritious colour, and, as appears from some analyses which I have made of it, is of a petrosiliceous base.

This glass, like other volcanic glasses, changes in the furnace into a vitreous froth.

It now remains to speak of the pumices, which are likewise enveloped in these tufas. These never form large masses, but are always found in detached pieces, of rather a small size, the largest rarely exceeding the bigness of the closed hand. In general they
are

are more plentiful than the glasses, and among the tufas of uncultivated places, it is only necessary to remove the surface to find them by hundreds. During my stay at Felicuda I resided in a place called La Valle della Chiesa (the Valley of the Church). This is a small plain, on the east side of the island, in which stand the parsonage-house and the church, two indifferent buildings, suitable to the poverty of the country. This place, as likewise a spacious declivity to the south, abounded with pumices, both on the surface of the tufas, and below the surface, wherever they were dug into.

These pumices are of two kinds; the one cellular, extremely friable, fibrous, and which float on the water; and the other compact, heavy, without pores, and of a smooth fracture; but which yet possess all the true characters of pumice. Some are of a reddish colour, others yellowish, and many ash-grey. All are plentifully furnished with extremely brilliant vitreous felspar-scales.

In my observations on the pumices of Vulcano I have remarked, that instead of swelling in the furnace, and being transformed into an ebullient product, as is almost always the case with glasses and compact enamels, they become of less bulk, lose their pores, if they had any before, or, at least, contract, and therefore become heavier. The present pumices do not differ in this respect from those of Vulcano; and the enamel which they produce in the furnace has a black and shining ground, interspersed with whitish spots, which are felspars that, having lost their lustre and transparency, are become white. This enamel puts the magnetic needle in motion at the distance of a full line, notwithstanding that it had no sensible effect on it when in the state of pumice.

There is no reason to suppose that these pumices have ever formed currents, both because they are always found in detached pieces, and because their pores have not that direction which is usually observable in pumices

pumices that have flowed in the manner of lavas. The figure of the pores in pumices that have flowed, is usually more or less oblong; whereas in the pumices of Felicuda (I mean the cellular) the pores are almost always orbicular. We must therefore conclude that they have been thrown out from the mouths of volcanoes; to which the globose figure of many of them is perfectly consonant.

I should esteem my account of the different productions of this island very defective, were I not to mention another which still more confirms its volcanization: I mean the puzzolana found here in several places, and which, when carefully examined, is found to be a mixture of minute fragments of pumices, tufas, and lavas. The inhabitants of Felicuda make use of it, as also the pumice, in building their houses; in the following manner. They bring carbonates of lime (calcareous earths) from Sicily; and burn them in furnaces, which are erected, for greater convenience, on the

sea-shore ; and at the end of forty hours an excellent lime is produced. One-third of this and two-thirds of puzzolana, mixed together with water, form a cement which unites and binds the pieces of lava here used instead of bricks and stones ; and to give, as they affirm, a greater strength and solidity to the cement, they mix with it pounded pumice of their own country.

Lavas are used as materials for the building of houses, not only by the inhabitants of Felicuda, but by those of all the other Eolian isles, each using those of their own island ; and it is the practice, not only in the country but even in cities, to build with such stones as the environs afford, especially when they are mountainous. I therefore, wherever I went, constantly examined the materials of which the villages, towns, and cities through which I passed were built ; which frequently afforded me a light and direction in my enquiries relative to the fossil substances of those countries.

On

On reviewing the different volcanic bodies which I met with at Felicuda, we shall find that they consist of glasses, pumices, tufas, puzzolana, and lavas with a base of shoerl, felspar in the mass, or horn-stone. The island at present exhibits no indication of subterranean fire, and even those signs which are uncertain and equivocal are wanting; such, for instance, as warm springs.

In the various excursions I made, I was particularly attentive to observe if by accident I should meet with any body not volcanized; and found one only of this description. This was a piece of detached granite, lying on the shore near the Grotta del Bove Marino. Its elements were of the most common kind; mica, felspar, and quartz. The mica was partly black, and partly white and silvery; both forming groups in which the black predominated. The quartz was in small semi-transparent masses, of a vitreous and brilliant fracture, soft to the touch, and of a colour between a blue and a white. The felspar, which in quantity exceeded

exceeded the two other principles, and therefore must be considered as the base of the stone, was in small masses of unequal surface, lamellar in the fractures, transparent in the angles, and of a changeable milky whiteness. Neither of the three principles has a determinate form of crystallization. I think I shall not be mistaken if I assert, that this granite has not suffered the action of the fire. In fact, a continuance of a quarter of an hour in the furnace produced in it so great an alteration, that every part of it was sensibly changed. The mica became pulverable, the quartz extremely friable and full of cracks, and, losing its transparency and vitreous brilliancy, became entirely white. The felspar, likewise, contracted a considerable friability; losing at the same time its changeable colour, and becoming whiter. It is not therefore extraordinary that a slight blow with a hammer should now break this stone into small pieces; though before it would only strike off, at most, a single fragment. When exposed to the furnace for several days successively, the quartz and mica did
not

not fuse ; and the felspar only exhibited, at the angles, a beginning of fusion, which made it appear as it were unctuous. This experiment is perfectly agreeable to many others which I made in the furnace on the granites treated of in Chap. XII. We must therefore conclude, that this piece of granite was thrown out untouched from some volcano in the island ; or, which appears more probable, that it is adventitious to it ; for it is to be observed, that it was not found in the interior part of the island, but on the beach, where it had been beaten, and had its corners smoothed by the waves. Were I to indulge conjecture, I should incline to suppose it might have been brought by the sea from Capo Melazzo in Sicily, or that vicinity, which is only fifty-four miles distant from Felicuda, and where immense masses of similar granite are found*.

* See Chap. XII.

CHAP.

C H A P. XVIII.

ALICUDA.

Danger to which the author was exposed, in a tempest, on his passage from Felicuda to Alicuda—Pumices and glasses found in the latter island—Examination of the coast of Alicuda—Several rocks formed of detached globes of lava—Enquiries relative to the origin of these globes—Confirmation of the uncertainty of any opinions formed relative to the greater or less antiquity of lavas, from the more or less sensible decomposition they may have undergone—Isolated masses of porphyry, which exhibit no signs of having been attacked by volcanic fire—Lavas of another kind—Shoerls of a greenish blue colour contained in all these lavas—The coast of Alicuda more rugged and threatening than that of any other of the Eolian isles—No mouth of any ancient crater in the sides of the island—The

—The appearance of a true crater found only at the summit—Lavæ in the interior part of the island similar to those of the shores—Improbability that Felicuda and Alicuda once formed a single conical mountain, the side of which has been opened and separated by the sea, as M. Dolomieu has supposed—Reasons for believing that each was originally a separate island—These two islands no longer manifest any signs of actual fire—The silence of the ancients relative to their fiery eruptions, a proof that they must have long ceased to burn.

ON the 13th of October, at sun-rise, I left Felicuda, in a small bark, with four rowers, which was steered by the parish-priest of Felicuda, who had the character of a skilful seaman. We sailed before a moderate east-wind : the sky was clear, the sea smooth, and we flattered ourselves we should soon reach the place of our destination, as the distance between these two small islands is not more than ten miles. But scarcely were we half way, when the wind began to in-crease

crease so that we were obliged to reef our sail, which it was dangerous to carry full; yet still we made more way than before; and the wind blowing with greater violence, and driving us rapidly towards Alicuda, from which we were now not far distant, endangered our being shipwrecked on the shore. Bays or harbours are things unknown in this island, and our bark driving before the wind, it was to be feared, might soon dash against a rock, or run upon a sand-bank; and we had the less hope of being able to avoid this danger, as our sailors, from unpardonable negligence, had not brought with them any anchor.

The sea, in the mean time, ran very high; and the waves, which would not, perhaps, have given much alarm to a large ship, were very formidable to our little vessel, which they broke over from side to side, and from stern to prow, whirling it round with their violence; while the danger of being wrecked continually increased by our approaching the island, notwithstanding all the exertions

we

we could make with our oars to keep off it. Our sailors, however, did not entirely abandon themselves to despair, but consulted whether it would be less dangerous to yield to the violence of the waves, and endeavour to run the bark on some sand-bank joining to the shore; or, avoiding the island, to adventure out to sea, and commit themselves to the mercy of the winds.

In this desperate situation, we perceived five men hastily descending from the eminences of Alicuda, and approaching the shore, which they quickly reached; when one of them called to us in a voice which might be distinctly heard notwithstanding the noise of the waves, advising us not to be terrified, but to endeavour to keep where we were, and he would exert his utmost efforts to deliver us from the danger by which we were threatened.

This person, as I afterwards found, was the parish-priest of Alicuda, who perceiving, from a distance, the situation in which
we

we were, had hastened, with four of the islanders, to give us assistance. He had brought with him a strong pulley, which, when fixed on the shore, was to receive a rope, by means of which the vessel might be drawn upon the land. But to effect this, it was necessary to form a kind of inclined plane on the shore, along which the boat might be drawn; which was soon done, with the spades and shovels that had been provided for the purpose.

We were not more than fifteen feet from the land, and, by incessantly plying our oars, made every effort to avoid approaching it nearer. We were obliged, at the same time, continually to bale the water out of the boat, to prevent its sinking; which was the continual employment of myself and my servant, the sailors being entirely occupied in using the oars. A rope coiled up was now thrown on shore by one of the sailors, and, after two or three unsuccessful attempts, caught by the persons on the beach and passed through the pulley; while the

sailor drew it tight, and fastened it to the prow of the bark. We now committed ourselves to the first wave that rolled upon the shore ; and, the five islanders pulling the rope with all their force, we were drawn with the bark up the shelving declivity they had made : but the wave on its return, dashing impetuously against the prow, drove us again into the sea ; and so violent was the shock, that the rope broke, and we lost all hope of getting safe on shore. At this unfortunate and unexpected accident the good priest struck his hand against his forehead, from vexation and disappointment, and our consternation was extreme.

We had now resolved to keep off from the island, and brave the fury of the winds and the waves, in the open sea, whatever might be the event : but from this we were dissuaded by these islanders, who assured us it was impossible so small and crazy a boat as ours should long resist the violence of the storm in the wide sea ; but that it must either overset, or bilge and sink. They advised

us rather to coast the island towards the north, where we might possibly find some small inlet, where we might be less exposed to the waves; promising us that they would proceed the same way along the shore, and afford us every assistance in their power. This advice we followed, and, bearing up to the north, without standing far from the shore, in about half an hour met with a cavity in a rock, which, from being wind-ing, was not much exposed to the agitation of the waves. Into this we happily carried our bark without damage, and landed, with the assistance of the worthy priest and the persons with him, towards whom I shall feel the warmest sensations of gratitude while life shall remain. He treated us, when on shore, with the utmost kindness and hospitality; and when I had presented to him the circular letter I had received from the Bishop of Lipari (in which I was warmly recommended to the parish-priests of those islands, who were requested to furnish me with every assistance necessary for my philosophical researches during my stay), he redoubled his

his civility, offering to serve me in every manner in his power ; and his whole conduct sufficiently evinced the sincerity of his offers.

It was not yet noon, by some hours, when we landed in Alicuda, but the fatigue I had undergone prevented my having any inclination to begin my researches that day ; and the following night I slept in the bark, which had been drawn on shore ; my deliverer (for so I may justly call the good priest of this island) having sent me a mattress, and a coverlet, to defend me from the moisture of the night, as I was too much fatigued to ascend to his habitation, which was situated half way up the mountainous island. He likewise hospitably invited me to share with him the provisions of his frugal table, and some bottles of excellent malmsey of Lipari, which revived my spirits, and restored my strength.

I remained at Alicuda two days (the 14th
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and 15th of October), during which I sufficiently gratified my curiosity, and acquired a satisfactory knowledge of the nature of the island. The observation of the ancient Grecian philosopher is well known, who having been driven by a tempest on the coast of Rhodes, and with great difficulty reached the land, seeing certain geometrical figures traced in the sands, immediately exclaimed : *I perceive the vestiges of men* : I, in like manner, the moment I set foot on the shore of Alicuda and surveyed it, might have exclaimed : *I perceive the vestiges of fire*. These were the pumices, glasses, and enamels, which presented themselves to my view on the skirts and sides of Alicuda, and which it is unnecessary particularly to describe, since they entirely resemble those of Felicuda, and are found like them mingled with tufaceous substances.

Of the two days which I allotted to my researches in Alicuda, I set apart the first to examine its circumference by sea, the night preceding

preceding the 14th of October having been sufficiently calm to permit me to make the circuit of it in my boat without danger.

I shall here, therefore, specify the principal products I discovered during my circuit round the shore of the island; this being the part which, more than any other, must interest the philosophical naturalist. I shall not name the places where I found them, since two of the inhabitants who accompanied me were unable to assign any names by which they were known; the different parts of the shore of the island having in fact no fixed names: I shall only indicate their distances from the place whence I set out.

At the distance of forty paces from that part of the island which fronts the east, we begin to find, as we turn towards the north, entire rocks, formed of globes of a blackish lava, with a petrosiliceous base, which, though porous, is heavy from the compactness of the solid parts, which have a little

lustre, are very hard, and in their fractures affect the conchoidal figure; they move the magnetic needle at the distance of more than a line, and give sparks tolerably freely with steel. The petrosiliceous substance contains a few felspars, and a considerable number of shoerls. These globes of lava are of various sizes, some of them being a foot in diameter. They are detached, and are never found in strata, but only in large accumulated heaps.

To what cause can we ascribe the division of this lava, and its conformation in the manner described? I at first imagined that its figure might be the consequence of the agitation of the sea, when its waters reached to a greater height; as these accumulations of globes are now some poles above its level. In fact, in my maritime excursions round the other Eolian isles, and at Etna, I have frequently met occasionally with similar balls of lava, which clearly indicated that they had been rounded by being continually rolled by the waves of the sea, in the same manner

manner as we find stones rounded in rivers. In the course of this work I have adduced several examples of this kind, even among the glasses and enamels of Lipari, which have taken a globose figure. But a more careful examination of these globes compelled me to change my opinion, on considering that the pieces of lava that have acquired an orbicular form from the agitation of the waters, are always more or less smooth on their surface; whereas these were rough all round—though their roughness, consisting in general of minute parts and points, must have been worn away by rubbing against any obstacle. I observed, besides, that these globes, in many places, had a shining and scoriaceous appearance, extremely similar to that of the pieces of lava incessantly thrown out by the volcano of Stromboli. I am therefore rather of opinion that they are pieces of lava that have been thrown out from a volcano in Alicuda, and taken a spherical form in the air, from their great softness, as similar phenomena may be

observed in the products of other burning mountains.

About a mile and a half beyond the lava now described, proceeding still towards the north, we find a second, not in globes, but in an ample current, which falls like a cataract into the sea. It is of a petrosiliceous base, has the colour of iron, is filiceous, or rather vitreous in the fracture, and full of shoerlaceous crystallizations. Whoever has seen lavas which have lately issued from the mouth of a volcano, would imagine this of extremely recent date. On the surface, it preserves that shining aspect, that freshness, which is peculiar to lavas that have not yet been exposed to the influences of the atmosphere. The specimens of it which I detached, might be taken for that scoria of iron which we find in the shops where that metal is fabricated. I have in my possession some pieces of the lava which was thrown from the highest crater of Etna, in 1787, which I collected on the spot, and have de-
scribed

scribed elsewhere *. These, with respect to the freshness of their appearance, are not distinguishable from the lava of which I now speak. Yet is the latter of an antiquity beyond our knowledge, for we have no record of any conflagration in Alicuda since history has been written. I have chosen to speak more at length on this peculiar property of the present lava, to prove, or rather to confirm what I have already proved, how uncertain are all conclusions relative to the greater or less antiquity of lavas, derived from the more or less sensible degree of decomposition which they manifest. Such conclusions may be well founded, when the lavas are of the same nature, and affected by the same extrinsic circumstances; since, then, those of a more ancient date must be most changed by time: but where their nature and qualities are different, one lava may be considerably altered in a few years, and even reduced to an earth, while another shall remain for ages, perfectly

* See Chap. VIII.

preserved,

preserved, and in the same state in which it was thrown out of the fire, of which the lava now described is an evident example.

At the distance of another full mile from the place whence I took my departure, the mountainous coast of the island becomes somewhat more level; and on this plain arise detached masses of porphyry, which shew no signs of having been touched, much less fused, by the fire. It is of a petrosiliceous base, of the colour of brick, affords sparks with steel, and is extremely compact, and without pores, except a few superficial vacuities, coated with a thin white crust of carbonate of lime, sometimes studded with crystals of the same kind. These small geodes, which have been produced, without doubt, by filtration, are decomposed in a few moments by the nitric acid, and dissolve with a strong effervescence. This porphyry, in its hardness, polish and lustre, is not inferior to the Egyptian. Besides shoerls, it contains numerous
cubical

cubical lamellar felspars, of a changeable whiteness.

When exposed to the furnace for a few hours it becomes black, and after a longer time fuses into a black, compact, and very smooth enamel, which sets in motion the magnetic needle, though it produced no such effect when it was porphyry. The felspars remain entire.

In this part of my circuit round Alicuda I have described two kinds of lavas, the one found in detached globes, and the other in a current; which, however, from the identity of their nature, may be considered as one only; both having for their base the petrosilex, and containing shorls and felspars: they are therefore both porphyritic. And as the rock last described is a porphyry with a petrosiliceous base, it appears that they all three derive their origin from one common matrix, except that one portion of it has been subjected to fusion, and the other remained untouched.

A little

A little beyond the plain abovementioned appear some tufas, which cover a long and steep declivity descending into the sea, and beyond the tufas we again meet with lavas forming broad currents. These lavas have the horn-stone for their base, and their external characteristics are the following :

They are light, extremely porous, and therefore easily penetrable by water ; they with difficulty give sparks with steel, which breaks off fragments at every stroke. They feel rough under the finger, and emit an argillaceous odour. They contain numerous felspars, which are conspicuous from their whiteness, on a dark red ground approaching to a black. Some shew a degree of calcination which they have suffered in the fire, and are, in consequence, easily crumbled. Others have suffered no injury ; and the difference observable in them is rather to be ascribed to the difference of the nature of the felspars, than to their having suffered a greater degree of heat, the lava in which they are both incorporated
 appearing

appearing to have been equally affected by that agent.

Alicuda is about six miles in circuit, and I have as yet made the tour of only the one half. On completing it, however, I only met with lavas of the same kind with those already described, diversified by a few varieties that do not merit a particular description.

I have given some faint sketches of the appearance of the lavas in some parts of this island; but it would be impossible for me to give an adequate idea of the fearful wildness of the scenes which present themselves to the eye for two-thirds of this circuit. Among all the volcanized places I have visited, I have yet seen none so convulsed by subterranean fires, so torn and shattered, and so filled with accumulated ruins by the devastations of time and the sea.

In some places we find a lava extending
for

for several hundred paces, which has been broken by the waves in such a manner as to form a rock surrounded by the water, abounding in craggy cliffs and precipices of a fearful height.

In others the lava descends perpendicularly from the most elevated summit of the mountain, and buries itself in the water, surrounded on the sides by projecting crags, and huge overhanging stones, which threaten every moment to thunder down into the deep.

Here the lavas do not form one continued body, but are composed of detached and loose globes, particularly dangerous to those who may attempt to ascend the mountain, as they roll from under and put in motion a great number of others, thus producing a destructive stony torrent. Even the large falcons, which frequent the highest summits of this island, if they chance to alight on these heaps of round, loose stones, will often, as I have myself seen, by moving

one, put others in motion, till bird and stones fall, all together, headlong into the sea.

In another place lavas are found, not of one kind alone, but a confused mixture of several, piled in disorder one on another to a prodigious height ; and in many of them there is no part which does not threaten immediate fall and ruin.

Through the midst, however, of these mishapen rocks and horrid precipices are formed, I will not say roads or paths, but narrow winding gutters, by which we may ascend to a certain height ; and through these I took my way, when from time to time I landed from my boat and went in search of the lavas I have described, and examined them on the spot. I was obliged, however, to advance with the greatest caution, as to have made a single false step would have been to have fallen headlong down a precipice. I could not but recollect the lines of Dante, in which he describes the laborious

borious passage over the horrid crags and precipices of one of the abyſſes of his Hell.

“ E proſequendo la ſolinga via
Fra le ſchegge, e tra rocchi de lo ſcoglio,
Lo piè ſenza la man non ſi ſpedia.”

“ And ſtill along the ſolitary way,
“ Proceeding over rocks and precipices,
“ The foot without the hand no progreſs made.”

And though the fatigue in again deſcending to the ſea might be leſs, the danger was equal, if not greater, from the unſtable and ſlippery nature of theſe deceitful places.

Having completed the circuit of the ſhores of Alicuda on the fourteenth of October, I appropriated the next day to the examination of the interior part of the iſland. I could, however, only make my reſearches in the part which fronts the eaſt and ſouth-eaſt; the remainder being inacceſſible from the dreadful crags and precipices already mentioned.

When

When seen from the sea, on the south-east side, at the distance of two or three miles, this island has the appearance of an obtuse cone, but with a considerable incavation on one side. This incavation has no resemblance to a crater, and on a nearer examination we find it is only a lower part of the mountain. In fact, we perceive no marks of the mouths of ancient volcanos in the whole circuit of Alicuda; either because they have never existed there, or because all traces of them have been effaced by time or some other destructive agent. I have discovered the appearances of a true crater nowhere but in the highest part of the island, where there is a hollow, not very deep indeed, but about half a mile in circumference; and I incline to believe it to have been a crater, from finding there a group of lava diverging as from a centre over the body of the island.

I examined the lavas which cover the sides of this mountainous island, at least where I could reach them without danger,

in the same manner that I did those which form the base or shore of it. I shall not describe them particularly, as it appears unnecessary, they generally having the petrofilex or horn-stone for their base, and abounding more or less, as usual, in felspars. Their external surface is covered with a yellowish and friable coating, originating in a beginning decomposition. The deep fractures which we find in many parts of them enabled me to perceive that they must have flowed at different periods, forming beds or strata one above the other, as is frequently observed in other volcanized countries.

M. Dolomieu was of opinion that “ Felicuda and Alicuda had once formed a single conical mountain, which had been opened and separated on one side.”

This is certainly not impossible, but I must say it appears to me extremely improbable. If the sea, or any other violent agent, had divided this conical mountain
into

into two parts, it is difficult to conceive that no record or tradition should remain of this convulsive separation. On the contrary, when I attentively examine and consider these two islands, they have every appearance of being each a distinct island, like Stromboli, Saline, and the others. Both likewise have on their highest summits the vestiges of their primitive crater, that is, of that which by its eruptions has given birth to its respective island. The lavas, likewise, which have flowed from these summits, as from central points, and enlarge and extend as they take their course down the sides of the mountain towards the sea, seem clearly to prove that each was a complete island in itself; nor can I doubt but the French naturalist, had he visited these islands themselves, would have been of my opinion. He only viewed them from the highest part of Saline, that is, at the distance of five-and-twenty miles from Felicuda, and five-and-thirty from Alicuda. At that distance they seem very near to each other; so that M. Dolomieu, judging from appearance, supposes Felicuda

to be only five miles from Alicuda, though it is in reality twice that number. As, therefore, at Saline, they appear to be so little distant from each other, nothing was more easy than to imagine that they once formed a single mountain, which, either by earthquakes, the violence of the sea, or some other unknown cause, had been broken and divided into two parts, an arm of the sea taking possession of the intermediate space.

From the summit of Saline he, likewise, estimated Alicuda to be only twenty miles from Cefalu, on the coast of Sicily; and, in fact, when I was on the same eminence, these two places appeared to me to be very near, and Felicuda seemed almost to join to Alicuda; yet it is certain that the distance between Alicuda and Cefalu exceeds five-and-forty miles. It is well known that this optical illusion takes place with respect to any object seen at a distance, either by land or water. Nothing happens more frequently to the traveller than to find that

two

two rocks, mountains or buildings, which when viewed at a distance he had imagined to be extremely near to each other, and almost to touch, are in fact separated by an interval of several miles.

The volcanic materials of Felicuda, as has been already seen in the preceding chapter, consist of lavas with a horn-stone base, shoerl, and felspar; not to mention pumices, tufas, and glasses. The latter three products are likewise found in Alicuda, but the greater part of the lavas have the petrosilex for their base.

Notwithstanding these two islands exhibit indubitable characters of fire, no signs of it in a state of activity are at present to be seen. It may indeed be conjectured that some remains still exist in the internal parts of Felicuda, from a warm spring, emitting the smell of sulphur, which issues from the northern side of a rock, a little above the level of the sea.

I shall here collect the notices that have been left us by the ancients relative to Felicuda and Alicuda, as they are extremely few and brief. We know that their names were Phenicusa and Ericusa (Φοινικουσα and Ερικουσα), which are said to have the following derivation: Aristotle, speaking of Phenicusa, or Felicuda as it is at present called, says, "it received that name from its abounding in palm-trees"—φοινίξ, in the genitive φοινικος, being the name of that tree in Greek*. Ericusa, or Alicuda, we are told by the author of the epitome of Stephanus, was so named from the *erica* or heath, which there grows plentifully†. Strabo, likewise, informs us that these two islands derive their names from plants‡. At present, however, though heath is not wanting in Alicuda, Felicuda does not afford a single

* Εν μια των Αιολῶν προσαγορευομένων νήσων πλῆθος τι φασὶ γενεσθαι φοινικων, οθεν καὶ φοινικωδὴ καλεῖσθαι.

In Mirandis.

† Ερικουσα, μια των Αιολῶν νήσων, ἀπο φύλῃ καλεσμένη.

‡ Των δὲ λοιπῶν Ερικουσα μὲν καὶ Φοινικουσα ἀπο των φυτῶν κεκληται. Lib. VI.

palm-tree, nor is there one to be found in any of the Eolian isles.

But neither the above-cited authors, nor any other ancient writers, make the least mention of any conflagrations in these two islands ; probably because, though, in their time, Stromboli, Vulcano, and even Lipari threw out fire, Felicuda and Alicuda, as we have seen was the case with Didyma and Euonimus, were entirely extinguished.

C H A P. XIX.

OBSERVATIONS WHICH HAVE AN IMMEDIATE RELATION WITH THE VOLCANIZATION OF THE EOLIAN ISLES—ENQUIRIES RELATIVE TO THE ORIGIN OF BASALTES.

Methods and instruments proper to raise stony bodies from the bottom of the sea surrounding the Eolian isles—The bottom of the channels between Vulcano, Lipari, and Saline, entirely volcanic—The same observable of the roots of the Eolian isles below the water—Gravel and volcanic sand in the channel that divides Panaria from Lipari—The rocks in the middle of the channels between Saline and Felicuda, and between Felicuda and Alicuda, analogous to those of the same islands, but, probably, primordial—Decisive proofs deduced from these observations, that the shoerls and crystallized felspars of the lavas have not been

been taken up by them when in a fluid state, nor formed within them at the time of their congelation—Confirmation of these proofs—The Eolian isles placed in a direct line from east to west—A similar direction observable in some islands and volcanic mountains in other countries—Not improbable that all the eight Eolian isles were formed at the same time, and perhaps very suddenly, with respect, at least, to their first rudiments—Explanation of the cause why islands and burning mountains are sometimes produced disposed in a right line—Materials of the Eolian isles, for the most part, porphyritic—Analysis made by the author, proving that the red Egyptian porphyries have not for their base the petrosilex, but rather the horn-stone—Enquiry whether the vitrifications found in such prodigious quantities at Vulcano and Lipari, are found in similar quantities in any other volcanic countries—Uncertainty of this from the want of accurate mineralogical descriptions of the greater part of volcanos—The accounts given of them usually

usually general and wonderful, but little instructive—Volcanic glass found in Iceland, but by no means in sufficient quantities to form mountains—No notices of vitrifications in the volcanos of the islands of Ferro, nor in those of Norway and Lapland—Little or no glass in the volcanized countries of Germany and Hungary—Nor in the extinguished volcanos of France—The quantity of vitrifications at Vesuvius, and several other parts of the Neapolitan territory, more considerable—Scarcely any at Mount Etna, or the volcanic mountains of Padua—A more extensive tract of pumices found perhaps in no part of Europe than in the island of Santorine—This island, however, affords no glass—Great scarcity of vitrifications in the three other quarters of the globe—Conclusion: that Vulcano and Lipari offer a greater abundance of glasses than any other volcanized part of the world; but that Santorine exceeds them in the quantity of pumices—Enquiries relative to this scarcity of vitrifications in volcanos, whether burning or extinct

extinct—It seems to proceed less from the quality of the stones acted on by the volcanic fire, than from the inefficacy of that agent to produce vitrification—A successively stronger degree of heat requisite for a stone to pass from the state of lava into pumice, and from that of pumice into perfect glass—Elucidation of the cause why some volcanos produce pumices, but not glasses—The formation of pumices hitherto not attainable in our furnaces—Black the natural colour of pumices, which are rendered white by external causes.

Enquiries relative to basaltcs—These originate in the humid way, when the word basalt is understood in the sense in which it was used by the ancients—The columnar stones which, from their prismatic configuration, resemble the basaltcs of the ancients, originate according to circumstances in the humid or the dry way.—Proofs of their origin in the dry way in Vulcano and Felicuda—Nature, in the fossil kingdom, produces crystals as well by the dry

4

way

way as by the humid—This exemplified in the generation of basaltcs—An abuse of analogy to conclude from it one common origin of basaltcs—When examined detached, they frequently bear no peculiar character of their origin, which must be determined from local circumstances—Enquiry whether basaltiform lavas have become such by a sudden condensation within the sea—Proofs which shew, first, that many basaltiform lavas have assumed this symmetrical configuration on coagulation in the waters of the sea; secondly, that in others it has taken place only by congelation in the air; thirdly, that very numerous lavas have proved refractory to this figure, both within the sea and in the air—The property of assuming a prismatic figure appears, in many lavas, not to depend on their being of a particular species, nor on their compactness and solidity, but on extrinsic and adventitious circumstances—These circumstances indicated, with an explanation in what manner, according to their presence or absence, lavas frequently assume a
prismatic

prismatic form in the air, while others remain irregular within the sea.

THE form, size, and structure of the Eolian isles, the different materials of which they are composed, and the primordial rocks from which these are derived; the fires which still burn in some, and the phenomena and changes which accompany them; with the comparison between the present conflagrations and those of ancient times, constitute the principal objects to be considered in writing the volcanic history of such a country. And though we have already employed nine chapters on these subjects, we conceive the candid reader will not accuse us of extreme prolixity; both because we have had to treat of seven islands, and because our object was to write the Lithology of this ancient and celebrated country. The present chapter, we flatter ourselves, will, in like manner, be acceptable to the enquiring naturalist, as it contains various observations and reflections

tions which have a direct and immediate relation to the deflagrations of the Eolian isles.

We have already observed and described these islands from the summit to the base, which buries itself in the waters of the sea. But it was impossible to examine their internal part in the same manner as the external; though the importance of such an examination merited that every effort in our power should be exerted to effect it. It would be equally interesting and instructive to ascertain the nature of the bottom in those tracts of sea which surround these islands, and separate them one from the other. I shall, therefore, here relate what I observed with respect to this subject, and describe the methods and instruments to which I had recourse to make my observations.

Where the depth was not great, I found extremely useful the large tongs, mentioned
by

by Donati *, furnished with strong pincers, fixed to one or more bars, which by means of a rope may be closed or opened at pleasure, and thus take hold of and bring up any substances from the bottom. But where the water was deep, I found it more convenient to employ one of those nets which fishermen use to envelop, and tear from the rocks, coral and other subaqueous bodies. These nets I easily procured, as coral is fished up on these coasts; of which fishery I shall treat further in a subsequent part of this work.

Employing, therefore, these two instruments, the following was the result of my observations, which were not made on pieces that lay detached on the bottom, but on such as formed a continued whole with it, as was evident from the recent appearance of the fractures where they were broken off.

* Saggio sopra la Storia naturale del Mare Adriatico
—Essay on the Natural History of the Adriatic Sea.

In the channels which divide Vulcano from Lipari, and Lipari from Saline, the bottom is entirely volcanic, and affords products of the same species with the two shores. The same is observable of the foot of the islands, which foot in some situations descends perpendicularly ; but in others has a considerable declivity, and thus enlarges the circuit of the island. The pieces of lava which I was here able to detach, did not differ from those of the shore, which I have already described.

But at a greater distance between island and island this was not the case. I made my experiments in three different places. The first was between Lipari and Panaria ; but here, the water being very deep, I did not succeed in my attempts to bring up any stony body from the bed of the sea, but only testaceous and crustaceous animals alive or dead, enveloped in sand and gravel, and forming a species of crust more or less thick. The sand and gravel, it is to be observed, were volcanic.

The

The second place in which I made this experiment was between Saline and Felicuda, and the third between Felicuda and Alicuda, in both instances, at the point of greatest distance, as nearly as the eye could measure, between the two islands. In each of these situations, besides drawing up from the bottom portions of the before-mentioned crust, I likewise obtained several stony fragments, which, from the great force it required to separate them, and the recent appearance of their fractures, evidently had an immediate communication with the solid and rocky bottom. The whole number of these fragments, great and small, was eleven; of which four were brought up between Felicuda and Alicuda, and seven between Saline and Felicuda. The base of five* of them was a petrosilex almost opaque, affording sparks with steel, compact, of a grain a little scaly, but fine; the colour

* The author must here have committed some mistake, as he, immediately before, said the whole number of pieces was eleven, and now mentions *five* and seven.
T.

of two of these pieces was a lightish blue, and that of the three others a grey. The base of the seven other pieces was a dark-green horn-stone moderately hard. None of them differed in their base, and shoerlaceous and felspathose crystallizations, from several volcanic lavas of the Eolian isles.

These eleven pieces, however, excited in me a strong suspicion that the rocks from which they were detached had not been exposed to the action of fire. The particles of the petrosilex in them were more closely united, had greater hardness, and a more siliceous appearance, than in the same stone of those islands which has been subjected to fusion. In like manner, the lavas of a horn-stone base usually have somewhat of a fibrous nature, and a thinness in their texture which is not seen in the stone of the same kind. These two rocks, therefore, appeared to me to be in their natural state.

I consider these experiments as very instructive with regard to the origin and formation

formation of these islands. We may conclude from them : First, That the part of the islands which is buried under the waters of the sea, has suffered the action of the fire in the same manner with that which is exposed to the eye of the observer. Secondly, That Vulcano, Lipari, and Saline form one continued group of volcanized substances, which, at first, might probably have one common central conflagration, that, dividing into three branches, and affording a passage to three distinct mouths, gave birth to three islands, which conflagration, by subaltern and successive ramifications, and ejections of new matters, afterwards increased in extent. No sensible remains, indeed, of such a fire are at present discoverable in the internal parts of Saline, nor are any observable in Lipari, its whole efficacy appearing to be confined to Vulcano. Thirdly, That Alicuda, Felicuda, and Saline do not appear to have any volcanic communication with each other, at least in the parts that form the bed of the sea, which separates these three islands from each other ;

since those parts, as far as the eye can perceive, shew no signs of the action of fire. Fourthly, That these three islands, and perhaps likewise Stromboli, are situated in the vicinity of analogous but primitive rocks. The perfect resemblance of the shoerls and feltspars in these rocks, both in those that have suffered change from the fire and those that have not, is a demonstration that these crystallizations have not been taken up by the lavas when they flowed in currents, nor formed in them at the time of their congelation.

From the very beginning of this work, I have adduced facts of the same nature, which I have the satisfaction to confirm by the present; and which become of the greater importance, as I have lately read that a naturalist of eminence inclines to believe that the shoerls of lavas are formed when the latter condense and become cold, because then the homogeneous molecules separate from the heterogeneous, and unite by affinity in small crystallized masses.

This

This ingenious theory is not only contradicted by the observation made above, but appears to me not to accord with the usual operations of Nature. Were it well founded, I can perceive no reason why the shoerls in lavas should not re-appear after they have been fused within them in the furnace, and, being removed into a cold place, have acquired their former hardness. But though I made experiments with fire on some thousands of pieces of lava, not one of them re-produced its shoerls, though many were continued a long time in a state of fusion, and afterwards suffered quietly and slowly to cool and consolidate ; which two circumstances are known to favour the formation of crystallizations. Shoerls were, indeed, sometimes found in the lavas, after fusion, when cooled and hardened ; but these had proved refractory to the fire ; as appeared on exposing them again to the furnace detached from the lava.

The eleven pieces of primordial rock

M 3

broken

broken from the bottom, exhibited in the furnace the same changes with their congenerous lavas exposed to the same fire : the felspars, however, remained refractory.

The Lipari islands extend in a right line from east to west the distance of about fifty miles, except that Vulcano makes a small angle. Stromboli is the first to the east, and Alicuda the last to the west. This is not the only instance of volcanos having produced islands, or rather mountains, arranged in a rectilinear direction. We find an example of this in the Moluccas, which are the produce of subterranean fires, and placed one beyond the other in a right line. When, in 1707, a new island was thrown up by a submarine volcano, in the Archipelago, near Santorine, other small islands arose from the sea near it, to the number of seventeen, in a right line, forming, as it were, a long chain of black and dark rocks, which visibly increased in dimensions and height, and, approaching each other, at length united,

united, and, joining that which first arose from the water, formed one single island*.

Another memorable instance of this direction of volcanic mountains (for islands are in fact only mountains buried in part under water) is the production of seven lesser mountains by the eruption of Vesuvius in 1760; the account of the formation of which, as it may throw some light on that of the Eolian isles, I shall here give, from the accurate relation of Professor Bottis, an ocular witness.

After repeated concussions of the earth, which were felt fifteen miles round Vesuvius, the sides of the fiery mountain opened in the territory of the Torre del Greco, and fifteen volcanos appeared, eight of which were soon after covered by a torrent of lava, which rushed from one of them; the other seven remaining entire, and incessantly ejecting from their mouths vast quantities of ig-

* Vallisneri Oper. fol. t. ii.

nited substances, which falling almost perpendicularly around the volcanos, produced, in the short space of ten days, seven small mountains, of various heights, disposed in a right line. During these ejections, the noise which accompanied them sometimes resembled that of violent thunder, and at others the discharge of a number of cannons. Several of the burning stones, even the largest, were thrown to the height of nine hundred and sixty feet, and some fell at a considerable distance from the mouth whence they were thrown. These eruptions shook all the neighbouring country, and the roarings of the mountain were dreadful to the inhabitants. After the tenth day, the eruptions ceased, and the newly-formed mountains, gradually cooling, permitted a nearer approach; when some were found to have at their summit a cavity resembling an inverted funnel, and others a simple hollow, of greater or less depth.

The production of the Eolian isles being anterior to the records of history, we know
not

not whether this took place at one time, or in different periods. The relation, however, just cited, of the origin of the seven Vesuvian mountains clearly proves the possibility of their being produced at the same time. It also proves, that the whole eight might be formed in no long space of time, with respect at least to their first rudiments, it having been seen that they have received successive additions.

We also evidently perceive, that the inflammable substances generative of the Mollucas in Asia, of the chain of islands at Santorine, of the Vesuvian mountains above described, and of the Eolian isles, have formed a direct subterranean zone incomparably longer than broad. This phenomenon may be explained by recurring to the clefts and fissures perpendicular to the horizon, existing in many places within the earth, as well in soft substances as in the more durable and solid ; within which clefts should substances proper for the production
of

of volcanos be found in abundance, and become inflamed, in separate heaps, burning mountains would arise, in a direct line, and more or less large, according to the quantity of the ejected matters.

From the particular descriptions of the islands of Lipari, we have seen that the combustible substances which have produced them have sometimes been contained within granite, as at Panaria and Basiluzzo, but for the most part within rocks which have for their base the petrosilex, the horn-stone, and the felspar. It likewise appears, from the observations made at Stromboli, that, even there, these burning substances have their seat in the horn-stone rock, though, from the size of the island they have produced, they must undoubtedly be buried at an immense depth. If we would simplify the facts relative to the materials of all these islands, we shall find that they are for the greater part porphyritic; as are likewise some of those submarine tracts, apparently
not

not touched by the fire, and placed among them; as has been shewn above*.

When I compared the effects of the furnace on volcanized porphyritic rocks with those it produces on the natural, I mentioned some red Egyptian porphyries, the base of which I believed to be horn-stone, rather than petrosilex, relying on the analyses of Bayen, as related by Delametherie, of an Egyptian porphyry of the same colour, and similar to those on which I made my experiments†. But not having then been able to analyse them, from want of time, I determined to do it afterwards, and give an account of the result, in another part of this work, when I should again have occasion to speak of this species of volcanic rock. I shall here give this analysis, which affords a confirmation that the base of these porphyries is not petrosilex, as they contain magnesia, which is not found in that stone.

* See the Note at page 82, Chap. XI, in which I have spoken of the essential characters of porphyry.

† See Chap. XI.

From this circumstance, and the nature of their constituent principles, their base ought rather to be called a horn-stone, of the nature of which it at least participates. This analytical observation is likewise here very opportune, as it is an additional proof that I have properly called porphyritic the lavas with a horn-stone base, and containing felspars, which are so numerous in these islands.

The red Egyptian porphyries which I analysed are of two species: the first has been described at page 118 of Vol. II.: the second differs only in its colour being of a less lively red, and in the abundance of its felspars. It is evident, that to render this experiment accurate, the substance of these two stones should be first freed from the shoerls and felspars which they contain.

First Species.

Silex, somewhat reddish,	-	80
Alumine	- - -	7
Lime	- - -	3
		Magnesia

Magnesia	-	-	-	2
Iron	-	-	-	6

Second Species.

Silex	-	-	-	81
Alumine	-	-	-	$7\frac{1}{2}$
Lime	-	-	-	4
Magnesia	-	-	-	2
Iron	-	-	-	$4\frac{1}{2}$

Besides the porphyritic lavas with which the Eolian isles abound, we have seen that they contain great quantities of tufas ; and that Stromboli is distinguished from the other islands not only by its volcano, but by the beautiful specular iron it affords ; and Lipari by its chrysolites and zeolites, but still more by the prodigious quantities of pumices and glasses which it contains. I cannot, indeed, reflect on those enormous masses of vitrifications, without renewed wonder ; which has been still more increased by the discovery, by means of the forceps and coral net, that these vitrifications are continued from Lipari, till they join those of Vulcano, which
on

on the north and north-east side abounds in pumices, enamels, and glasses. The vitreous substances, therefore, of this island, and those of Lipari, which, as has been said, occupy about two-thirds of the latter, compose an accumulation of glass, not less than fifteen miles in circuit. It is impossible to attend to this stupendous phenomenon without feeling our curiosity excited to know whether it be peculiar to these islands, or found likewise in other volcanized countries. But satisfactorily to answer such a question, it would be requisite that we should be acquainted with the volcanic mineralogy of all the volcanos in the world; not only those at present burning, but those extinguished, which are infinitely more numerous; in the same manner as we are with that of Vivarais and Velay, the islands of Ponza, Vesuvius, Etna, the Eolian isles, and the mountains of Old-Brissach, by the labours of Faujas, Gioeni, Dolomieu, Dietrich, and myself. Of such a mineralogy, however, we are entirely destitute. The greater part of those who, either by chance, or from curiosity, have

have viewed burning volcanos, have only described in their relations the most common and general phenomena, less adapted to increase the knowledge than to amuse the imagination of their readers, and excite their wonder——Shocks and undulations of the earth—the sea in commotion, and raging without a tempest; here retiring and leaving its shores dry, and there inundating vast tracts of land—subterranean thunders, and roarings in the air above—the sun disappearing in thick darkness at noon—whirlwinds of smoke, ashes, and flame, bursting from the yawning gulf—burning stones hurled towards heaven, and falling in a fiery hail—torrents and rivers of liquid lava, sulphur, and bitumen, pouring down on the valleys below, and carrying terror, desolation, and death—lands, now suddenly produced by submarine eruptions, and now torn from their foundations, and swallowed up by earthquakes——these compose the usual descriptions of volcanos, which, though they may not be useless when the facts are faithfully stated, and not magnified by the imagination

gination of the narrator; yet they commonly want one essential requisite; that is, lithological descriptions of the bodies ejected by these burning mountains. As glass and pumices, however, are known even to those who are unacquainted with this part of natural science, we may, with certainty, or, at least, with the strongest probability, conclude, that they are produced by the volcanos in the descriptions of which we find them expressly mentioned as making a part of the ejected matters, and that they are not produced when not mentioned. Thus in Iceland, the greater part of which island is only an accumulation of volcanos either extinct or active, it is certain, from the accounts of travellers, that numerous glasses are found, to which the name of Icelandic agate has improperly been given, only because they have the lustre and beauty of that stone. The present eruptions of this island, likewise, not unfrequently contain pumices; but no person has ever asserted that there are entire mountains of these stones, or of glasses.

The islands of Ferro are considered as volcanic, and produce the famous zeolites, mixed, as it is said, with lava ; but as yet we know nothing more of them. The minute account of each of these seventeen islands, published by Jacobson Debes, in which no mention is made of the vitrifications, authorizes us to conclude they do not exist there.

Norway and Lapland have their volcanos, which from time to time burst forth in fearful eruptions, according to the accounts of Pennant and others, who, however, give us no further information.

Leaving these cold regions, and passing to Germany and Hungary, we find some tracts of these countries that have likewise been subjected to subterranean conflagrations, which, however, have produced no vitrifications, or scarcely any. " I have sought in vain the black agate of Iceland, and the true pumice," says the above-cited Baron Dietrich, in his long and circumstan-

tial Memoir relative to the volcanos near Old-Brifach.

Proceeding to a milder climate, and approaching nearer to our own country, we find that the extinct volcanos of France afford no pumices or glaffes ; which assertion I can make on the authority of M. Faujas, who has written fo well concerning them, than which one more unquestionable cannot be adduced.

It is not the fame with Italy ; the country in which fire has principally extended its empire. The Neapolitan territory peculiarly abounds in pumices, enamels, and glaffes, as appears in the iflands of Ponza, at Herculaneum, Pompeii, Mifeno, Monte Nuovo, the Rock of Burnt Stones, Proci-da, Ifchia, and the valley of Metelona *. Even in our times Vefuvius has ejected fimilar bodies ; but, with refpect to Etna, its fires rarely produce the flightest vitri-fication.

* See Chaps. IV, V, VI.

The only place in Europe, which, in the abundance of its pumices, can equal, or perhaps surpass Lipari, is the island of Santorine. On this subject we may consult Thevenot and Tournefort, two intelligent travellers, who at different periods examined this island, which has not hitherto, to my knowledge, been considered by volcanists in this point of view.

The former, who visited Santorine in 1655, observes, that "many of the inhabitants live in caves, made under the earth, which is extremely light, and easily dug into, as it consists entirely of pumices." He afterwards relates a fact, which has a particular relation to our present subject, since it teaches us in what manner these light stones may be thrown up, immediately by the sea, in volcanic eruptions. His account is as follows :

"About eighteen years ago, on a Sunday
 "night, a violent noise began to be heard
 "in the port of Santorine, which was like-

“ wife heard even to Chios, distant more
“ than two hundred miles, and was thought
“ to be occasioned by the Venetian fleet
“ having engaged the Turks ; in conse-
“ quence of which great numbers of people
“ got upon the highest places early in the
“ morning, to be spectators of the battle ;
“ and I remember the Reverend Father
“ Bernardo, a venerable man, perfectly de-
“ serving credit, told me he was one among
“ the number of those who were so de-
“ ceived, imagining they heard a violent
“ cannonade. They could however see no-
“ thing. In fact, this noise was caused by
“ a fire kindled in the earth, under the har-
“ bour, the effect of which was, that from
“ the morning to the evening a vast quan-
“ tity of pumices rose from the bottom of
“ the sea, with such violence and noise as to
“ resemble repeated discharges of cannon,
“ and so infected the air that several persons
“ died at Santorine, and many lost their
“ sight, which they did not recover till
“ some days after. This infection extended
“ as far as the noise which had preceded it had
“ been

“ been heard ; since not only in this island,
 “ but at Chios and Smyrna, all the silver
 “ became red, whether kept in coffers or
 “ in the pocket ; and the religious who re-
 “ sided there told me that all their chalices
 “ became red. After some days the infec-
 “ tion ceased, and the silver returned to its
 “ former colour.

“ The pumices which were thrown up
 “ covered the Archipelago in such a man-
 “ ner, that, for some time, when certain
 “ winds prevailed, the harbours were so
 “ blocked with them, that not even the
 “ smallest vessels could get out till a way
 “ was made for them by removing the
 “ pumices with long poles, and they are
 “ still seen scattered over the whole Medi-
 “ terranean, though in a small quantity *.”

Tournefort, after having remarked from
 Herodotus that Santorine was once called
 Καλλιτυνη or “ the most beautiful island,”
 adds, that “ its ancient inhabitants would

* Voyages de M. de Thevenot, Prem. Part.

“ not at present know it, since it is covered
 “ with pumices, or, more properly, is a
 “ mine of those stones, which may be cut
 “ into great square blocks, as other stones
 “ are cut in the quarries *.”

According to this traveller and to Thevenot, Santorine is thirty-six miles in circuit ; whence it appears what a prodigious accumulation of pumices there must be in this island and the adjacent sea. It merits notice, however, that neither these two travellers, nor others who have written of Santorine, make the least mention of glasses of any kind ; we may therefore venture to affirm that the subterraneous fires have, there, never produced them.

If from Europe we pass to the three other quarters of the globe, we shall find in each a great number of volcanos, which it would be superfluous to enumerate particularly, such an enumeration having al-

* Voyage du Levant.

ready been made by Faujas, Buffon and others. I shall only mention those which afford products that have relation to our present subject.

We read that the island of Ternate, in Asia, throws out a considerable quantity of pumices, as does, likewise, one of the numerous volcanos of Kamschatka.

As to those of Africa, we have but very imperfect accounts of them, with the single exception of the peak of Teneriffe, one of the loftiest of volcanos ; which, with respect to its situation, height, form, and crater, and the hot fumes which issue from it, has been accurately described by the Chevalier Borda. But it were to be wished that we had a more complete description of the materials of which it is composed ; as the French traveller only tells us that they are “ sand, black and red calcined stones, pumices, and flints of different kinds *.”

* Voyage en diverses Parties de l'Europe.

It admits of no doubt that the highest mountains of America, as Chimborazo, Coltopaxi, Sangai, Pichenchá, &c. form a chain of burning volcanos, the largest existing in nature. We are indebted for the accounts we have of them to M. Bouguer ; but these are such as only tend strongly to excite our curiosity without gratifying it. With respect to what relates to our present enquiry, we only learn from this writer, that “ some mountains in the vicinity of Quito “ are composed entirely, to a great depth, “ of scorizæ, pumices, and fragments of “ burnt stones of every size*.” As to volcanic glasses, he does not make the slightest mention of them ; though it is well known that the famous gallinaceous stone, which is universally acknowledged to be a most beautiful American volcanic glass, of a black colour, is found in Peru, and that, according to M. Godin, there is a mine of it, several days journey from Quito.

* Acad. Royale des Sciences, 1744.

If we now consider those parts of these imperfect accounts which relate to glasses and pumices, we shall find, with respect to the former, that the much greater part of volcanos produce none, and that those which do produce them, as in the Neapolitan territory, Iceland, and Peru, are by no means to be compared in this respect with Lipari and Vulcano. The same may be asserted of Alicuda and Felicuda, the glasses of which, though abundant in many parts of those islands, are only found in flakes and fragments. These observations might likewise be applied to the pumices, did not the immense quantity of them in the island of Santorine equal, if not exceed, that of the two Eolian islands above mentioned.

If we consider the volcanos known to us under one general point of view, we shall find that, though they have changed into lavas an infinity of rocks, by which they have produced mountains and islands very considerable both in number and dimensions, it is very rarely that they vitrify the

7

substances

substances exposed to their fires. Reflecting on the immense quantities of vitrifications at Vulcano and Lipari, which are almost all derived from felspars and petrosilex, the idea suggested itself to my mind, whether so great an abundance in these two places, and so great a scarcity in others, might not be attributed to these stones being here extremely abundant, and very rare elsewhere. But this supposition does not accord with fact; as we have seen in many other volcanic tracts, which I have described, and shall describe when I come to speak of the Euganean mountains, that both these stones may be changed into lava without that lava exhibiting the slightest appearance of glass. On the other hand we have shown, that, besides felspar and petrosilex, many pumices have for their base the hornstone and asbestos, and many granite, as M. Dolomieu has observed. I am, therefore, of opinion that the cause which has produced them should rather be sought in the volcanic fire, which rarely has sufficient activity to vitrify the stones and rocks on
which

which it exerts its power ; though I grant that the petrosilex and felspar are more adapted to this vitrification than other stones. To produce a lava, a certain degree of heat is necessary ; and a still greater to convert it into pumice. The lavas, at least those of the compact species, usually preserve the grain, hardness, and sometimes the weight and colour of the primordial rock ; but the greater part of these external qualities disappear in the pumice, from the stronger action of the fire. This must operate still more in glass, in which the homogeneity and fineness of the paste efface every trace of its primitive texture.

These gradual transitions of lava into pumice, and pumice into glass, I have several times observed, and indeed have already described, in the same volcanic piece. It has also been observed, that a lava frequently passes immediately into perfect glass, which must be caused by a sudden heat, greater than that required to change it into pumice. This theory satisfactorily explains
why

why some volcanos produce pumices, but never glafs ; as may be remarked of Santorine. Their fires are only fufficiently powerful to generate pumices, but not to produce glafs ; an obfervation applicable to the prodigious eruption from the fea defcribed by Thevenot. On the contrary, at Rotaro in Ifchia, at Vefuvius, and other parts of the Phlegræan Fields, as alfo at Vulcano, Lipari, Felicuda, and Alicuda, glaffes are found mixed with lavas ; which fhews that the fire has acted unequally in thofe places. It is to be remarked, at the fame time, that the heat requifite for vitrification is not of the moft violent kind, as I have fhewn in Chap. XVI.

We muft however obferve, that as the production of compact lavas is a fecret which Nature has hitherto referved to herfelf ; fince we are unable to imitate them with our common fires ; fo alfo are we ignorant of the precise caufes of the formation of pumices. Among fome thoufands of fufions which I have made in the furnace,

nace, both of lavas and primordial rocks and stones, those likewise from which pumices are most frequently produced, as petrosilices and felspars, I never obtained a product which could be said to possess all the characteristics of pumice. It has always been either a glass, an enamel, or scoriæ ; nor do I remember to have read or heard, that among the innumerable experiments which chemists have made upon earths with fire, the result ever was a true pumice : and though in lime-furnaces we may frequently observe a change of certain stones into glass ; yet they never produce lavas similar to the volcanic ; and equally incapable are they to form pumices. It cannot be alleged that the fire of our furnaces is too strong to induce that slight degree of vitrification which characterizes pumices ; since, when I have used a more moderate fire, the substances on which I made my experiments have either not melted, or been more or less vitrified.

I shall conclude these observations on the
pumices

pumices of Lipari with a remark relative to their colour. Except a few that are dark, they are all white as snow. Hence the mountain of Lipari, which forms the great magazine of these stones, is called *Campo Bianco* (the White Field): but certainly there must have been a time when it should have been denominated *Campo Nero* (the Black Field); at least it is certain that pumices when newly ejected from volcanos are of a black colour. This remark, which has been omitted by almost all who have made observations on this subject, who content themselves with saying that this or the other volcano throws out pumices, has been expressly made by Don Gaetano de Bottis in his "History of the Conflagrations of Vesuvius*." He tells us, the pumices ejected at various periods by this volcano are black. He likewise remarks, that on comparing them with those which overwhelmed Pompeii, he found them perfectly similar in their structure.

* Istoria di varj Incendj del Vesuvio.

Their

Their whiteness was subsequently acquired, and probably was caused by the impressions of the atmosphere.

Before I conclude these observations on the Eolian isles, I think it necessary to say a few words on a subject which has a relation to the productions of Vulcano and Alicuda, and on which the opinions of modern naturalists are divided; I mean the basaltiform lavas which are found within the crater of the former island, and along the shores of the latter*, and which by their conformation cannot but remind the reader of the enquiries and disputes which have taken place within these few years relative to the origin of basaltes. To repeat all that has been written on the subject would fill a volume; but I am far from purposing to tire either my own or the reader's patience in any such manner. It, besides, appears to me that this long agitated question may, at present, be determined

* See Chaps. XIII and XVII.

without any very prolix argumentation. Literary disputes and differences of opinion frequently arise from want of previously fixing the state of the controversy ; that is, from not defining in precise and clear terms the thing in question. Before we enquire what is the origin of basaltes, that is to say, whether they are the result of the action of fire or water, it will be proper to decide what we mean by the term ; or rather what the ancients understood by this word, which is the name they gave to a certain kind of stones. It is now generally known, because it has been repeated by a hundred writers, though perhaps by the greater part without due consideration, that the word basaltes is used by Pliny and Strabo to denominate an opaque and solid stone, of the hardness, and nearly of the colour, of iron, commonly configurated in prisms, and originally brought from Ethiopia ; of which stone the Egyptians made statues, sarcophagi, mortars, and various utensils. This premised, it remains to enquire whether this stone was of volcanic origin or not,

by

by repairing to the places where it was found, and attentively examining the country to discover whether it bears the characteristics of volcanization. This labour, however, has not, to my knowledge, been hitherto undertaken by any one; but M. Dolomieu, to whom Lithology and the History of Volcanos are so much indebted, has discovered, during his stay at Rome, an equivalent, in some measure, with respect to the solution of this question. Among the many noble monuments in that superb capital which are instructive not only to the admirers of the arts, but to the contemplators of nature, are a great number of statues, sarcophagi, and mortars brought from Egypt, which have all the characters attributed to basaltes, and likewise preserve the name. These he has studied with the greatest attention, and declares that the stone of which they are formed manifests no sign of the action of fire. Among other Egyptian monuments, he observed some of a green basaltes, which change colour, and assume a brown tinge, similar to

that of bronze, on being exposed to the slightest heat. All those that have been burned have acquired this colour ; which proves, as he very judiciously observes, that the green basaltcs have never suffered the action of fire *.

The Egyptian stones, therefore, to which the ancients gave the appellation of basaltcs, have been produced by Nature in the humid way. These observations perfectly agree with those of Bergmann on the trapps produced in the same way ; and which have, both externally and internally, the same characteristics with the basaltcs †.

Werner, taking the term basaltcs in a wider sense, and understanding by it all those columnar stones which, by their prismatic configuration, resemble the Egyptian basaltcs, supposes both to have the same origin, and adduces, as a proof of that origin, the basaltcs of the hill of Scheibenberg,

* Rozier, tom. xxxvii. an. 1790.

† De Productis Vulcanicis.

which

which are the effect of a precipitation by means of water ; and concludes that “ all basaltcs are formed in the humid way *.”

Though I am willing to bestow the praise due to his discovery, I cannot admit his conclusion ; for though many basaltcs, taking that term in the sense of this author and other naturalists, may derive their origin from water, many others are certainly the product of fire.

I shall not repeat what various volcanists have written on this subject, but merely refer the reader to what I have already said relative to the basaltine lavas of Vulcano and Felicuda. With respect to the former island, I have remarked, in Chap. XIII, that I found within its crater a range of articulated prisms, with unequal sides and angles, which, in part, composed one whole with a mass of lava ; and, in part, were detached from it. I have also there

* Rozier, tom. xxxviii. an. 1791.

described the qualities and nature of these prisms. In Chap. XVII I have particularly described the litoral lavas of Felicuda, which, near the water, are prismatic.

It is therefore evident, that, in these two situations, the origin of the basaltés there found cannot be what it has been assumed, generally, by Werner and other Germans, but that it is truly volcanic. It consequently appears that Nature obtains the same effect by two different ways. In the fossil kingdom, one of her grand operations is crystallization ; which, though it be most frequently effected in the humid way, is sometimes produced in the dry ; as we see, among other instances, in iron, which Nature crystallizes within the earth, both by the means of water and of fire, in which latter way the beautiful specular iron of Stromboli is produced *. Nor are there wanting other instances, of the crystallization of the same metal by the action of fire.

* See Chap. XI.

And did other metals exist in the entrails of volcanos, and the necessary circumstances concur to their crystallization, it is indubitable that this may be effected by fire as well as by water. Thus we see that, by taking certain precautions, metallic substances assume a regular and symmetrical disposition within the crucible. The same is true of basaltes, the prismatic configuration of which, though not strictly a crystallization, has the most exact resemblance to it. Observation, likewise, teaches us that the same combination of earths, according to different circumstances, forms prismatic basaltes, sometimes in the humid, and sometimes in the dry way. The stone called trapp, found in the mountains of Sweden, is configured in prisms, though those mountains are of aqueous origin; and the horn-stone, which is so analogous to the trapp, has the same configuration at Felicuda, notwithstanding it is a true lava. In the same island, likewise, other basaltiform lavas have for their base shoerl in mass, and those of the crater of Vulcano,

the petrosilex ; which two stones, according to the observations of M. Dolomieu, form some of the Egyptian basalt, which are a work of the waters. These two agents, fire and water, are not, in fact, so different in their action as we might at first be inclined to imagine. The prismatic figure in the humid way arises in the soft earth by the evaporation of the water ; in consequence of which the parts dry, contract their volume, and split into polygonal pieces. The same phenomenon may be remarked in margaceous earths, imbued with water, and exposed to the ventilation of the air ; and I have frequently seen the mud of rivers, when dried in the sun, in summer, to make pottery-ware, divide, when it became dry, into small polyedrous tablets. Similar configurations are produced in different lavas by the congelation and contraction that take place by the privation of the fire which held them in a state of fluidity.

It appears to me, therefore, that the dis-
pute

pute relative to the origin of basalt is at an end ; nor would there be any difference of opinion if, instead of generalizing ideas and fabricating systems, naturalists would make an impartial use of their own observations and those of others. Some volcanists, perceiving that the generation of various basalt is evidently igneous, have immediately inferred that all must have the same origin. In consequence of this principle, they have drawn lines or zones, in different parts of the globe, indicative of extinct volcanos, which they have inferred from finding basalt there ; and thus portrayed a picture of prodigious dimensions, representing the ruins caused in the world by subterranean conflagrations. Other naturalists, on the contrary, being convinced that certain basalt is the produce of water, have assigned to all the same origin. From the facts now adduced, it is, however, sufficiently evident that both these hypotheses are erroneous. The basalt, taking the term generally, when examined detached, do not bear exclusively any decisive

marks of their origin. Local circumstances alone can determine to which of the two principles it is to be ascribed ; to discover which we must attentively examine whether the places where these figured stones are found exhibit any indubitable signs of volcanization. Yet even these are frequently not sufficient, as there are many hills and mountains which owe their origin to both the great agents of nature, fire and water ; in which case it will be necessary to redouble our attention, and fix it on the substances originating from each ; to determine, by the relations these have to the basaltés, from which of the two the latter derive their formation. By diligently employing these means, we shall be certain, without fear of error, to elucidate and advance the enquiries relative to basaltés, and be enabled accurately to determine which of them are to be ascribed to the action of water, and which to that of fire.

But here a second question occurs, not less interesting than the first, relative to the
cause

cause why certain lavas, differing from innumerable others, become basaltiform; since, if this configuration depended on congelation, it must be found in all lavas when they had ceased to flow. The first writer, to my knowledge, who has adverted to this is M. de Luc, who, in the second volume of his Travels, is of opinion that they have taken this regular figure in the sea, by the sudden condensation which took place on their flowing into it in a liquid state; other secondary circumstances, however, concurring, such as a greater homogeneity, and a certain attraction of their parts.

Of the same opinion is M. Dolomieu; though he does not deny that even porous lavas may sometimes, likewise, take the form of prisms. The former of these opinions is little less than hypothetic, while the latter is supported by facts too important to be cursorily stated. M. Dolomieu observes that all the currents of the lavas of Etna, the periods of which are preserved in
 history,

history, have constantly experienced two effects in their congelation. Those which have cooled in the air, have divided, in consequence of the contraction they have suffered by the loss of their caloric (heat), into irregular masses ; while all the others, which have precipitated into the sea, have, on their sudden congelation, contracted in a regular form, and divided into prismatic columns, which form they have only taken in the parts in contact with the water of the sea. Of this he met with evident proofs along the shore which extends from Catania to Castello di Jaci ; and the famous lava of 1669, though unapt to the prismatic form, from being spongy and little in quantity, yet in some parts exhibits a kind of rude imperfect prisms.

Among the objects to which I was attentive in my volcanic travels through the two Sicilies, the prismatic lavas were certainly not the last. While making the circuit of the Eolian islands, of Etna and of Ischia, I constantly observed carefully the conformation of the stony currents which
fall

fall into the sea. I have remarked, when treating of Ischia, that this configuration is frequently prismatic, and that the prisms are constantly formed in those parts of the currents which immerse into the water, and reach to a few feet above the level. This observation of mine certainly accords admirably with those of M. Dolomieu; the situation of these prisms clearly showing that they were formed at the time of the immersion of the lava into the sea, which, when it flowed, rose to where they begin to appear. But, though I agree with him in this, I cannot in the remainder of my observations. Alicuda, as well as Felicuda, presents us with numerous currents and rocks that descend into the sea; and they are likewise found at Saline, Lipari, Stromboli, Panaria, Basiluzzo, and Vulcano; but these rocks and currents, which together extend over a space of more than sixty miles, do not afford the slightest indication of prisms.

As I went by sea from Messina to Catania,

nia, and returned to Messina from Catania, I had an opportunity twice to examine, at my leisure, that tract of shore, which, for the space of nearly three-and-twenty miles, is volcanic. One third of it, beginning at Catania, and proceeding to Castello di Jaci, consists of prisms more or less characterized, and such as they have been described by M. Dolomieu; but the other two thirds, though equally composed of lavas with the former, and for the most part falling perpendicularly into the sea, have no such figure; and only present, here and there, irregular fissures and angular pieces, such as are, generally, observable in all lavas, which separate more or less on their congelation.

In my circuit by sea round the shores of Ischia, I was particularly attentive, as I was every where else, to the conformation of the lavas; and here there seemed a great probability of finding them prismatic, from the abundance of them which in different directions and angles fall into
the

the sea : but I have already observed, when treating of the island, and I now repeat it, that I did not find one with a regular form.

At Naples, the prismatic lavas of the currents of Vesuvius, under the Park of Portici, have been much spoken of. When I made my observations on this burning mountain, I had not time to visit these lavas. It is with great pleasure, therefore, that I learn they have been examined by a person so well experienced in matters of this nature as the Chevalier Gioeni undoubtedly is. But the celebrated prisms disappeared in the presence of so accurate an observer. The following is the account he gives ; which is of considerable importance to our present subject :—" I wished
 " to examine the basaltic which were
 " pointed out to me as to be found on the
 " sea-shore, under the Royal Park of Portici ; but they proved to be only a compact lava, with perpendicular and extremely irregular fissures, forming quadrangular,

“ drangular, and sometimes trapezoidal pi-
 “ lasters, which have been employed in
 “ buildings. Similar fissures are likewise
 “ observed in tufas, and earths of different
 “ kinds, and can never mislead any person
 “ accustomed to them, and acquainted with
 “ their true causes.”

By this faithful relation of facts, I flatter
 myself, I have clearly shown that it cannot
 be supported as a general hypothesis, that
 flowing lavas take a prismatical configura-
 tion from the sudden coagulation they suffer
 on falling into the sea.

It may, perhaps, be objected, that these
 prisms once existed in the lavas I observed,
 but that the irresistible violence of the
 waves, in a long series of years, has cor-
 roded and destroyed them.

Every person acquainted with the sub-
 ject must immediately perceive how little
 solidity there is in this objection. I admit
 that the violence of the sea may, in some
 lavas,

lavas, have totally destroyed these prisms; but that it can have had that effect on all, and through so extensive a space, is utterly improbable. Nor is it conceivable that Felicuda, among the Eolian isles, should still preserve its prisms perfect, while the rest of those islands have entirely lost theirs, notwithstanding they are all equally exposed to the shocks of the waves.

I cannot here omit another remark. It is certain that more than one of these islands were not formed by one eruption, but by successive ejections of lavas accumulating on each other; and in some deep fissures, occasioned by the sea, this successive formation is discoverable by the eye, as we may perceive five or six different strata of lava one above the other. The internal strata in very remote periods, having flowed into the sea, as the external flowed afterwards; it is evident that, if the latter, on touching the water, became prismatic, the same change must have taken place, also, in the former; which being defended

from the injuries of the sea, by the external strata, must still preserve their prismatic configuration; of which, however, no traces remain. We must, therefore, conclude that innumerable lavas may fall into the sea, without having their external appearance in the least changed by the sudden congelation which then takes place.

That the prismatic configuration of lavas is not always the effect of their immersion in the waters of the sea, likewise appears from many of them taking the same form in the air; of which we have a distinguished example in the crater of Vulcano. Here, certainly, we cannot suppose any intervention of the waters of the sea. Similar observations have been made on Mount Etna by the Chevalier Gioeni. "I have observed," says he, in the work before cited, "basaltic columns, at the
 "summit of Etna, and nearly on a level
 "with the base of its vast crater, where
 "there is certainly no probability of the
 "sea ever having reached; and I have
 "frequently

“ frequently found- polyhedrous basaltes
 “ perfectly characterized in excavations
 “ made by men in the centre of lavas,
 “ which have issued from the sides of
 “ Mount Etna, in periods much posterior
 “ to the retiring of the sea.”

I should, however, appear deficient in candour, did I not mention that M. Dolomieu admits that lavas may sometimes, in the air, assume the prismatic form, if they fall into clefts and fissures where they suddenly cool, of which he adduces an example in the islands of Ponza.

I shall only remark, that I do not perceive the absolute necessity of the fissures in this case ; since we frequently find lavas with this configuration in perfectly open places ; as I have seen in the great mouth of Vulcano. And with this opinion the observations of Gioeni on Etna certainly accord ; for, had he remarked the concurrence of such a circumstance, he, undoubtedly, would have mentioned it.

What conclusion, then, ought we to deduce from all these facts and observations?

First : that many basaltiform lavas have assumed this organization on coagulating within the sea.

Secondly : that others have taken the same form, merely in cooling in the open air.

Thirdly : that innumerable other lavas have not taken this figure, either in the sea or in the air.

It appears, at first view, that these differences depend on the different nature of the lavas themselves. This opinion, at least, is rendered probable by what we observe in earths penetrated with water, which, in drying, take, more or less, prismatic forms, as has been observed frequently in the argillaceous kinds. I have seen, when a turbid torrent has been introduced into a ditch through an argillaceous marle, the latter, in drying, divide
into

into polyhedrous pieces ; but when the water passed through chalk, or calcareous marle, the greater part of the pieces were amorphous. When we however observe lavas with requisite attention, this conformation in them seems to be effected differently.

It has already been said, that several of the prismatic lavas of Felicuda have for their base shoerl in mass ; but it is true that other congenerous lavas of the same island, which form as it were walls perpendicular to the sea, are smooth over their whole superficies. A similar smoothness is observable in some of those of Mount Etna, on the shore between Messina and Catania, which have for their base the horn-stone ; though others extremely resembling them, between Jaci Reale and Catania, are formed in prisms.

Compactness and solidity are, likewise, not a necessary condition in lavas, to this appropriate crystallization. This has already been remarked by M. Dolomieu ;

and I have observed that many amorphous lavas on the shores of several of the Eolian islands are more compact than the prismatic lavas of Felicuda.

What then can be the intrinsic circumstance of the lava which determines it thus to cleave in the prismatic form ? I confess I am ignorant : and who can say that we do not seek it in vain within the lava, since it may be extrinsic and adventitious ? Such, certainly, appears to be the opinion of M. de Luc ; and, more expressly, that of M. Dolomieu, who, to explain the phenomenon of volcanic prisms, has recourse to a sudden congelation, and instantaneous contraction of lavas.

The facts which we have adduced relative to lavas, both prismatic and not prismatic, it has been seen, do not always accord with those related by the French naturalist. But even on this supposition, which is incontestable, may we not retain the same principle of explanation, which,

to say the truth, appears to be sufficient, with some requisite modifications ? These I will endeavour to suggest, illustrating my conjecture by the two cases above adduced ; the one, that of the lavas which take the form of prisms merely from the contact of the atmosphere, as in Vulcano and near the summit of Etna ; the other, that of the lavas which refuse to take such a form even within the sea, as at Ischia, in some parts of the base of Etna, and in all the Eolian isles except Felicuda.

As to the former, may not a sudden coagulation and contraction have taken place in some lavas from the mere influence of the atmosphere, though the lava was not included in any cleft or fissure ? It is sufficient that it be suddenly deprived of the caloric (heat) by which it is penetrated, and which rendered it rarefied and fluid. To this deprivation a lava of little thickness will be very liable ; since a body loses its heat the sooner, the less its thickness and density. This sudden contraction

may also be produced by the circumstances of the atmosphere ; as, should a strong wind, of a very cold temperature, blow at the time. The melted lavas in our crucibles will be found to give greater weight to this latter conjecture. If they are taken from the furnace, and caused to pass through a heat gradually less ; their surface, as they cool, will only split in a few cracks, of little depth, and usually irregular ; but, when they are immediately, in the winter time, carried into the cold air, the fissures, besides being deeper, will frequently be disposed in such a manner, as to form small polyhedral prisms, which may easily be detached from the rest of the lava.

With respect to those lavas which do not assume a prismatic form though they fall into the sea, it is certain that, to take that conformation, their mass must have a strong degree of effervescence and dilatation, and that it must be deeply penetrated with the igneous fluid, otherwise the contraction
 necessary

necessary to produce prisms cannot take place. But many currents which descend from the summit of burning mountains to the sea, must have lost their effervescence with their heat in so long a course, and scarcely contain sufficient to continue their motion downwards, which, perhaps, would cease, were it not for the impelling gravity of the lava, which frequently falls into the sea perpendicularly.

Such is the hypothesis by which I would explain the cause why some lavas have assumed a prismatic conformation without any concurrence of the sea-water, and others exhibit no appearance of it in places where they have immersed into the sea. I nevertheless leave every one to form his own opinion; and should an explanation of these important facts be discovered, preferable to mine, which I consider as only conjectural, I shall receive the communication of it with sincere gratitude, and adopt it with pleasure.

C H A P. XX.

DIGRESSION RELATIVE TO THE DIFFER-
ENT VOLCANIC PRODUCTIONS OF THE
EUGANEAN MOUNTAINS.

Excursion made to the Euganean mountains, by the author, during the vacations of 1789, in order to compare the products of the volcanos he had visited with those of the mountains of Padua—Description of different specimens collected by him in this excursion—Three kinds of lavas at Monte Castello—Erratic petrosilices mingled with them, of uncertain origin—Lavas of Monte del Donati, some with a petrosiliceous base, and others with a horn-stone—Proof that one of these once formed currents—The accumulated prismatic columns of Monte Rosso have not for their base the granite, but the porphyry—Monte Ortone abounds in prismatic lavas, but such as are less characterised in their configuration—Lavas of Monte Merlo with a granitous base

base—Black mica one of the component parts of this granite, which has the property of being attracted like iron by the magnet, a property possessed likewise by the other micas of the Euganean mountains—The micas of the primitive granites destitute of this property, but capable of receiving it by the action of fire—This important fact furnishes a clear proof of the volcanization of the Euganean mountains—Nodosities of quartz contained in this granitous lava, probably produced by filtration posterior to ignition—The same observable of some shoerlaceous nodosities included in it—The shoerls of the Euganean mountains act on the magnetic needle, like those of other volcanic countries, and in that differ from those which are not volcanic—Calcareous carbonates intermixed with the lavas of the Euganean mountains—Flints frequently found among these calcareous carbonates, which present the most specious appearance of the change of lime into flint—Proof, by chemical analysis, that it is not necessary to have recourse to any such change to explain
this

this appearance—Strata of globes near Teolo abounding in particles of pitch-stone—Veins of pitch-stone lavas at Bajamonte and Sieva—Groups of pumices enclosed in one of these veins—Comparison, in the dry way, of the non-volcanic pitch-stones with the volcanic—Proof, by the humid way, that both are of the same kind—Essential differences between the pitch-stone lavas and the volcanic glasses—Volcanic productions of Schivanoja, Monte Merlo, Mascabo, Tremonte and Pendise, which have been styled volcanic glass by a living writer, but which in reality can only be called pitch-stone lavas, and but one of them, at the utmost, a vitreous lava—Mistake of this author in having taken for volcanic glass some pieces of glass from the furnaces of Murano, near Venice, which he casually found in those mountains—Remarks on this accident, which should teach us to be cautious in forming a judgment whether a mountain be volcanic or not, from finding a detached piece of glass, or other production of the fire; since it may be uncertain whether

whether that fire was volcanic or not—Possibility of being equally deceived by productions truly volcanic but erratic—Proof of this from a circumstance which happened to the author—Little credit to be given to accounts intended to prove the existence of ancient volcanos—Necessity that such accounts should be lithologically detailed—In what manner our judgments relative to lavas may be frequently mistaken—Volcanic rocks may have the most specious appearances of lavas, though they never formed currents—When other proofs are wanting, cellulosity the most certain indication that volcanic rocks have flowed in a stream—This cellulosity found in many Euganean lavas—Singularity of the felspars of a lava near Rua, which have, almost all, a portion of that lava for their central nucleus—Lavas of Galzignano, Pigozzo, Monte Nuovo, Monselice, and Arqua—Singular lava of Monte Nuovo containing felspars become earth; and another at Monselice containing pumices—Lavas of Catajo, one of which forms columnar

lunar prisms—Reflections and corollaries
—The Euganean mountains once were
islands, like those of Ponza, the Eolian,
Santorine, &c.—Their prodigious antiqui-
ty, and vicinity to civilized places, two
causes of the great changes they have un-
dergone—Their lavas analogous to those
of other volcanos, in having rocks for their
base—Comparison between the rocks of
other volcanos and those of the Euganean
mountains—Immense depth of these rocks,
which would remain unknown to men
were it not for volcanos—Three different
bases in the Euganean rocks, deserving ob-
servation: the felspar in the mass, the
volcanized petrosilex, extremely resembling
the natural, and the pitch-stone—Volcanos
which have not this stone, and others in
which it is found more or less—Magnesia
not one of the elements of the pitch-stone of
volcanos, as some have thought—Interest-
ing observation of the change of petrosilex
into pitch-stone—Chemical analysis of these
two stones agreeing with this observation—
Probability that some volcanic pitch-stones
are

are derived from the non-volcanic—Our common fire equally vitrifies the Euganean lavas, and those of other volcanos—Singular observation relative to the easy fusion of felspars—Euganean basaltes the products of fire—One of the stones of these mountains formed in prisms in one place in the dry way, and in another in the humid—Confirmation of the assertion, that it can only be determined by local circumstances, which of the two modes Nature has employed in the conformation of basaltes.

IN the year 1788, I presented the Imperial Museum of Pavia with an ample collection of volcanic productions, from the two Sicilies ; and afterwards formed the design of increasing it, during the vacations of the following year, with others of the same kind from the mountains of Padua which had been extinct from time immemorial. This design I carried into effect with the assistance of a companion, than whom I could not have wished for one better

better qualified to aid my researches ; the Marchese Antonio Orologio, an accomplished gentleman, and well acquainted with those mountains, as he has proved by several Essays replete with accurate and interesting observations relative to them.

Having made several excursions with this able guide, I examined the products I met with at my leisure, and selected those that appeared most suitable to my purpose ; several of which I shall now proceed to describe ; as they are extremely well adapted to form a comparison between the Paduan rocks and those of other countries equally volcanic, which I visited ; as also to shew the nature of the modifications caused in both by fire ; which comparative observations, I flatter myself, will not a little conduce to enlarge the sphere of our knowledge respecting volcanos *.

I repaired,

* At first view, it may, perhaps, appear superfluous that I should say any thing on the Euganean products, as a *Descriptive Catalogue* has already been given of them by Sir John Strange. This naturalist has undoubtedly

I repaired, therefore, to Giara, in September 1789, to the delightful villa of the Marchese Orologio abovementioned, situated

doubtedly contributed much to the fossil history of these mountains, the volcanization of which he first discovered and made known. We are likewise greatly indebted to him for the catalogue he has annexed, and which forms a kind of appendix, to his history. But, besides that I frequently met with objects different from those observed and described by him, the views with which we treated the same subject were entirely different. I proposed to describe lithologically, and thence to characterize, the Euganean products I met with in my excursions, in the same manner as I have described those of the two Sicilies: Sir J. Strange was satisfied with giving only simple indications of them; nor do I think I shall in the least detract from the merit of this excellent author, if I say these indications were not always the most accurate; such a defect being less imputable to him than to the time in which he wrote; since it is only within these few years that the mineralogy of volcanos has been studied with precision and accuracy.

I shall take this opportunity to answer a question which may be asked; which is: Why, if I intended to give a lithological essay on the Paduan volcanoes, I did not mention it in the Introduction, where I enumerate the principal heads of the work. I reply that,

ated nearly at the foot of the Euganean hills, and proceeded with him, without delay, to make researches in them ; examining first the stones of Monte Castello. This is a small woody mountain, from which arise several rocky points adhering to the body of it, and affording three specimens of lava.

The first has an argillaceous base, a coarse grain, and blackish colour. It shines in many parts with black micaceous points, and is sprinkled with reddish spots, like those of felspar, in many oriental porphyries ; and which are no other than scaly flakes of felspar, accompanied with a few black shorls.

that, when I wrote that Introduction, I did not perceive the importance of the subject ; and of separating the observations I had made on other volcanoes from my remarks on the Euganean hills. I likewise, at that time, did not think it proper to mention this excursion particularly, as the remarks I made in the course of it then remained unmethodized in my journals, and I feared that I might not find sufficient leisure to reduce them to order, as I afterwards was enabled.

The

The second lava, which is of a light grey colour, might at first be taken for a carbonate of lime; but, when attentively examined in the recent fractures, its base is found to be a hard horn-stone, containing some black mica, and a few felspathose points.

The third lava, with some varieties little differing from it, has, in like manner, its base of horn-stone. Its colour is a pale grey, its paste earthy, with an argillaceous smell; and, besides numerous particles of black mica, it contains thick rectangular felspar lamellæ.

The shoerls, micas, and felspars of these three lavas, when fused in the furnace, are, together with the base, reduced to an enamellar and cellular scoria.

Though the three stones above described have not the appearance of having ever formed currents, nor the porosity of some lavas, I do not hesitate to call them by that

name ; not only because they are integral parts of this volcanic mountain, but because they appertain to a kind of stones of the Euganean hills, which, as will appear from facts hereafter adduced, bear evident marks of having suffered fusion.

In the midst of these lavas are found pieces of petrosilex of a very fine grain, which, as they are detached and scattered, I am unable to say whether they have been affected by the fire, or thrown out untouched by some volcano. All of them contain crystallizations of micas, shoerls, and felspars ; and these crystallizations fuse in the furnace together with the petrosiliceous base.

From Monte-Castello I proceeded to the neighbouring mountain Donati. At the top it has a double summit ; and both there and at the base, having broken off several pieces from the stony mass of the mountain, it appeared to me that the lavas of which it is composed may be reduced to two

kinds—lavas with a petrosiliceous base, and lavas with a horn-stone base. The former have a smooth, and, sometimes, conchoidal fracture, a fine and compact texture, and contain a considerable quantity of shoerls and rhomboidal felspars. The glass produced from them in the furnace is white, with a complete fusion of the above-mentioned crystallizations.

The lavas with a horn-stone base are soft; all emit an argillaceous smell, have an earthy texture, and, for the most part, abound in felspars, crystallized shoerls, and black hexagonal micas. One of these lavas bears the most evident marks of having flowed. It is full of small pores and vacuities, not only on the surface but in the internal part. These vacuities are of different sizes, from those that can only be discovered with the microscope, to those half an inch in breadth. Many of them are oval, and the longer diameter is almost always placed in the same direction. This observation is of considerable importance; first, because it

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shows

shows that this rock was once fluid from the action of the fire ; since otherwise these innumerable vacuities would not have been produced ; and, secondly, that it has been in motion, in consequence of which the bubbles, naturally of a round figure, have taken a form more or less oblong. The truth of this deduction is confirmed by what has been observed in many of the lavas of Lipari. Some of these cavities are filled with crystallized carbonate of lime.

This lava is likewise remarkable for the large size of the shoerls it contains ; several of which are ten lines in length, and some even an inch. They are of a black colour, have a scaly fracture, and facets of so lively a lustre, that they may compare with the most beautiful crystals of specular iron. Both when detached, and when incorporated with the lava, they melt, in the furnace, into a black, compact enamel, giving sparks copiously with steel, and of a lustre little inferior to that of the shoerls themselves. Fusion succeeds equally in the other
lavas

lavas of the horn-stone base, with the vitrification of the shoerls, feltspars, and micas.

From Monte del Donati I proceeded to Monte Rosso, celebrated for its mass of prismatic columns. The first naturalist who pointed them out was Ferber; they afterwards were described by Sir John Strange*, who observed that they are almost perpendicular to the horizon, and parallel to each other; that they differ in form and size, and seem intimately connected with the stony body of the mountain. On examining them, I found the observations of the English writer perfectly accurate; but I cannot refrain from making a few remarks on the nature of this columnar aggregate which he calls granitous. Both in the internal part and on the surface of these prismatic columns, felt-

* Opusc. Scelt. di Milano, t. i. in 4to. This description was read to the Royal Society in 1774, and is inserted in the *Philos. Transact.* vol. lxxv. part i. for 1775. T.

spars, mica, and shoerls, are very conspicuous to the eye. The shoerls are rhomboidal prisms, a line, or two lines, in length, at the most, and about half as broad, semi-transparent, of a whitish colour, shining but little on the surface, but very considerably in the fractures, and with a lustre of changeable colours. The mica is, for the most part, black; but sometimes of a golden yellow, and in flat, hexaëdral, opaque, laminous, and extremely lucid prisms, the largest of which are little more than a line in length. These two stones are rather numerous; but the shoerls, which are, for the most part, linear, are but few. They are all three contained in a petrosiliceous paste, become earthy by decomposition, and, at the surface of the prismatic columns, almost pulverulent, and of the colour of a dead leaf; but internally it preserves the character of the petrosilex, giving sparks more or less with steel, and being of a dark colour. The furnace converts these columns into an enamel inclining to a black colour,

colour, with few but large bubbles ; a fusion takes place in the shoerls, but not completely in the felspars.

From this description we perceive that this mass of columns cannot properly be called granitous ; the generality of naturalists, and the most respectable chemists, agreeing that by the term granite is understood a rock or stone composed of two or more substances, frequently crystallized and united together without the appearance of any connecting ground or cement. But here the shoerls, the mica, and the felspars are enveloped in a petrosiliceous paste ; whence we ought rather to denominate these columns porphyritic. The same is true of the remaining mass of Monte Rosso, which is almost entirely formed of the same rock.

Under this basaltiform group we find numerous globes of the same rock, which I judge to be pieces of prisms that have fallen down and become round by the erosion of

their angles, in consequence of the decomposition they have suffered by time and the humid elements ; as it cannot be supposed that their globular figure has been produced by their being rolled by the waters, since there is here no trace of either river or torrent, and their decomposition is, besides, very considerable.

Monte Rosso is an isolated mountain, about a mile and a half in circumference. On one side of it, there is at its foot an excavation which the Benedictine Monks of Praglia caused to be made, to obtain stones, but which has been for some time abandoned. The sides of this cavity exhibit very apparent prisms ; though not so perfectly characterized as those before described. Should other parts of the mountain be dug into, it is probable that other groups would be discovered.

This certainly is not the only place productive of these figured stones ; for we find prodigious masses of them at Monte Or-
tone,

tone, rudely formed, it is true, but very distinguishable. They consist of a lava of a cinereous grey colour, of a petrosiliceous base, and marked, in many parts, with thin reddish streaks parallel to each other. A considerable number of rhomboidal, shining, and transparent felspars, and a few black, hexagonal particles of mica are contained in the base of this lava, which changes in the furnace into a dark grey enamel, with the fusion of the felspars and the micas. In several parts of the mountain, when we dig into it, we find imperfect prisms; and they frequently project out near the summit, and on the sides; as we may observe in the road leading to Praglia. The mountain is formed of this lava, which, on the surface, is decomposed and become earth, in which a number of olive-trees grow and thrive. A similar decomposition is observable at Monte Rosso, the earth of which is, in a great measure, a mixture of fragments of micas, felspars, and shoerls.

The

The Euganean mountains, which form masses, for the most part conical, some detached, and others contiguous at their bases, are principally composed of lavas, with which, in several of them, are mixed calcareous carbonates. These two kinds of stones are of some value to the Venetians, who use the lavas, which they call *mas egne*, to pave the streets, and the carbonates to make lime. There are therefore here several quarries, some of which are now worked, while others, that are either exhausted, or become less productive, are abandoned.

I entered two of these quarries, the one at Monte Rosso, and the other at Monte Ortone; and, having continued there some time, determined to go down into some others, as I found they were extremely convenient for observing in their sides the stony substances I wished to examine. I therefore proceeded to Monte Merlo, where there is a very large excavation of this kind within the lava. To extract the stones,
which

which are very hard, the labourers have recourse to the following dangerous method. A man, fastened by a rope, is let down to a certain depth against the perpendicular sides of the cavern ; and, the other end of the rope being made fast at the top, breaks the stone in pieces with pickaxes, availing himself of certain vertical fissures, which greatly facilitate the labour. Mines are likewise prepared, in some cases, which blow the fragments of the stone into the air.

In this excavation, and in another of less dimensions, not far distant, the lava of the mountain is truly granitous, and the granite has for its base the felspar, which is so abundant that it composes the greater part of the rock. It would be superfluous to describe it, as it is perfectly similar, even in its crystallization, to that of Monte Rosso and Monte Ortone. Besides the felspars, which, by their brilliancy and other exclusive characters, immediately declare their nature, certain white spots present themselves

selfes to the eye, which at first view may excite a doubt to what kind of st ones they appertain ; but, when examined attentively and under different reflections of the light, we are convinced that they are true felspars, but in part calcined. These felspars are accompanied with the usual hexagonal micas, and some shoerlaceous points.

This granite, liquefied by the volcanic fire, reminds me of the great activity requisite in our common fires, for the fusion of granites that are not volcanic, and even of those which are ; as I have shown in Chap. XII. I have since thought that possibly so great a degree of heat was not necessary in the present instance, from this granitous lava being deprived of quartz, one of the elements of the granites on which I made my experiments, and which certainly is that among them most refractory to fusion. I have found, in fact, that this lava, when continued a long time in the furnace, affords a vitreous product of a black colour, and nearly homogeneous,
some

some felspars only being perceivable in it in the form of white spots.

I have said, a little above, that black mica is one of the component parts of this granite. I shall here add, that when it is detached from the volcanic rock and approached to the magnet, it will adhere to it like a particle of iron ; which property it shares with other black micas, before described, and with almost all I shall hereafter have occasion to mention. This curious phenomenon was pointed out to me at Venice, before I made my excursion to the Euganean mountains, by that excellent naturalist Sig. Giovanni Arduino. The greater part of the streets of that capital are paved with these Paduan stones, and it was in some of them I was shown this quality by Sig. Arduino. He, indeed, was of opinion that these shining black particles were rather particles of iron than of mica ; but ocular examination convinced me that they appertain to this stone ; since with the lens we may perceive that they consist of delicately
thin

thin and semitransparent laminæ, which, when touched with the point of a needle, are found to be flexible and elastic, and separate from each other. In the fire, as has been said, they vitrify, and the glass produced from them is of a blackish colour, and semitransparent.

The magnetic property of these micas, among the many I have examined, I have found in none which enter into the composition of granites not affected by the fire. In my return by land from Constantinople to Italy, I collected specimens of the stones composing the mountains over which my road led me, and, among others, of a considerable number of granites, which, from the nature of the places where they were found, were certainly not volcanic. Many more I found in the Alps, and other countries not volcanic. On the micas they contained I made experiments with the magnet; but I did not find one, whatever was its colour, which showed the least sign of attraction. In several of them, indeed, I found

found it after they had been exposed for some time to the fire. This exclusive property of the Euganean micæ is therefore a proof that they have felt the influence of this agent, and is a strong confirmation of their volcanization.

Before I dismiss the quarries of Monte Merlo, I shall briefly state two facts not undeserving the attention of the reader. First, it is not unusual to find within the granitous lava nodosities of pure quartz, of the thickness of one, two, and sometimes even five inches. Besides giving sparks plentifully with steel, which is the peculiar property of this stone, it has a colour lightly amethystine; it is transparent, somewhat unctuous to the touch, solid, and of an indeterminate figure. But to what are we to attribute the existence of these quartzose nodosities, which are uninjured, within this volcanic granite? I cannot persuade myself that they existed in it previous to its ignition; since, had this taken place afterwards, it must have altered the quartz, by depriving

depriving it of its transparency, and rendering it full of cracks, and extremely friable ; all which changes follow on exposing it a short time to the furnace. I shall observe, further, that two of these nodosities being left in a crucible placed on burning charcoal only for a quarter of an hour, lost their amethystine colour, and acquired a more than superficial whiteness, with a number of cracks, and very apparent friability. I, therefore, cannot believe that they have been taken up by the way, and enveloped in the lava when it flowed, as sometimes happens, when fiery torrents meet with extraneous stones in their passage. I am, in fact, of opinion, that these small masses of quartz have been produced posterior to the congelation of the lava, by the filtration of water impregnated with the molecules of quartz, which has penetrated into some small cavities, and gradually filled them ; in the same manner as we have explained the formation of the calcedonic globes found in some of the lavas of Lipari *.

* See Chap. XV.

The other fact is very similar to this, and may be explained in the same manner. It relates to the large pieces of shoerl which are contained in this volcanic rock, and are discovered on its being broken into pieces, in the same manner as the quartz. These are composed of a number of rhomboidal shoerlaceous prisms, so confusedly heaped and joined together, that it is impossible to obtain a single prism entire. Excepting in the largeness of their size, they perfectly resemble those of the porous lava, with the horn-stone base, of Monte Donati, of which we have spoken above. These shoerls, like all the others of the Euganean mountains, concur to prove the volcanization of the latter, by the same property which is found in the black micas of this country ; I mean their magnetism. Baron Dietrich, describing the volcanos of Old-Brissach, shews that the action on the magnet of the black crystallized shoerls, is the exclusive property of those that are volcanic. Though, in the course of this work, I believe, I have only mentioned the shoerls of Monte Rosso, at

Etna, as possessing the property of strongly moving the magnetic needle*, I did not fail to make the same examination relative to numerous shoerls of the Phlegrean Fields and Eolian Isles, and can positively affirm that I found this quality in them all. It is at the same time to be observed, that I could not perceive it in eleven species of shoerls, whatever was their colour, some of which were detached from granites, and others found solitary. This observation, when treating of the Euganean mountains, appears to me too important to be omitted.

These shoerlaceous lumps or groups, I am of opinion, must have been produced in the granitous rock by filtration, with this single difference, that the quartzose groups have remained amorphous, and the shoerlaceous are confusedly crystallized; probably from the more ready tendency of the integrant molecules to take a determinate form.

* See Chap. VII.

Having examined some of the quarries which furnish volcanic stones, I proceeded to visit those where carbonate of lime is dug, of which stone there is no scarcity in the Euganean mountains. Such are the quarries of Battaglia, Frassinelle, and Saint James, situated on the declivities of the Monte Grande, above Teolo. Before we reach the lava of Battaglia, we meet with this carbonate. It is scissile, and easily divides in flakes, for the most part, horizontal. This quarry is very large, and in some places forty-five or fifty feet deep. It principally consists of this stone, which is excellent for making lime. The lime-stone is disposed in strata of different thickness; from those of one inch or less to those of a foot. We seldom meet with stony strata which preserve so well their parallelism to each other, and to the horizon. In the midst of the carbonates are found numerous flints, or fire-stones, already well known from the mention made of them by other writers; for the Euganean mountains, wherever they afford calcareous carbonates, con-

tain likewise flints. On examining those of the quarry of Battaglia, I found several of them so closely united with the calcareous carbonate, as to present the most specious appearance of a transmutation of the lime into flint. But to give a clearer idea of this apparent transmutation, it will be necessary to describe both the carbonate of lime and the flint.

The lime-stone is white, compact, not very heavy, composed of impalpable particles, soft to the touch, with a smooth and sometimes conchoidal fracture, and breaking into obtuse and amorphous fragments. It is dissolved by acids with considerable effervescence. Both internally, and on the surface of this white stone, black, dendritic, and not inelegant spots and streaks are very conspicuous.

The flint is of a deep flesh-colour, sometimes brown and even black; its grain is extremely compact and fine; its fracture smooth, and almost always conchoidal, and
its

its fragments angular, acute at the extremities, and semi-pellucid. It is more than moderately heavy, the file will not touch it, and it gives sparks strongly with steel. Notwithstanding their great hardness, however, the generality of these flints easily break into small pieces under the hammer. Some of them, in the quarry of Battaglia, are placed between the strata of the carbonates of lime; but they frequently also form a continuation with them; sometimes, indeed, divided by a sudden and abrupt separation, but frequently, likewise, by insensible gradations; in which latter case there is a specious appearance of an insensible transition of the lime into flint; and the opinion that this is really the fact has been adopted by many.

A piece which exhibits this appearance has one part of it white; which colour insensibly disappears, and is succeeded by a reddish tinge, that gradually increases till the remainder of the piece at length assumes the red, brown, or black colour which is

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proper

proper to this flint. The change of colour is accompanied by a difference in the hardness, which successively increases, as appears from its scintillation with steel; the white part of the stone yielding no sparks; the light red, very few; but the deep red, or black, affording them plentifully. If a stream of nitric acid be poured from one end to the other of such a piece, where the colour is white an effervescence arises, which becomes less sensible in the pale red parts, diminishing as that colour increases, until no appearance of it is discoverable where the redness is deepest, and the scintillation with steel strongest. These characters, however, to the chemical eye are not decisive of the fact in question. For, not to mention that difference of colour never constitutes a diversity of species in either of the three kingdoms of Nature, the properties of hardness, and giving sparks with steel, do not exclude the presence of carbonate of lime; since, though it has been considered as the distinguishing property of calcareous carbonates, that they do not af-

ford

ford sparks with steel, it has been proved that there are several which have this quality. I possess several specimens of marbles, that I collected some years since in the quarries of Carrara, which when struck against steel afford no inconsiderable quantity of sparks. The same may be said of the effervescence with acids, there being several kinds of these carbonates in which acids cause no motion, though they sufficiently dissolve them.

To obtain proofs less equivocal, whether this transmutation really took place, I resolved to have recourse to chemical analysis, making my experiments on fragments of the same piece, some entirely white, others of a very light red, others still redder, and others of a deep red. The results were as follow :

In the fragments of the first kind, I found the quantity of lime very great, and that of silex very small ; neglecting, at that time, the carbonic acid^d gas, and the small

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portion

portion of alumine. In those of the second, the quantity of lime was great, and that of the filex moderate. In the third, the portion of the lime was moderate, and that of the filex large. In the last, the quantity of filex was very great, and that of the lime small.

From these facts it appeared to me evident, that it was not necessary to have recourse to an imaginary transmutation, since the gradations in the same stone above described might be explained without it. Those flints which make a part of the same stratum with the calcareous carbonates, shew that they were formed at the same time with them; that is, when they were produced by the numerous sediments of the sea-water loaded with calcareous mixed with filiceous particles. When the latter were abundant in the same place, they united by the force of affinity; forming, by their precipitation, filiceous strata continued with calcareous; and when the filiceous particles were few in proportion to the calcareous, they united with

with the latter, generating mixtures of the two earths such as they have been found when analysed.

It must, however, be observed, that not unfrequently they have not an immediate connexion with the calcareous carbonates; but are only found under them in the form of globes and lenses invested externally with that light grey crust which is observable in a multitude of other flints. It is very possible that the production of these globes and lenses may be posterior, and caused by filtration, after the formation of the calcareous strata.

I shall say nothing of other quarries of lime-stone situated in other parts of the Euganean mountains, nor of the flints they contain, as they do not essentially differ from the quarry above described.

But to return to the stones which derive their origin from fire, I shall now proceed to speak of a kind of lava, the most noble
and

and beautiful which any volcanos afford. Near Teolo rises a small hill, called the Monte del Boldu, principally composed of stony globes of various sizes, disposed in strata, tenaciously adherent, with a central nucleus. These globes are of an iron colour, and sprinkled over in every part with lucid points, which at first view I imagined micaceous; but, on examining them attentively, I discovered they were so many particles of pitch-stone, the *pechstein* of the Germans. When viewed in a bright light, they appear white, some more and some less, and all have a degree of transparence. They are rather mechanically united than combined with a granular base, which appeared to me a soft horn-stone. The furnace changes these globes into an enamel, as black and opaque, as it is solid and compact.

What I observed in this lava induced me to hope that in some other part of the Euganean mountains I might find a pure pitch-stone lava; which I, in fact, afterwards

wards discovered, in a small valley, to the south, below Bajamonte. It there forms a vein about thirty-five feet long, and nine and a half broad. On the surface it is so much decomposed, that it will crumble between the fingers. At a little depth it is less soft, but always retains a considerable degree of friability. The pieces into which this vein breaks frequently take an oval form, which they likewise have when broken into smaller pieces. To render more apparent the colour of this stone, it is proper to wet it; for wetting is to rough stones a kind of half polish. It then has the exact appearance of the pitch-stones. In some parts it is of a red colour; sometimes pale, sometimes more lively, and sometimes inclining to a yellow; in which latter case, it resembles certain kinds of amber; but in other parts the colour is a mixture of blue, green, and white, but all of them very pale. The fractures are always amorphous, of unequal surface, and little brilliancy. The thinner flakes are transparent; as is the property of some pitch-

pitch-stones. This lava contains unequally distributed felspars of a flat form, friable, and not very brilliant. Every stroke with the steel breaks off some pieces, but extracts no sparks.

A few hours in the furnace deprive this stone of its colours, rendering it of an ash grey: it likewise loses its friability and softness, and becomes capable of giving sparks with steel; resembling then a paste of porcelain. Continuing the heat longer, the cinereous colour remains, with the appearance of very numerous bubbles; and the lava passes into a homogeneous vesicular enamel, with a fusion of the felspars.

The small valley of Bajamonte is not, however, the only place in which this pitch-stone lava is found; it is met with in several others; as at Monte Sieva, and its environs. We there find banks or veins inclined in different angles to the horizon, and sometimes perpendicular to it. The lava of one of these has exactly the
 £ colour

colour and lustre of pitch, and contains numerous felspars. In its external appearance it does not differ from that before described. It has, however, one peculiarity which must render it valuable in the eyes of the volcanist.

Pumices are a kind of products which bear in them, demonstratively, the evidences of fire; and the traveller who on any mountains meets with a vein of uncertain origin which passes immediately into the state of pumice, is fully warranted to declare it volcanic. This is the case in the present pitch-stone. It contains groups, more or less large, of fibrous, light, cellular pumice, not merely contained within it, but composing one single body with it: whence it appears that some parts of this rock, either by a more violent action of the fire, or because they were more easily vitrifiable, have passed into the state of pumice.

In the same Monte Sieva, besides a lava
with

with a petrosiliceous base, which, from its compactness, extremely resembles the natural petrosilex, but which is fusible in the furnace, we find another vein of pitchstone lava, but of much greater extent, and which is disposed almost vertically. On digging into this vein, we find very beautiful and well preserved pieces of pitchstone lava. For the most part it has the colour of resin, an elegant lustre, a fine grain, and great compactness. It is smooth and clear in the fracture, with amorphous fragments, semi-transparent in the points. It is not, however, sufficiently hard to give sparks with steel. It is not without feltspars, which have a vitreous aspect.

This lava does not entirely compose this extensive vein; but is found there in pieces, usually small, which are closely bound together by a stony substance which acts with respect to them as a gluten or cement. These pieces have not been rolled by a stream or waves, and thereby become round, but are amorphous, and with acute angles.

angles. It is evident, therefore, that this lava has been broken by some violent agent ; and its pieces afterwards have been taken up, and inclosed within the stony substance, which, when carefully examined, is found to be only a conglutination of very fine dust of the same pitch-stone ; which also contains stones of several other kinds.

At Cataio, where is the villa of the Marchese degli Obizzi, are large excavations in the side of a mountain, made in the same brecciated pitch-stone. We here, likewise, find only very small, but numerous, fragments of this stone bound together, in like manner, by a congenerous ground.

In another part of this mountain the same stone again appears ; it does not, however, resemble a breccia, but forms thin veins, and is extremely similar to that of Bajamonte.

The experiments which I made in the furnace on the first species of lava I repeated
on

on the others ; not excepting the base of those I have termed breccias ; and I obtained from them the same kind of grey and cellular enamel.

I have called the lavas now described pitch-stone lavas, because they resemble in their external appearance the stone designed by that name. I have likewise the authority of M. Dolomieu, who treating of lavas found by him in the Paduan mountains, and in the islands of Ponza, gives them that denomination. He asserts, however, that the lavas differ from the pitch-stone in a peculiar property, which consists in the extreme ease with which the volcanic pitch-stones may be fused, and the infusibility of the true pitch-stone even in a violent fire*.

Having obtained a number of pitch-stones that were not volcanic, I determined to make experiments on them in the fur-

* In his Notes to Bergmann's Dissertation on Volcanic Products.

nace. They were, in the whole, nine : three from the isle of Elba ; one cineritious and almost opake ; the second semitransparent and yellowish ; and the third opake and inclining to black : three from Germany ; the first yellow, the second red, the third black, and all opake : the three last from the Pyrenees ; one reddish, the other green, and the third of a colour between a green and a pale blue ; and all three somewhat transparent in the angles. The first six, after having continued forty-eight hours in the furnace, shewed no sign of liquefaction ; but only became white, extremely light, and pulverable under the finger. Those of the Pyrenees were changed into a beautiful white enamel, giving sparks with steel, and full of minute bubbles. The pitch-stones of Saxony, which are found in places not volcanic, are easily fusible in a not very strong fire, as Delametherie has observed.

Several analyses have been made of pech-stein or pitch-stones. In one, Berg-

mann found the portion of flint to be greatest, that of alumine, little, and that of lime, least.

Another, analyzed by Wiegand, gave

Silex	-	-	-	65
Alumine	-	-	-	16
Iron	-	-	-	5

The other 14 parts requisite to complete the 100 were dispersed in the operation*.

A third by Gmelin

Silex	-	-	-	90
Alumine	-	-	-	7
Iron	-	-	-	3

The pitch-stone lavas of the Euganean mountains having never to my knowledge been analysed, I undertook this operation on the three species mentioned above; and the following were the results:

* Kirwan's Mineralogy.

Pitch-stone lava below Bajamonte,

Silex	-	-	-	71
Alumine	-	-	-	18
Lime	-	-	-	4
Iron	-	-	-	5

Pitch-stone lava of Monte Sieva in beautiful and well preserved pieces,

Silex	-	-	-	$73\frac{1}{2}$
Alumine	-	-	-	14
Lime	-	-	-	8
Iron	-	-	-	$3\frac{1}{3}$

Pitch-stone lava of the same Monte Sieva, serving as a cement or base to the above pieces,

Silex	-	-	-	$68\frac{3}{4}$
Alumine	-	-	-	19
Lime	-	-	-	8
Iron	-	-	-	2

When these three analyses of mine of the volcanic pitch-stones of the Paduan mountains are compared with those of Bergmann, Wiegleb, and Gmelin, we shall

find that the principle most abounding in these six stones is the flint ; that the alumine is but in a moderate or small proportion ; as are likewise the lime and iron when they enter into the composition of these stones. It is therefore evident that these six stones are of the same species ; nor can the infusibility of several pitch-stones, which are not volcanic, distinguish them as essentially different from the volcanic, since we find in the genus of petrosilices some which fuse in the furnace while others remain refractory. It is, besides, not invariably true that volcanic pitch-stones are easily fusible. Those of Monte Muffato, of which I shall presently treat, require a continuance of several days in the furnace before they are completely fused. Some pitch-stone lavas of the islands of Ponza, which are of a pale white colour, and of a smooth and shining fracture, after continuing several hours in the furnace, only become of a deep red colour, and fusion does not take place till after thirty hours. It is remarkable that almost all volcanic

canic

canic pitch-stone lavas, whatever may be their colour, as soon as they are exposed to our common fire, become red.

These pitch-stone lavas, which are found in other parts of the Euganean mountains besides those already mentioned, have induced Father Terzi, a Benedictine, to suppose that they were no other than real glass, an opinion which he published a few years since in some letters on the Euganean products. He informs us that he discovered large veins of them in the Monte del Muffato, and at Breccalon, as well as in other places. The novelty of the discovery greatly excited the surprise of many Paduan naturalists, and especially of the Abbé Fortis, who having frequently made excursions to these mountains to examine their products, could never meet with this extraordinary glass. To ascertain the truth, he, with some other persons well acquainted with this branch of natural science, repaired to the mountains, and soon discovered the error which had been committed by the good Father mistaking

taking these pitch-stone lavas for glass, which error he detected and proved in a Memoir entitled *On certain parts of the Paduan Mountains* *.

In September 1792, the Marchese Antonio Orologio and myself, having made an excursion to the Euganean mountains, to visit this celebrated naturalist, who resided at the village of Galzignano, he conducted us to Monte del Muffato, where these supposed veins of glass were to be seen; but we found that they were only large masses of pitch-stone lava, similar to that above described; of which I was still more convinced afterwards, as I took some specimens from the spot and carried them with me to Pavia. This pitch-stone lava is of two kinds. The one is interrupted with thin streaks of a white earth, which attaches to the tongue and emits an argillaceous smell, and by which the lava often appears as if divided in small pieces; it also, in

* Sopra parecchie località de' Monti Padovani.

many places, includes extraneous bodies, some of which are of considerable importance to volcanic enquiries. These are small pieces of horn-stone possessing that porosity which characterizes them for true lavas. One of the specimens above mentioned contains a fragment of this kind two inches in thickness, extremely perfect, and very porous. The vacuities are round and elliptical: satisfactory signs that it has made a part of some current.

The other lava from the same mountain resembles the former, as far, at least, as can be judged from the specimens I brought away, in its colour, which is that of turpentine, only much darker and less lively: and in its consistence; except that it forms unmixed masses, and contains amorphous felspars, of little or no brilliancy. Among all the pitch-stone lavas of the Euganean mountains that fell under my observation, this is the most compact, heavy, and hard. The eye alone, however, is sufficient to discern the great difference between these

pitch-stone lavas and volcanic glafs. The idea of volcanic glafs is derived from that we have from our common glaffes; the inseparable characters of which, as we well know, are, that they should have a shining and bright surface; be composed of indiscernible particles; break into angular pieces, extremely thin at the edges, and with acute and piercing points; with a fracture either entirely smooth and clear, or, as we frequently find, with waving and curved streaks; not to mention its transparency, a quality known to every one, and, in glafs, one of the most valuable. The same, precisely, are the characters of the greater part of volcanic glaffes; but the description of the pitch-stone lavas is very different. They have commonly a dead and dull lustre; their paste is fine, indeed, but not comparable in fineness to that of glafs; they are less smooth in the fractures, less sharp and cutting at the edges, and have little or no transparency. They are likewise distinguished by another property from volcanic glaffes, the greater part of which are sufficiently

ciently hard to extract sparks from steel, that is to say, to melt it : on the contrary, I was never able to extract the smallest spark from the pitch-stone lavas above mentioned, though I made the experiment on them with the best steel. They are therefore less hard than volcanic glass, as is indeed apparent from the facility with which pieces fly off at every stroke. To these evident dissimilarities we may likewise add the weight, which in pieces of the same size is always greater in volcanic glass than in pitch-stone lavas.

Father Terzi may, however, easily convince himself that those veins of the Euganean mountains which he calls glass, are by no means entitled to that appellation, if he will fuse a small portion of them in the furnace. He will then find the product a true enamel, exhibiting a vitreous aspect not at all discoverable in the pitch-stone lava from which it was produced. This is true, likewise, of the veins of Monte Muffato ; and shews that the pitch-stone lavas must not only

only be excluded from the class of volcanic glasses, but even from that of enamels.

When, in the year 1789, I made an excursion over the mountains of Padua, in search of volcanic objects, accompanied by the Marchese Orologio, we, at Praglia, were received and most hospitably entertained in the ancient and magnificent monastery of the Benedictines by the excellent Father Terzi, who, after dinner, took us into his private cabinet of volcanic-marine products, collected on the Euganean mountains. He presented us likewise with some specimens, informing us at the same time where they had been found, which I think deserving of a particular description.

The first, which, according to the account he gave us, was brought from Schivanoja, is a mixture of amorphous, white, and friable felspar, and black, prismatic, and extremely brilliant shoerls, much resembling some species of tourmalins. From this mixture is obtained, in the furnace, an extremely
ly

ly black enamel, of the greatest compactness, scattered over with white points, which are felspars not entirely vitrified. The magnetic needle is sensible to these shoerls at the distance of one line and four-fifths.

The second product, which is from Monte Merlo, consists of an aggregate of extremely white and shining half-crystallized felspars, of a changeable colour, which in the furnace produce a white, and spongy, but hard glass.

The third, which is from the same mountain, at first view, might be taken for a pumice, as it swims in water; but, when properly examined, appears to be a vitreous scoria, in the solid parts sufficiently hard to give sparks with steel; inflated and rendered spongy by the action of fire, and aëriform substances. The furnace perfectly vitrifies it.

Two other products, one from Mascabo, near Praglia, the other from Tramonte, were

were true pitch-stone lavas, though Father Terzi believed them to be real glasses.

I had not time to certify myself with respect to the places where these productions were found; but I cannot doubt the truth of the accounts I received concerning them. I can at least affirm, that there was no error with respect to the two products of which I shall now proceed to speak, as I found them precisely in the places which had been pointed out to me by the Reverend Father.

The first of these is met with at the foot of a very high rock, called Pendife, and forms a vein, which runs from east to west, and, in the opinion of Father Terzi, is glass. Certainly, when we take off the outer coating, which, as in a great number of other stony substances, is in a state of decomposition, and, consequently, has lost, in a great degree, its external characters, the interior mass may at first deceive the eye of the observer, and induce him to consider it

as real glass. The aspect is smooth and shining, like that of glass; but with some unctuousity, as is the property of some less perfect volcanic glasses. But on examining, with greater attention, the pieces recently fractured, we do not find in them the characteristics of volcanic glass; as they have not the fineness of consistence, the undulating superficial streaks, the sharp edges, nor the acute points. We may even handle and press the flakes and fragments of them without fear, which cannot be done with impunity by volcanic glasses.

We know, likewise, that the primordial rocks, when they are changed by the action of subterranean fires into the nature of glass, are no longer recognizable; as they have lost their primitive structure, and are reduced, together with the extraneous substances they contain, as shoerls and felspars, to one similar and homogeneous mass; whereas, on the contrary, the vein in question sufficiently declares its origin, which is a petroflex of a dark green colour, a fracture
somewhat

somewhat scaly and conchoidal, of a grain moderately fine, giving scarcely any sparks with steel, and having, in the points, a very slight degree of transparency. The felspars and micas, however (of the former of which the number is but small, but that of the latter very considerable), do not form one homogeneous paste with the base, but are both in a state of the greatest preservation. The felspars exhibit a crystallized form, but it is impossible to define it where the petrosilex has not been altered. It is not the same with the superficial crust, the base of which, having been in part destroyed, holds these stones but feebly; so that they may easily be detached entire with a knife; when they appear to be prismatic crystals, with tetrahedral rectangular facets. We cannot, therefore, in any manner, call this vein a glass, but only, at the utmost, a vitreous lava.

By the side of this volcanic rock, there is another, of a congenerous base, and containing the same micas and felspars; but it is of a pale green colour, and tolerably

hard: it has not, however, the brilliancy of the former. Both these rocks produce in the furnace a greyish enamel, with an entire fusion of the felspars, but not of the micas, which leave black points within the enamel.

The other product of which I went in search, according to the directions given me by Father Terzi, was, in like manner, in his opinion, a volcanic glass, but detached and scattered. It is found near the Church of Valsanzibio. Having taken a specimen of this into my hands, and examined it carefully on every side, I perceived that in this instance he was not mistaken, and congratulated him and myself on the discovery. It exhibited, in fact, the most indubitable characters of a true glass. It was black, and gave sparks with steel. I was, therefore, very anxious to examine the place where it was found, and repaired without delay to Valsanzibio; where I found more than one piece of it, not infixed in the earth, nor in the midst of any rock or stony vein, but loose, and scattered over the ground, like
stones

stones in a public road. I was somewhat surprised at this ; and, on making enquiries of some peasants on the spot, they told me, that some shepherds had brought that glass from the grottos round the fountains of the garden of N. U. Barbarizo, at a little distance from the Church of Valsanzibio, and, finding it useless, had thrown it away there. I repaired, accordingly, to the place they pointed out, and found that it was, without the least doubt, of the same kind. I, afterwards, learned from the keepers of the garden, that it had been procured from the scoriæ of the furnaces of Murano, near Venice.

I shall conclude this account of the volcanic specimens of the Euganean mountains shown me by Father Terzi, in his cabinet of natural curiosities, with mentioning one more, which in his opinion was a volcanic glass, and had been found detached on Monte Merlo. To this, likewise, I cannot refuse the appellation of glass. It is, like the former, black, compact, and heavy. As I did not go to the place where it was found, I cannot

cannot pronounce with certainty relative to its origin. It is possible that this glass may be the production of those very ancient volcanos, since Sir John Strange, at number 62 of his Catalogue before cited, mentions some pieces of fossil glass, but which are solitary and accidental, found in some parts of the Euganean mountains. It is not, however, absolutely impossible but that it may be glass from the furnace; at least the accident of the glass of Murano ought to teach us to be cautious, and suspend our judgment relative to the question, whether a mountain may have been volcanic or not, when we have no other proof than finding a loose piece of glass, scoria, or other substance deriving its origin from fire, while we are uncertain whether that fire was, or was not, volcanic. For, even though the pieces found should be really volcanic, they cannot afford a certain proof of the volcanization of the place where they are found detached. Of this I can produce an instance which happened to myself in a cursory visit that I made to Capo Colonne, a promontory

of Attica distant twenty miles from Athens, when, in 1785, I accompanied his Excellency the Venetian Envoy, the Cavaliere Zulian, to Constantinople. I there found pumices scattered over the ground, to my no little surprise, as the place exhibited no indications of being volcanic. They were of that kind which, from their levity, swim in water; and, being of a globose figure, I suspected that they had once flowed. On descending the promontory on the top of which these pumices are found, and proceeding to the shore, near a narrow peninsula, exposed to the dashing of the waves, I found three other similar pumices, which authorised me to conclude that those on the height above, which is about one hundred and sixty feet above the level of the sea, were some of those that had been thrown by the waves on the shore, and afterwards carried thither by men: the only explanation of which, in my opinion, the case admitted. To the shore they had been brought by the sea; for it is well known that many islands in the Archipelago are volcanic;

volcanic; and that Santorine, in particular, is only one immense mine of pumices*.

The objections which may be made to the relations that ascribe a volcanic origin to a country, merely because certain substances that bear the marks of subterranean fires are found in it, permit me to say, are equally applicable to other proofs of the same kind which are by no means more decisive. Here, it is said, there must have been a volcano, because the matters found are extremely black, and therefore bear the characters of fire. There we are authorised to form the same opinion, because lavas have issued from the entrails of a mountain, or volcanic veins and strata are found in its fissures.

There are many writers who, without adding any other proof, use these expressions to signify to their readers the discovery of some ancient volcano. I do not

* See Chap. XIX.

deny the possibility of there having been a volcano in such places; but I must affirm that these indications are equivocal, and, therefore, may be fallacious. It is true that many volcanic products are black, with a colour varying from the blackness of iron to a greyish black. It is equally true that, in a long series of time, this colour is not lost by many volcanic productions, as appears from some lavas in the Eolian isles. But it is likewise true, that in many others the blackness diminishes in time, and, at length, totally disappears, as we see in the greater part of the lavas of Vesuvius and Etna, which, though at first they approached more or less to a black colour, have gradually lost that colour, till at last they have acquired one resembling that of common earth. It is sufficient merely to cast the eye on the recent currents, those of a moderate age, and the most ancient, of those two volcanos, to perceive these successive changes. Every lava, however, though of a recent date, is not black. The colour which is proper to the primordial

primordial rocks frequently does not disappear in consequence of the action of fire. The colour of many lavas approaches to a black, because that was the colour of their respective primitive rocks, as we see in the lavas with a horn-stone base. In others it is a cinereous grey, and even white, because they derive their origin from stones of a similar colour, as, for instance, felspars and petrosilex. This diversity of colours, black, grey, cinereous, and more or less white, is not unfrequently preserved even in the enamels and glasses produced from these rocks when fused in the crucible. It is therefore certain that the colour of the products alone is not a certain indication of a volcano.

I consider as illusory, and not merely inconclusive, the asserting the existence of ancient volcanos because there exist veins or volcanic matters; since this is the same thing as saying there are volcanos because there are volcanos. And though a writer should be convinced

from his own observation that these matters have really suffered the action of fire, if he wishes to convince the philosophical world he must specify their nature ; as whether they are puzzolanas, ashes, glasses, enamels, scoriæ or lavas. The precision and exactness required in the present discerning age likewise render it necessary that he should characterize these different volcanized substances ; and it will be to little purpose that he adduces in proof of an extinguished volcano the remains of a current of lava, unless he properly describes it, since the advancement of this science depends entirely on exact descriptions of products affected by the fire. The most able volcanists of the present time write after the manner of accurate mineralogists. Among these volcanists, the first place is certainly due to M. Faujas de Saint Fond, as is sufficiently proved by his *Mineralogy of Volcanos*.

And here I cannot refrain from making some observations relative to lavas in general.

ral. By the word lava is understood, as every one knows, a liquefied stony substance which has been in motion. When a mountain is of a conical form, and has a cavity resembling an inverted tunnel on its top, or evident marks of one, and when from this tunnel, as from a central point, a number of stony strata diverge towards the lower parts with a waving form, or with inequalities and tumours, we cannot doubt the presence of lavas. It is equally indubitable, when we are certain of the volcanization of the mountain from other signs, and see these stony strata arising from its summit, and tending downwards, with the wavy appearance and inequalities before mentioned, though there should be no apparent indication of a crater. When we ascend to the summit of those Eolian Isles in which the remains of craters are no longer visible, we immediately discover conspicuous currents of lava. There may, however, be cases, with respect to mountains that have suffered the action of fire, in which, from want of local circumstances,

we may remain in doubt whether the volcanized rocks that present themselves to our view, have ever actually flowed. This doubt I experienced myself, when I first visited the Euganean mountains, in consequence of my observations relative to the primitive rocks, and the experiments I had made on lavas in the furnace. I considered that it was possible the rocks of the Euganean hills might never have flowed in currents, and consequently that they could not have been lavas, though they might bear very sensible marks of fire, and even the same with vitreous lavas; as I was convinced from the experiments I had made in the furnace, which, without wandering too far from my subject, I will here briefly describe.

In Chap. XI, I have spoken of the fusion of some porphyries with a horn-stone and petrosiliceous base. The following are the appearances I observed some time before their fusion. The pieces, though before their fractures were scabrous and angular,
assumed

assumed a smooth and vitreous surface. Their internal grain acquired an aspect rather vitreous than siliceous, even in those stones, which, having for their base the horn-stone, had an earthy appearance. The pieces, except that they adhered by some points, preserved their former figure and angles; which preservation of the figure takes place in other cases that I shall proceed to mention.

The felspar of Mount St. Gothard, or the adularia of Father Pini, lost its changeable colour and transparency, became white within, semi-enamellar, and vitreous externally.

In the felspars of Ischia, the vitrification penetrated to the depth of some lines.

In some of the potteries of Pavia, they use a kind of earth, which, from the place where it is digged, is called *biella*, which strongly resists the fire. It is commonly
found

found to be composed of alumine, silice, and a very small quantity of lime. It is usually refractory to the fire of a glass furnace; but sometimes will fuse when it contains a rather larger proportion of lime. Of this kind of earth I made some small spheres and cubes, which I left four or five hours in the furnace; when the vitrification had penetrated to the depth of two thirds of a line, and in some even a whole line, and the central part had become semi-vitreous.

Similar effects take place in lavas. Their surface assumes an enamel or vitreous aspect, which in the internal part is less apparent. In some, however, we find points which have become vitreous, though these lavas before did not contain a single atom of glass. In general, they lose that grain and texture, which indicate the primitive rocks whence they were derived, and they all, or nearly all, may be called vitreous.

Thus

Thus we have a prodigious number of fossil productions which have the most specious appearances of lavas, and vitreous lavas, though they have never suffered liquefaction ; as is incontrovertibly proved by the pieces, which, when they come out of the furnace, retain exactly the configuration they had before they were exposed to the fire.

Instructed by these facts, I confess that the first time I saw the Euganean mountains, and found myself in a theatre very different from that presented by the Eolian isles, not to mention Etna and Vesuvius, I could not avoid entertaining doubts whether the numerous rocks, which in a great part form these mountains, owed their origin to volcanic eruptions, or were pre-existent to the subterranean conflagrations, that had only penetrated them, infixing in them indelible traces of their action, but still leaving them in the place where we at present see them. Every doubt however was removed, and I remained convinced that
these

these prodigious masses of rocks were igneous eruptions, or, in fact, currents of lava, of which the porosity of some of them was a very evident and satisfactory proof. It is indubitable that the elastic gases, which generate pores and vacuities in the rocks acted on by fire, cannot produce that effect unless these rocks are softened sufficiently to yield to the expansive force of these aëriform substances, which must precisely happen in their actual liquefaction. This, though sufficiently evident in itself, is undeniably proved by experiments I made in the furnace. When the porphyries with a petrosiliceous or hornstone base, and, generally, when compact lavas assumed the simple vitreous varnish, and somewhat of a vitreous aspect internally, but without the pieces conglomerating and forming one single uniform mass, they rarely or never contained bubbles; which, on the contrary, were conspicuous and numerous when the fusion was complete, and the larger, the greater the degree of liquidity produced by the fire in the stony bodies.

The

The porosity of volcanic rocks is, therefore, a decisive proof that they were once in a fluid state. Several of the Euganean rocks are porous and cellular, as I have already shown of more than one, and shall proceed to show of some others.

There is a declivity on one of the Euganean mountains, the name of which I cannot give, having neglected to note it in my journal, an omission of little importance to the truth of the fact; which declivity is composed of a rock with a horn-stone base, containing felspathose crystals, and full, both on the surface and in the internal parts, of round vacuities, such, precisely, as are usually produced in lavas by aëriform fluids.

I shall make a few more observations on the Euganean lavas; and shall notice that one of them containing bubbles, and that in a considerable number, is found in immense quantities in, and on the side of, the road leading from Bajamonte to Rua.

This lava, which has for its base the hornstone, and emits a strong argillaceous odour, has the colour of a dead leaf, a grain somewhat sandy, and a great number of round pores, from those of a size scarcely discernible, to others seven lines in diameter. Many of these pores are occupied by crystallized globules of carbonate of lime, produced by filtration. This lava has the external appearance of being very ancient. In the furnace it affords one of the usual black and opaque enamels.

To the south-west of a declivity of Rua we find great masses of a volcanic rock that has fallen down, the felspars of which are an exception to those of the innumerable lavas described in this work on account of the extraneous bodies enclosed within them. This rock, the different pieces of which are of different colours (some being ash-grey, others red, others of a pale violet), is of a petrosiliceous base, with an earthy grain, and contains, besides hexagonal micas with oblique sides, transparent felspars, cubical, prismatical,

prismatical, and sometimes amorphous, which give sparks strongly with steel, and form very brilliant plates. The largest are five lines and three quarters in length. Each of these felspars includes within it a small portion of the petrosiliceous base, which forms in it a kind of nucleus, and occupies a considerable part of its substance. But to what cause are we to ascribe this singularity? I can conceive no other method of explaining it, but by supposing, that when the integrant particles of the felspars, disseminated in the earthy and liquid base, united by the force of aggregation in crystallized masses, each of these masses included a small part of this base, greater or less in quantity. The rarity of the phenomenon, however, supposes a local circumstance, which had a direct relation to this singular combination, and of the nature of which I am ignorant.

The felspars fuse in the furnace, and become intimately mixed with the base in such a manner, that the result is a solid, white, semi-transparent glass, with black spots, occasioned

fioned by the micas of that colour which have remained, in a great measure, refractory.

I shall omit to describe another porous lava, likewise from Rua; and two of the compact species, with a horn-stone base, found in that vicinity. I think more deserving of attention one disposed in strata oblique to the horizon, which is found on the sides of the road leading from Galzignano to Ciesà.

This lava is white, and has the compactness of fine carbonates of lime, which it resembles in appearance, fracture, and weight. It affords a few sparks with steel, and is distinguished from other lavas by numerous points of a delicate green, scattered over the white ground; but which, to be viewed distinctly, require a lens with a strong light. When thus magnified, we find that they are a semi-pulverous earth, which may be detached with the point of a needle, and is placed between the fissures of minute amorphous masses of shining, white, and extremely

extremely transparent quartz. I know not whether this powder be a decomposition of quartz, which, however, does not appear very probable, as it is found deep in the internal part of the lava, where it is not in the least altered; or whether it be an extraneous and adventitious substance. Besides the quartzose grains, the petrosiliceous base contains a few very small felspars, which, from their changeable brilliancy, their rhomboidal form, and their being composed of minute laminæ, cannot be confounded with the quartzose grains.

It is necessary to observe that the basis of this lava, in the furnace, serves for a flux to these quartzose grains; the result being a homogeneous and white enamel, without the smallest appearance of any remains of the quartzose grains, or the felspars.

Another lava, found on each side of the road, in a place called the Pigozzo, opposite

Catajo, is in no respect different from this, except that the quartzose grains are not accompanied with green spots. It yields in the furnace the same volcanic product.

At Monte Nuovo we find several masses of a lava which deserves our notice, from its being reduced to such a state that it is pulverable by the mere pressure of the finger. It has an argillaceous base, and contains an abundance of felspars which have preserved their prismatic figure, but are nevertheless pulverable. It is rare, in volcanic places, to find felspars so much injured, even where they have been acted on by sulphureous acids; of which there are here no traces: and therefore this decomposition seems to be derivable from the humid elements, and other causes in the atmosphere. On breaking this lava we discover some minute octagonal and hexagonal prisms, obliquely truncated, less soft than the base to which they are attached. They do not in the least appertain to the genus of either
 shoerls

hoerls or felspars; and, in their external characters, seem not to differ essentially from the lava itself.

Among the number of the pitch-stone lavas already mentioned there is one which must peculiarly attract the attention of volcanists, from the pumices it contains. Montefelice, one of the Euganean mountains, which stands detached, and is of a moderate extent and height, is partly composed of a white argillaceous lava, of an earthy aspect, in which we find this peculiarity; only that, while the pumices of the pitch-stone lava are derived from the parts of it being dilated and tumefied by gaseous elastic substances, those of the present lava appear to be adventitious, consisting in white globules easily separable from the base, from which probably they were taken when it was in a fluid state. Except that they are less, they considerably resemble the pumiceous globules of Pompeii near Vesuvius; and both, in the furnace, produce a similar enamel.

This lava, besides the pumices, contains elegant felspathose crystals, which, together with it, completely vitrify in the furnace.

Monte d'Arqua was the last which I visited. Its summit is composed of a grey compact lava, which has a horn-stone base, affords sparks with steel, and contains micaceous and felspathose crystals. This lava is found in some places in strata nearly horizontal.

To these lavas, which I found on the spot, while accompanied in my researches by the Marchese Orologio, I shall add a few others from the Monte del Catajo, which were afterwards noticed and examined by that illustrious nobleman and naturalist, who visited every part of that mountain to which his villa is contiguous, and collected specimens of the species of most importance, observing the places where they were found. At my request he transmitted them to me, with their several

veral descriptions, which I shall here briefly give the reader, only making such alterations as appear to be necessary.

I. Is one of the finest lavas of the Euganean mountains. Its base is felspar in the mass, but it is with difficulty recognized from its exterior characters, the fire having changed it into a vitreous lava. It is of a cinereous colour, compact, but not very hard, on account of its numerous fissures. It contains crystallized micas and felspars; and the enamel it produces in the furnace, similar to that of the pitch-stone lavas, forms one homogeneous mass with the fused micas and felspars.

This lava, on which the noble palace of the Marchese degli Obizzi is built, occupies an extensive tract of the sides of Catajo, to the south; and branches off, likewise, to the north-east; though, from its being there in a state of the greatest decomposition, it has lost the characters of a vitreous lava, and taken those of an earthy and
U 3 pulverulent.

pulverulent. The experienced, however, may still discern within it the vitreous lineaments ; and I am convinced that, were a deep excavation to be made in this lava, we should more completely discover its vitreous nature ; as, by the same means, we ascertain the real quality of other stones, both natural and volcanized, the surface of which has been changed by the action of corrosive agents.

In the internal part of this decomposed lava, we find several globes of petrosilex as strongly characterized, as in the natural state. As it is detached, I dare not number it among the lavas. Similar to many congenerous stones, it is surrounded with a white argillaceous crust, which attaches to the tongue ; and contains a number of micaceous points, and felspathose laminæ.

In the furnace it becomes white, and acquires a thin vitreous coating : the pieces, however, do not lose their primitive figure.

II. This

II. This lava is found at about one quarter of the ascent up the mountain, and continues to the top: it is also met with in detached pieces along the declivities. The base of this lava is a compact, heavy trapp, of very fine particles, interrupted with felspathose scales. It has the black colour of iron. The furnace changes it into an enamel full of bubbles; but it retains its former colour.

III. This species is in part buried within the lava No. II; and, in part, issues from it, forming tortuous veins of various sizes, and running in various directions, one of which intersects the decomposed vitreous lava No. III. The base of this lava is an extremely compact petrosilex; it is of a fine grain, accompanied with micaceous and felspathose crystals. It is of a greyish blue colour, inclining to a black. Its fusion in the furnace was complete at the end of thirty-eight hours.

IV. This lava is white, light, and de-
U 4 composed

composed in the same manner as some tracts of that of No. I. Its base is argillaceous, and it attaches to the tongue; the small crystals of black mica and felspar which it contains, are, however, uninjured. This lava, likewise, issues in veins from the body of that of No. II.

Its product in the furnace is a semi-transparent grey glass, with the fusion of the felspars. This lava has the peculiarity of strongly attacking the crucible; combining with the earth of which, it forms round the sides an elegant, extremely transparent glass, resembling the emerald.

V. Besides several beds of pitch-stone lava, which concur to the formation of Catajo, there is one, near the summit, towards the south-west, interspersed with innumerable very fine white streaks parallel to each other, and which form a strong contrast to the red streaks of the pitch-stone lava. These white streaks, as far as I could discover, are the same lava decomposed,

and perhaps rendered such by the filtration of the rains which have insinuated through the small fissures of the lava.

In the furnace it changes into an enamel similar to that afforded by the other pitch-stone lavas, with the liquefaction of the felspars it contains.

VI. This lava is thus described by the Marchese Orologio :

“ Near the top of the first summit” (the Monte del Catajo is bifurcated) “ there is a
 “ spacious irregular plain with many inequalities, which I incline to suspect was
 “ an ancient crater destroyed by time, and
 “ filled by the falling in of its sides. We
 “ here find enormous masses of a species of
 “ breccia, or pudding-stone, composed of
 “ small fragments of many varieties of lava,
 “ united and bound together in a hardened
 “ clay.”

This breccia I carefully examined, and
 consider

consider it as well deserving attention. Black shoerl in the mass constitutes the greatest part of it. It is found in pieces surrounded by a grey earthy crust, which attaches to the tongue, and is a decomposition of the shoerl. The crust in some pieces is extremely thin, but in others extends to a greater or less depth; and in some leaves only a black shoerlaceous point in the middle. These small pieces are usually angular; whence we may infer that they have not been in a fluid state. They are all bound together by a cement, small in quantity, of a pale yellow colour, and a vitreous aspect, which is likewise changed by the decomposition. The breccia in the furnace is reduced to a black and frothy scoria.

The decomposition of this breccia appears to be a consequence of the action of the atmosphere and of time. The shoerlaceous fragments evidently shew that they existed previously to the vitreous substance; which passing over them when it was in a fluid state, included them within it, and formed

one

one body with them. They may, also, possibly be small fragments of a very ancient lava, with a base of shoerl in the mass; unless we rather choose to suppose that some vein of shoerl, broken by the impetuosity of the elastic gases, and reduced to minute pieces by the shock, has been thrown out from a volcanic mouth, without having been fused or changed by the fire.

VII and last Lava. Though this be specifically the same with No. II, it claims to be distinctly mentioned from the manner of its conformation. About half way up one of the summits of the mountain, there is an overhanging precipice, from which go off two ranges of prismatic columns; the one higher than the other, but both nearly vertical. Their height differs from those of one foot to those of three. When we consider the precipice, or rent in the mountain to which they adhere, and the circumference of it, we perceive, that, when it was entire, they extended to but a little distance from their central point. The base of this column

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is

is a trapp, which, in respect to its consistence, and the felspars it contains, extremely resembles that of No. II.

This stone puts in motion the magnetic needle at the distance of scarcely two lines; and may serve for a touchstone; a quality remarked by Cronstedt in the Swedish trapps.

REFLECTIONS AND COROLLARIES.

THE facts explained in the present chapter are highly instructive, from their teaching us the nature of the different volcanic rocks of the Euganean mountains; but they are still much more so from their enabling us to form a comparison between these volcanos and others in Italy and its vicinity, either extinguished or at present burning. We are taught by observation and experience, that nothing exists in nature detached and solitary; but that the whole is connected with a variety of relations, and that we can acquire an accurate knowledge of no single part but by means of comparison. In my other works on physical subjects, I have constantly made it the primary object of my studies and researches to analyse and compare the facts I discovered with each other, and with similar facts discovered by
other

other authors ; and in the present work I certainly shall not depart from a method which appears to me best adapted to enlarge the limits of our knowledge of nature, and increase the treasure of useful science. With this view, therefore, I shall add the following brief reflections :

Though the sea is now some miles distant from the mountains of Padua, it is beyond all doubt that it anciently washed them ; as is proved by the calcareous carbonates, and their horizontal stratifications, besides the marine shells found on them, and mentioned by many authors. It seems equally indubitable, from the observations of Sir J. Strange and the Abbé Fortis *, that this group of low mountains and hills was once so many volcanic islands, resembling those of Lipari, Ponza, Santorine, and innumerable others of the same

* Memoria Geografico-Fisica intorno la vera situazione dell' Isole Elettridi degli Antichi———A Memoir relative to the true situation of the Isles Electrides of the Ancients.

kind ; except that in the very ancient volcanos of Padua any perceptible ignition has gradually diminished and disappeared, nothing remaining but some feeble residue in the well-known warm baths. This antiquity, it cannot be doubted, likewise, is the reason why these mountains, notwithstanding they still retain the figure which characterizes them as volcanic, are greatly changed in their external appearance, being deprived of their craters, probably by the falling in of their sides and the effects of rains ; as also their porous and scoriaceous lavas having been reduced to cultivable earth by the industry of men. The vicinity of these places to others that have long been cultivated, may likewise have greatly contributed to diminish their original wild aspect, and render them very different, in consequence of cultivation, from other mountains which, though they have long ceased to burn, have been destitute of population.

It may here be proper to consider how
great

great an analogy the lavas of the Euganean hills have with those ejected by other volcanos more known to be such, as these are not simple stones, but compound; I mean what are called rocks. The lavas of Etna, which usually have for their base the horn-stone or shoerl in the mass, contain felspars, crystallized shoerls, or chrysolites. Felspars, garnets, and crystallized shoerls are incorporated in the lavas of the volcanos of the Eolian isles, in a base of petrosilex, horn-stone, and shoerl in the mass. Petrosilex, horn-stone, and garnets are constantly accompanied by shoerls, felspars, and micas in the lavas of Vesuvius *. Those of Ischia with a horn-stone base abound in felspars †. The islands of Ponza afford both granitous and siliceous lavas, accompanied with shoerls, felspars, and micas; and St. Fiora in Tuscany is composed of granitous lavas ‡.

* Gioeni, ubi sup.

† See Chap. V.

‡ Dolomieu, ubi sup.

The products of the Euganean mountains, we have seen, are perfectly similar. The base of their lavas, which is shoerl, felspar in the mass, pitch-stone, horn-stone, or petrosilex, is combined with felspar, crystallized shoerl, or quartzose grains. And though I only examined a part of these mountains, yet, from the more extensive observations of Sir J. Strange, we are authorized to say that the nucleus of them all is composed of this stone. It is therefore evident that the ancient subterranean fires, which have laid waste a great part of Italy and the adjacent countries, have had their seat in these rocks; and who can say to how immense a depth they may have extended beneath the surface of the earth? I say beneath the surface, because, though by the violence of volcanic fires large and numerous masses arise above the surface, both on this and the other side of the Apennines, they never, or scarcely ever, concur to the formation of these, which principally result, as may be observed in many parts of them, from the calcareous

carbonates, steatites, arenacious stones, and of a species of quartzose, micaceous, schistus, on which, in a great measure, they rest. It is not, however, improbable that this order of rocks, unaffected by the fire, lies buried under the great body of the Apennines.

I made no excursions to the Vicentine mountains, which we know to be at once of a volcanic and marine origin. We have, likewise, no accurate lithology of that interesting country. But from some specimens which I received from some friends, and, among others, from Signor Giovanni Arduino, and especially from the conversations I had with him on the subject at Venice; I clearly understand that the lavas found there have rock for their base; which rock is sometimes a petrosilex, and sometimes a horn-stone; the extraneous bodies contained within them are shoerls, felspars, and micas. Sometimes the volcanic rock is granitous.

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I should wander beyond the limits I have proposed to myself, should I proceed to consider the nature of the stony substances which have been acted on by volcanic fires out of Italy, and have been described by naturalists of experience and worthy of credit. I shall only say that these descriptions are sufficient to show that they are all, or almost all, rocks or compound stones. As therefore the fires of volcanos extend to a prodigious depth, as may be deduced from the vast mountains they raise above the earth ; it follows that these rocks, besides constituting numerous chains of very lofty mountains, descend to an immense depth, even in those places where we should not know that they existed, were they not discovered by fiery eruptions. We thus perceive how extensively those rocks contribute to form the rind, or superficial coating, of this globe ; the only part of it which man is permitted to examine ; and which we never could have obtained knowledge

of to so great a depth, but for the fiery torrents that have issued from it.

Three different bases of the Euganean lavas have engaged my attention; the felspar in the mass, the petrosilex, and the pitch-stone. The former of these is changed by the action of the fire into a vitreous lava, the equal to which I have not seen among the products of any other volcanos that I have examined. It has been already observed, that in the Eolian isles the felspar in the mass has contributed to the formation of many lavas; but these cannot claim the name of vitreous, as they retain more or less of the external appearance of the felspar; or this felspar has passed immediately into glass or enamel.

The petrosilex, likewise, forms a kind of general exception with respect to the Eolian volcanos. We have seen that many of their lavas have the petrosilex
for

for their base. This stone almost always sufficiently preserves in them its primitive characters; but it is accompanied with a principle, if I may use the expression, of fibrosity and expansion in its parts, which exhibits no obscure sign of its having been acted on by the fire. The lava with a petrosiliceous base, of the crater of Vulcano *, is the only exception. On the contrary, several of the Euganean petrosilices, with respect to their texture, grain, compactness, and fracture, so exactly resemble the most perfectly characterized natural petrosilices, that they might be mistaken for them, if we did not find that they have passed into the state of lava. This peculiarity, however, is not confined to the Euganean volcanos; it likewise appertains to those of the isles of Ponza, as has been shown by M. Dolomieu in great numbers of lavas with a petrosiliceous base. These lavas cannot but greatly excite our admiration, as we find it impossible to conceive,

* See Chap. XIII.

from the knowledge we have of our common fire, how such a stone can be liquefied and flow without losing one of its natural lineaments.

Lastly, the lavas with a pitch-stone base, which are very abundant in these mountains, are a third object deserving our attention. It is not certain that Etna or Vesuvius have ever thrown out a single fragment of them: and the same observation may be made of the rest of the Phlegrean fields. In Lipari alone, among all the Eolian islands, I have found detached and scattered pieces, but which had rather passed into the state of enamel*. The volcanic pitch-stone is not peculiar to the Euganean mountains: the volcanos of Hungary and those of Auvergne furnish some noble specimens of it. It remains, however, to enquire whether it is to be classed among the lavas, or rather whether it has ever formed currents. We may be

* See Chap. XVII.

satisfied that it must, as well as the pitch-stones of the isles of Ponza, from the observations of Dolomieu. According to this author, the similar kinds of lavas found in these two countries have for their base the felspar, with a very considerable quantity of magnesia * ; and, in a note to his work on the islands of Ponza, speaking of the Vicentine lavas, he remarks, that he found among them some productions of pitch-stone, which he could not consider as a true volcanic product, but rather as a concretion formed afterwards by the decomposition of volcanic matters ; and that they contained a great quantity of magnesia. From which we may gather that magnesia, in the opinion of this author, is one of the constituent principles of the pitch-stones of volcanos. The truth however is, that in the three analyses above mentioned, of the pitch-stone lavas of the mountains of Sieva and Bajamonte, two of the Euganean mountains, I did not find an atom of this earth.

* Notes on Bergmann.

The Abbé Fortis affirms that he had discovered, in the pitch-stone lavas of Monte Breccalon, the evident transition of petrosilex into pitch-stone lava; and on comparing the analyses of petrosilex made by others, with those I have made of three pitch-stones, it will be found that they perfectly agree—with no other difference deserving notice, but that the petrosilex usually contains no iron, of which a very small quantity was found in the pitch-stones I analysed.

As it has been already shown, that pitch-stones that are not volcanic and those which are, are of the same genus, I find little difficulty in believing that many of the latter are derived from the former.

In all my researches relative to the rocks of the volcanos in the two Sicilies, I have always been attentive to discover at what degree of heat they fuse in our common fire, that I might infer the activity of the
subterranean

subterranean conflagrations by which they have been melted. I have proceeded in the same manner with respect to the volcanic rocks of the Euganean mountains, employing constantly the same fire, I mean that of the glass-furnace. As to the bases of these rocks, we have already seen that not one of them proved refractory, not even excepting the hardest and most compact petrosilices, which have formed currents. The felspars and micas, with which the Euganean lavas so abound, appeared equally fusible.

The easy fusibility of the felspars excited in me some surprise, when I considered the infusibility which, if not constantly, is very frequently the property of the same stones in the rocks of other volcanos when exposed to the same degree of heat ; and, as I obtained the same fusion when the Euganean felspars were detached from their base, it cannot be alleged that this base served as a flux. A difference so remarkable, it seems probable, can only proceed from the different proportions

of the constituent principles, unless we choose to suppose that in the Euganean felspars, besides the elements common to that stone, there exists some other which facilitates their fusion, though it is imperceptible to the eye, the external appearance of the fusible exactly resembling that of the infusible felspars.

With respect to the product by fusion in common fire, of the lavas of the Euganean mountains, it is found to be exactly the same with that of other lavas, I mean an enamel or glass, as appears from what has been said above. The action of our common fire, therefore, destroys in these volcanic products that primitive characteristic structure which had been left in them by the subterranean conflagrations.

The basaltcs of Vulcano and Felicuda are products of fire, and equally so are those of Monte Rosso, Monte Ortone, and Catajo ; for they are integrant parts of continued volcanic rocks ; which truth did not escape
the

the acute observation of Sir J. Strange and other discerning naturalists. It deserves remark, likewise, that the trapp has taken a prismatic configuration at Catajo, in the dry way, and in Sweden in the humid, as has been elsewhere shown. This may teach us, that we can only determine by local circumstances in which of the two ways basaltcs have been formed.

These two ways, however, have united in the formation of the hills and mountains of Padua, as appears from the mixture of calcareous carbonates with lavas. This combination, which is not found in the Eolian isles, but is observable in the Vicentine mountains, at Vesuvius, in the extinguished volcanos of the Val di Noto in Sicily, in those of Portugal, and Germany near Old-Brifach, and probably in other volcanized mountains, should incite the naturalist to enquire which of these two contrary agents was prior in point of time. I shall not enter into this question, which indeed appears to be precluded by the observations of the

Abbé

Abbé Fortis ; my only object, in fact, being, in this short excursion to the Euganean mountains, to collect some of their volcanic products in the places where they are found, without entering into a very minute examination of the nature of those places, and faithfully to give such a description of them as might contribute to enlarge our knowledge relative to volcanos.

C H A P. XXI.

EXPERIMENTAL ENQUIRIES RELATIVE
TO THE NATURE OF THE GASES OF
VOLCANOS, AND THE CAUSES OF
THEIR ERUPTIONS.

The perfect resemblance of the effects produced by some gases of volcanos and those of others generated in lavas, and other similar substances, when re-melted in our common fire, may enable us to discover the nature of the former, by investigating that of the latter—Matrasses of clay, filled to a certain height with volcanic products, exposed to the fire of a chemical furnace, and communicating with a pneumatic-chemical apparatus prepared with mercury—Experiments made in this manner on the spotted glass of Lipari—Phenomena observed within the matrafs during ignition—No gas appeared above the mercury—Ebullient state in which the glass was found when

when left to cool in the matrafs, after having been eight hours exposed to the fire—No reason to believe that the bubbles were an effect either of the atmospheric air included in the interstices of the glass, or of any permanent gas—Conjecture that these bubbles proceeded from the gasification of the glass itself, occasioned by the vehemence of the heat—Proof of this conjecture in the purest glass of Lipari—The breaking of the matrafs in the strongest heat occasioned by this gasification—Cause why the glass rendered gaseous does not pass into the pneumatic apparatus—Breaking of a third matrafs by the violent gasification of an enamel of Ischia—Enamel of Procida during the gasification sublimed, and adhered to the sides of the matrafs in the form of a thin crust, and enamel points—Confirmation of this in another matrafs, using the same enamel—Evident signs of this sublimation in the fusion of some volcanic substances placed in the furnace in covered crucibles—Reason why this sublimation does not appear in every experiment—Black factitious

flous glass which does not produce gas in the furnace, but which produces it, within matrasses, in a strong heat—Experiments on six other volcanic bodies, which produce little or no gas in the furnace, but a considerable quantity in matrasses, without any appearance of permanent gas—Conclusion that the bubbles and inflations of various sizes, which we so frequently observe in the productions of volcanos, are not the effect of any permanent gas which has acted on them, but of an aëriform fluid proceeding from the excessive subtilization of those productions by means of heat—Not but that volcanic products, exposed to our common fire, sometimes emit permanent gas—Proofs, deduced from facts on a smaller scale, that this aëriform fluid, in the deep recesses of a volcanic crater, being abundantly mixed with the liquid lava, and strongly excited by the subterranean conflagrations, may, by its violent force, raise the lava to the summit of the crater, and compel it to flow over the sides and form currents—Another proof of this fact, which

which renders probable the hypothesis, that this elastic vapour, collected in a large quantity, and finding some impenetrable obstacle under the earth, may cause earthquakes, subterraneous roarings, and burst the sides of the mountains, forcing the lava to flow out—Improbable, however, that this vapour is the cause of the fiery hail ejected by volcanos—Necessity of recurring to other more powerful gases to explain these eruptions—The presence of these different gases clearly indicated in some volcanos—Probable, that in the greater and more terrible ejections another agent much more energetic concurs, that is, water, principally that of the sea, reduced to vapour—Connection between burning volcanos and the sea—The sudden retiring of the latter, in the vicinity of Vesuvius, at the time of the most terrible eruptions, probably occasioned by great quantities of its waters being absorbed in the caverns of the mountain—Experiments and accidents which prove the terrible nature of the explosions and detonations of volcanos, in consequence

of

of waters being reduced to vapour by their conflagration—Enquiry whether water falling upon a burning volcano may be capable to produce explosions, as it is certain it will if it insinuates itself in from below, and its vapours cannot otherwise obtain a passage out—Water falling upon oily and boiling matters generates feeble explosions, which seems to favour the affirmative—Arguments for the negative deduced from the effects of water poured on some melted substances, which are more analogous than oily to the liquefied matters of volcanos—No explosion or detonation occasioned by water falling on crystal liquefied in the furnace—Curious phenomena observed in this experiment—Similar effects produced by letting fall the same fluid on iron or copper in a state of fusion—Explosions and detonations in water, as soon as it touches the surface of melted tin or lead—These explosions greater when the water remains enclosed within these melted metals—Remarkable diversities in these experiments—Experiments on lavas melted in the

VOL. III. Y *furnace—*

furnace—No explosion produced by pouring water on them, when it is not introduced within them—The explosion the stronger the more the water penetrates into them—The results the same when sea-water is used instead of fresh—Conclusion, that water is incapable of producing ejections when it falls on the burning craters of volcanos ; but that it must produce very violent ones when it penetrates into them from below or by the sides—The different permanent gases discoverable in volcanos seem alone to be the cause of the more moderate and smaller eruptions—The symptoms, and incessant ejections, of Stromboli cannot be caused by the evaporation of water, nor by that of the liquefied lava, but must depend on the activity of some permanent gases—Enquiry whether this gas be hydrogenous—That supposition rejected—It cannot be supposed to be atmospheric air—The hypothesis which has recourse to oxygenous gas to explain the phenomena of the volcano of Stromboli, seems least improbable.

HAVING

HAVING finished the description of the products I observed in my excursion to the Euganean mountains, I might consider my volcanic travels as concluded ; but agreeably to the plan I proposed to myself in the Introduction to this work, it still remains for me to discuss some particulars which have a relation to volcanos in general, and are too intimately connected with the subjects hitherto treated of to be omitted, without justly incurring the blame of the reader. In various parts of this work mention has been made of the gases of volcanos. It has been shown that, by their elasticity, stony substances fused in the fire are rarefied, inflated, and become cellular ; as is proved by a great number of lavas, glasses and enamels. We have seen that, by the violence of these gases, the liquefied matters are hastily raised from the bottom of the craters to the top, filling their whole internal capacity, and flowing over their sides ; since, by the action of the same gases, we frequently observe similar pheno-

mena in the furnace. But, in the present age, in which naturalists and chemists are so earnestly employed in analytical researches relative to the nature of aëriform fluids, it is not sufficient to assert and prove the presence of gases in liquefied volcanic products ; it is likewise incumbent on us to endeavour to discover their peculiar nature, and thus prepare the means to ascertain what part they may take in the eruptions of volcanos.

A second interesting object pointed out in the Introduction, and which well merits discussion, is the enquiry relative to the activity of volcanic fires. It is true, that from a number of experiments which I made in the furnace, both on volcanic productions, and on the primitive rocks, almost all of which I subjected to fusion, it appears to be proved that this activity may not be very great ; as a not very strong common fire is sufficient to produce the same effects. From these experiments we certainly acquire some knowledge of which we were
not

not before in possession ; but I do not consider the problem as undeniably solved ; since to these facts a great number of others of a contrary nature may be opposed, of which, as they are related by writers well deserving credit, I cannot omit the examination. I shall impartially consider the weight of each, and afterwards give my sincere and unbiassed opinion.

These two subjects I shall proceed to consider in two chapters, between which I shall insert a very short one, containing an account of a chemical discovery made in the course of my experiments. These will conclude my enquiries relative to these truly terrific phenomena.

Having observed that the bubbles, vacuities and tumours, which are generated by aëriform fluids in many lavas, glasses, and enamels, are likewise produced by the same fluids in the same bodies, when exposed to common fire ; I determined to avail myself of that means to discover the nature of

these fluids. I resolved, in consequence, to fuse within matraffes various volcanic products ; such, especially, as, by the superabundance of their gaseous bubbles, rise from the bottom of the crucibles, and expand over them. I fitted the necks of the matraffes to a chemical pneumatic apparatus with mercury, in order to collect and examine the gases which should be disengaged, by the action of the fire, from the liquefied substances. The matraffes were of clay, of the same kind with that used for the receivers in which melted glass is kept for the making of different vessels in a glass-house. They had a spherical bottom with a long neck, and were of the thickness of six full lines. I tried them by plunging them into water and blowing strongly into them, when I did not find the smallest bubble of air escape. For the greater security I coated them externally, and tried them with the air-pump ; but I did not perceive the least hissing sound that might indicate the escape of air. I repeated these proofs, likewise, after I had made my experiments, and thus

was

was certain that the fluids I found in the vessels could not have entered them from without. To the neck of the matraffes I luted a glass tube, the other extremity of which was inserted in the mercury; in order that, if any liquor should be separated from the volcanic matters, I might collect it. Such a liquor was, in fact, separated; and I found it to be of a nature which I never could have imagined. I shall describe it in a distinct chapter, to prevent the confounding of objects totally unlike in one discussion.

The first product on which I made my experiments, was the sixth species of the glasses of Lipari; that which I have described as having a black ground spotted with white points*. I placed twelve ounces of it in a matrafs, reducing it first to powder, as I did all these products, before I began my experiments, to destroy the bubbles that might have been produced by

* See Chap. XV.

the volcanic fires. The matraffes were of that capacity, that the twelve ounces of every product scarcely occupied one third of their body ; so that the melted matter might inflate and tumefy without impediment.

This glass I exposed in a chemical furnace to a fire of eight hours continuance ; three with a moderate, and five with a strong heat. At the end of an hour and three quarters, there appeared upon the mercury a small quantity of aëriform fluid, which, when examined, did not take fire at the flame of a candle immersed in it, nor extinguish that flame, nor render it brighter, but left it precisely as it was in the atmosphere ; consequently this fluid must be considered as common air, that is, a portion of that contained in the vessels used in the experiment. That such was the fact, I was still more convinced by subjecting this fluid to other experiments. Another small quantity of fluid afterwards collected from time to time on the mercury, which I examined

as

as it was produced, but continually found it to be atmospheric air, which continued to appear during four hours after the fire began to act : in the last four hours none was produced.

Directing my eye along the glass tube luted to the neck of the matrafs, I could see the bottom of that vessel by the light of the fire which surrounded it ; and, attentively observing it in that part, I began, after it had remained three quarters of an hour in a strong fire, to perceive a slight inflation in the vitreous matter, which afterwards increased, and consisted of tumours that rose extremely slowly from the surface of the fused glass, and sunk again as slowly ; and some of which, having attained their greatest dilatation, burst. This kind of slow ebullition extremely resembled that which, making use of the same glass and many other volcanic substances, I observed in the crucibles of a glass furnace ; it continued as long as the intensity of the heat remained the same.

When

When the matrafs had cooled, I broke it lengthwife, and observed the following appearances : The glafs when fufed had filled two thirds and more of the body of the matrafs, to which it was ftrongly attached, and formed in the upper part a plain furface, from which rofe a prodigious number of fmall, vitreous, femitransparent veficles or bubbles, partly entire, and partly broken at the top.

On breaking the mafs of glafs I found it entirely full of bubbles, of various fizes, from thofe which were only a third or quarter of a line in diameter, to thofe which were half an inch. They all inclined, more or lefs, to an orbicular form, and their internal furface was fmooth and fhining. But on one fide of the glafs, which corre-fponded to the place where the fire was hotteft, there was a bubble nearly as large as a hen's egg ; in which was obfervable a thick vitreous thread, that croffed it with the two ends adhering to its fides, and which no doubt was produced by the vifcofity

cosity of the matter at the time it separated and formed this bubble.

Where the glass was not full of bubbles to the naked eye, it was sufficiently solid and hard to give sparks with steel ; I say, to the naked eye, because, with the lens, the solid parts likewise were seen to be full of innumerable extremely minute bubbles.

When we compare the fusion obtained in this matrafs with that observed in open crucibles, in a glass furnace, when the same spotted glass is the subject, we find the same results.

We will now proceed to treat on the origin and cause of these bubbles, which, in fact, is the principal object of our present enquiry. It seems undeniable that these must have been produced by an elastic fluid, which penetrated the glass when in a state of fusion, and compelled it to dilate in that manner. This supposition I have always made in the course of this work,
when

when I have spoken of volcanic products become ebullient within the crucibles, and also of those which have passed into such a state by the action of subterranean fires; nor do I conceive that it will be controverted by any persons. Whoever has seen such productions, will admit that this supposition is supported by the strongest evidence.

But what may be the nature of this fluid? We cannot imagine it to be atmospheric air which occupied the pores of the pulverised glass contained in the matrafs, since this must have been expelled at the very beginning of the fusion; whereas the tumours on the surface of the liquid glass were produced in the strongest heat of the fire, and continued as long as it remained; an incontestable proof that, then, the fluid in question copiously invested and agitated the vitreous mass. This fluid, likewise, cannot be called permanent, like the different aëriform gases, since, were it so, it would have collected on the mercury. I therefore
began

began to suspect that it must be an evaporation of the glass itself, which, in consequence of the vehement heat, passed from the state of fluidity to that of vapour or gas, and continued so while the degree of heat remained the same. Thus, we see metals, acted on by a violent fire, boil and evaporate: and the opinion of Lavoisier seems extremely probable—that almost all natural bodies are susceptible of existing in a solid state, the state of fluidity, and the æriform state; these three different states depending on the quantity of caloric combined with them. The evaporated glass, however, which caused the bubbles, did not pass into the chemical-pneumatic apparatus, because the heat near the neck of the matrafs, being less violent, was incapable of preserving it in a gaseous state.

To ascertain the truth of this conjecture, it was necessary to have recourse to other proofs. I, therefore, proceed to the second experiment, in which the circumstances were the same as in the former; except

except that, during the last four hours, the fire was violent. The glass on which I made this experiment was the fifth species of the glasses of Lipari; which is the most perfect and the purest glass afforded by the island. The results were as follow :

The small quantity of air which rose above the mercury during the ignition was found to be purely atmospheric. After half an hour's violent fire, I perceived, through the glass tube inserted into the matrafs, the vitreous mass beginning to rise in tumours, which presently rose so strongly that I could only see a tumultuary intestine motion of the liquid fiery mass. In these experiments I took the precaution to open, from time to time, the small door of the furnace, to examine the appearance of the outsides of the matraffes. After a continuance of a very strong fire for two hours and three quarters, I perceived that the matrafs was broken, and that a long thread of glass had begun to issue through the fracture.

fracture. I therefore caused the fire to be extinguished, and, after the matrafs had cooled, examined it within and without. I found, on one side, an angular fissure, fourteen lines in length, from which hung, externally, two thin cones of glass, which, however, was the only part of the fluid that had issued from the matrafs. Within was an oval bubble, occupying two full thirds of the body of the matrafs. This fact appeared to me of considerable importance. It is evident that this bubble was the effect of an aëriform fluid, which by its expansive force had not only produced that vacuity, but broken the matrafs by striking forcibly against its sides. It is likewise equally clear, that this fluid could be no other than the glass itself, rendered here much more gaseous from the greater violence of the fire. The remainder of the glass not occupied by that bubble was full of minute cavities.

The accident of breaking, accompanied with a very large bubble, happened to another matrafs containing an enamel of Is-

chia. Here, therefore, the strong gasification of the enamel, by the violent energy of the fire, had produced a vacuity which occupied more than half the matrafs, forcing up the enamel, and compelling it to ascend through the neck; breaking at the same time the sides of the matrafs.

In a fourth experiment I made use of an enamel of Procida. During a continuance of eight hours in the fire, I observed it attentively, but could not perceive any sign of ebullition. I afterwards broke the matrafs, and found that, notwithstanding its complete fusion, and that it was in every part full of bubbles, the bubbles were in general small. No particular gas appeared above the mercury.

Examining, afterwards, the internal sides of the matrafs, above the hardened enamel, I made an observation that appeared to me important. A great number of very minute globules of the same enamel adhered, here and there, to the sides, at the distance of
half

half an inch, an inch, or two inches, from the enamel below. Besides these globules a kind of thin streaks of enamel were attached to the sides ; and where the neck was widest there was an accidental swelling, which formed a ring round the inner surface. Around this ring, on the side next to the body of the matrafs, was attached a very thin thread of the same enamel. It is not to be supposed that the enamel during its vehement fusion could have risen to the places where the traces of it so evidently appeared ; since then the sides would have been varnished over with it ; as we see in crucibles in which the melted matter has risen and sunk again. Here, on the contrary, the sides of the matrafs, in the places between these streaks, were as perfectly free from any appearance of enamel, as they were before the experiment was made. I then could not but recollect the experiment of Lavoisier, and others, of a plate of gold silvered over by exposing it to the fumes of silver exhaling by the action of a vehement fire ; as also another, its companion, in

which a plate of silver was gilt by a like effect of fire on gold. I concluded, therefore, that the globules and the other traces of enamel congealed on the sides of the matrass were the result of the sublimation of the enamel itself at the time it was exposed to the most violent heat.

A doubt however remained, which it was necessary to remove. It seemed not impossible that, in putting the pulverised enamel into the matrass, some small portion of the powder might have adhered to the sides or the swelling in the neck, and afterwards have been melted by the action of the fire. But this doubt was completely removed by observing the same appearance on the sides and neck of another matrass, in which an equal quantity of the same enamel had been placed, not in powder, but in pieces.

This observation, which confirmed me in my opinion that the ebullition of substances fused in matrasses was a consequence of their vaporisation, determined me to make
a general

a general revision of the various crucibles I had before made use of in the furnace, and which had contained vesicular volcanic products ; as I had not before examined them with a view to this object, believing that the vesicles or bubbles were caused by some permanent gas. There were not a few, to say the truth, the internal sides of which exhibited, above the fused product, small drops of the same substance : but it was easy to perceive that these were not collected there by sublimation ; but were thrown to that height by the intestine motion of the products in fusion. There was, however, no crucible which presented that thin coating, or that aggregate of infinitesimal globules, observable in the last experiment, and which manifested an evident sublimation of the fused substances. This, indeed, did not surprise me ; as the crucibles were of a cylindrical, or inverted conical form, and open at the top ; so that the particles which might sublime met with no opposing body to detain and collect them.

I, therefore, resolved to endeavour to ascertain whether this sublimation took place, likewise, in crucibles in the furnace when covered with other crucibles. I had nineteen in the whole, within which I placed those kinds of volcanic matters which are most liable to inflate in large bubbles. On the sides, and at the top of three of the inverted crucibles that served as covers to the others, I perceived evident signs of sublimation ; in some fine vitreous traces, and a great number of extremely minute vitreous globules, which, in substance and colour, did not in the least differ from the respective matters fused in the three crucibles. But nothing similar was apparent in the other three crucibles. The former of these facts, which is positive, is a new and luminous proof of the gasification of volcanised productions ; and the latter, which is negative, no proof to the contrary ; since, though every one of these sixteen products were ebullient within the crucibles, and therefore, from what has been above said, there is the strongest reason to believe they were rendered so
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by internal vaporisation ; it is not necessary that they should sublime with evident external indications ; this depending on the nature of these substances ; some subliming with one degree of heat, and others requiring another and a greater. Hence we may perceive why, in the different experiments in different matraffes, indications were not discernible of this sublimation ; though I have no doubt that it would have been obtained likewise in them, had the fire been sufficiently increased.

But to return to the experiments I was relating. After having made those now described on volcanic glasses and enamels, I proceeded to subject to the same proof a factitious glass ; of that kind which is of a black colour, and has little transparency, and which is used in many countries to make thick bottles to contain wine. I took one of these bottles, which had never had in it any wine or other liquor, and placed twelve ounces of it, as before, in powder, within a matrafs. I had before observed that this

glass in the furnaces of Pavia requires a longer time to fuse it than common white glass, and that in its actual fusion it is little or not at all inflated. The fact, however, is, that after remaining the usual eight hours in the furnace, the matrafs having been broken, the ebullition and exaltation appeared to have been such, that the glass had risen to the middle of the neck ; though when the heat had ceased it had sunk to the bottom of the belly. This was evident from a shining thin vitreous coating, occupying the whole interior surface of the matrafs, beginning from the level surface of the glass lying at the bottom, and proceeding to the middle of the neck, where there remained a lump of glass that entirely closed the aperture.

The appearances which took place in this factitious glass, both in the matrafs and the glass-furnace, may be understood and satisfactorily explained by the theory of the gassification of the substances hitherto treated of. The heat of the furnace was sufficient

to

fuse this glass, but not to convert it into gas. The chemical furnace, being more active, rendered it gaseous. Hence arose that violent tumefaction ; though the action of the fire having afterwards diminished, the glass consequently passed from the aëri-form to the liquid state, and descended to the bottom of the matrafs, where it congealed. That no permanent gas had any part in this ebullition is proved by the mercurial pneumatic apparatus, in which it must have collected, more or less, above the mercury : but nothing was found except common air, as in the other experiments.

Hitherto I had only used those volcanic products, which, in the furnace, are filled with bubbles more than others ; being desirous to observe whether the same effect would take place in the matrasses, as was in fact the case. I afterwards resolved to make experiments on others less liable to inflate in bubbles. To avoid needless prolixity, however, I shall only state the qualities

lities of the substances I used, and the results obtained.

These substances were six in number : a lava with garnets from Vesuvius ; another, which, when I visited that volcano, had recently flowed ; a lava of Vulcano, invested with a crust of enamel ; the lava continually ejected by Stromboli ; the lava which, in 1787, issued from the highest crater of Etna ; and a solid pumice of Lipari. I have already described each of these products, when treating of their respective volcanos.

After they had been exposed to the fire eight hours, in matrasses, nothing was found to ascend above the mercury but atmospheric air, or a portion of that the vessels contained. These six products, therefore, afforded no indication of any permanent gas ; but they evidently showed that they had passed from the state of liquidity to that of a strong gasification, from the
quantity

quantity and size of the bubbles they contained. This is consequently another and a most convincing proof, that a greater gasification of stony substances may be obtained in a very strong heat than in a weaker.

From these ten experiments I conceive myself sufficiently warranted to conclude, that those bubbles and inflations of various sizes, which we so frequently observe in the products of volcanos, are by no means caused by the action of any permanent gas, but by that of an aëriform fluid produced by the excessive attenuation of those same products in consequence of heat.

I do not know that similar experiments have been made by any other person excepting Dr. Priestley, who describes three, which I think proper to be mentioned here, as they differ somewhat from mine. This naturalist, having fused in a sand-stone retort $4\frac{1}{5}$ ounces of Iceland lava, obtained 20 measures of air, the half of which, about the beginning

beginning of the process, was carbonic acid gas, and the remainder in purity 1.72 ; and extinguished a candle. He remarked that the interstices of this lava contained a sand, which he was not able to separate from it.

$5\frac{1}{2}$ ounces of lava of Vesuvius gave 30 measures of air ; the first portion of which showed a slight appearance of carbonic acid gas ; and the remainder was azotic gas from the degree 1.64 to 1.38, with respect to what came last. The retort broke by the inflation of the residue, when it became cold.

Another ounce of lava, of the consistence of a hard stone, gave only $3\frac{1}{2}$ measures of gas, principally hydrogenous, derived, as he conjectured, from the gun-barrel in which this experiment was made.

From these results the English naturalist infers, that it is probable that the true lavas do not afford much air ; which, however,
according

according to him, must depend on the degree of heat to which they have been exposed in subterranean fires *.

Leaving unnoticed the last of these experiments, as being too equivocal, and considering only the two former, I could have wished that Dr. Priestley had explained himself more fully relative to these two lavas ; and afforded us certainty that the two stones on which he made his experiments were really volcanic.

But supposing they actually were such, if we oppose our ten processes to the two of Dr. Priestley, the consequence to be derived will be, that volcanic products are not always destitute of permanent gases ; which deduction will be found perfectly to agree with observations we shall have hereafter to make, and is by no means contrary to those already made. In the latter, I have principally shown that the numerous pores in volcanic products exposed to our common

* Experiments and Observations on Air, Vol. IV.

fire, and, consequently, those so extremely similar frequently found in lavas, are probably not the effects of permanent gases, but of the gasification of the lavas themselves: and this discovery remains uncontroverted notwithstanding the above-cited observations of Dr. Priestley.

I shall now proceed to enquire what part this aëriform vapour acts in the eruptions of volcanos. Where it exists in the depths of a volcanic crater, abundantly mixed with a liquid lava violently urged by subterranean conflagrations, I can easily conceive that by its energetic force it may raise the lava to the top of the crater, and compel it to flow over the sides, and form a current. Art can imitate this great operation of nature, on an infinitely less scale. I placed in a glass-furnace a cylindric crucible, one foot high, and two inches and a half in breadth, which I filled half full with one of those volcanic products which most inflate and boil in the fire. After some hours, I observed that the liquid matter began slowly to rise, and afterwards to rise higher until
it

it at last overflowed the edges of the crucible, forming small streams down its sides, which, when they reached the plane on which the crucible stood, gave origin to small currents, if that plane was at all inclined. When I put more of the same product into the crucible, the currents became larger. If the plane was then taken from the furnace, and the small currents thus produced examined, they were found full of minute bubbles, as was likewise the matter which remained in the crucible. This curious experiment I made with several glasses and volcanic enamels, as also with a variety of cellular lavas, and always with the same success.

It is likewise probable that this elastic vapour, when collected in a large quantity, if it finds under the earth any impenetrable obstacle, produces local earthquakes, and subterraneous thunders and roarings ; bursting open the sides of the lava, and forcing out the lava. We have an example of this, if I may so speak, in miniature, in the two
matraffes

matrasses broken by this fluid from its exuberance and the resistance it met with. I afterwards made in the furnace some experiments more decisive. I caused three matrasses to be made, on purpose, of clay, the sides of which were an inch thick, and the belly, which I more than half filled with a cellular lava, four inches and three quarters in diameter; the neck projected in part from the furnace. At the end of eleven hours the three matrasses were broken in the belly, with several fissures, through which the lava issued. Having afterwards broken up the matrasses, I observed that they were entirely filled with a glass full of large bubbles, which did not extend beyond about half the neck, because there the heat was no longer sufficient to keep it in fusion. It was easy to understand the cause of the matrafs breaking. The glass rarefied by the aëriform vapour, the belly being unable to contain it, had risen into the neck; but losing there its fluidity from the cold, it could advance no further; and, its inflation increasing from the vehemence of the heat,

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the matrafs at length was forced to open. I find, therefore, no difficulty in believing that fuch a vapour may produce fimilar effects, on a larger fcale, within the earth, when it meets any obftacle to its expanſion.

I cannot, however, ſo eaſily admit that the ſame vapour is the cauſe of the fiery hail or ejections of volcanos, as the breaking of the matraſſes happens without the leaſt noiſe, and without the ejection or ſcattering of the contained matter. I attentively watched two matraſſes placed in the furnace when they began to open, and I obſerved that the apertures enlarged inſenſibly ; which proves that the power of this vapour, though ſuperior to the reſiſtance of the matraſſes, acts nevertheless very ſlowly ; whereas the agent which hurls the burning matters into the air from the volcanic mouths muſt act with the utmoſt rapidity and violence.

To explain theſe ejections, therefore, we muſt have recourſe to other principles.

Modern

Modern volcanists have supposed that these are various gases, which, endeavouring to obtain a passage through the liquid substances in which they are enveloped, force them impetuously out of the crater, and sometimes to an enormous height. The presence of these gases is certainly not obscurely manifested by the hissing sounds that are heard during the raging of volcanos, as has been observed of Vesuvius, which, from its vicinity to Naples, is the volcano that has been most attentively examined. Similar hissing sounds I likewise observed at Stromboli, of the eruptions of which volcano I shall presently have occasion again to speak.

But what is the nature of these different gases? It is evident that to ascertain this it would be necessary to collect them in the volcanic effervescences for a chemical examination, which is perhaps impossible, from the manifest danger there would be of falling a victim to so imprudent a curiosity. We can therefore obtain no knowledge of
 them

them but by an indirect way, that is, by observing the gaseous substances which arise from volcanos when they have returned to a state of tranquillity. If we peruse the works of writers on this subject, we shall find several of them named; such as hydrogenous gas, sulphurated hydrogenous gas, carbonic acid gas, sulphureous acid gas, azotic gas, &c. these different gases having been found in volcanic countries *.

But, besides these concurrent causes, it is extremely probable that, in the greater and more terrible ejections, another more powerful principle comes in aid, which is

* From the agents which by their expansive force produce the eruptions of volcanos I do not mean to exclude caloric, which sometimes must necessarily co-operate; that is, when in the volcanic recesses a greater quantity of this fluid is suddenly disengaged than can easily find a passage through the pores of the surrounding bodies. Then, as Lavoisier has observed, caloric will act like other common elastic fluids, and overturn every thing which opposes it. Except in this circumstance, however, I do not see what immediate action it can have in volcanic ejections.

water, principally that of the sea. It would be superfluous to show, since it is generally known, that the volcanos scattered over the globe, and which at present throw out fire, are either furrounded by the sea, or at a short distance from it ; and that those which have long since ceased to burn are, for the most part, at a considerable distance from it. The conservation, and we may likewise say the origin of these subterranean conflagrations, have therefore a secret relation to the waters of the sea. There is little doubt but these waters communicate by secret passages with the spacious caverns and profound depths which exist, certainly, in burning mountains ; and, though we are not able to discover this immediate communication from without, it is sufficiently visible by its effects ; I mean the sudden retiring of the sea at the time of the most violent eruptions, occasioned, probably, by the vast volume of its waters absorbed in those immense caverns. One of these retirings of the sea, according to the observation of Pliny the younger, hap-

pened in the reign of the Emperor Titus, in that dreadful ejection of lava, smoke, and ashes, which Vesuvius cast forth, and in which Pliny the Naturalist perished. Another similar took place in modern times, in the same sea, during another terrible eruption of Vesuvius, as is recorded by authors worthy of credit who lived at the time. Serao, in his Relation of the Conflagration of Vesuvius in 1737, referring to the accounts of former conflagrations of that mountain, remarks, that “ if not in all, at least in the more terrible conflagrations, mention is made of the retiring of the sea as a concurrent circumstance.” Steller, in his Observations on the Volcanos of Kamtschatka, remarks, that the greater part of earthquakes happen at the time of the equinoxes, when the sea is most swelled, and especially at the autumnal equinox, when its waters are highest.

It is therefore evident that a great mass of water suddenly reduced to vapour by subterranean fires must cause prodigious ex-

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plosions, and detonations, far more violent than those occasioned by the elastic gases before mentioned. Thus, if a cannon, after having been fired several times, be spunged with a wet rammer which too exactly fits the calibre, the vapour produced at the bottom of the cannon, unable to escape as it expands, will force the rammer out with such violence as sometimes to carry away the arm of the gunner. If a small quantity of water be inclosed in a globe of iron, or any other metal, so that the vapour cannot escape, and the globe be exposed to a strong fire, it will soon burst with a loud noise, in the same manner as if the explosion had been caused by gunpowder.

But nothing, in my opinion, more aptly shows the nature of the destructive explosions which volcanos may produce by the evaporation of water, than the fatal accidents which sometimes happen in consequence of pouring melted metals into moulds not sufficiently dried. An account of one of this kind may be found in the
fourth

fourth volume of the Memoirs of the Academy of Bologna, which I shall here briefly state, as it is particularly applicable to the present subject. A bell of a very large size was to be cast at Modena under a spacious portico. The metal was melted, and was let flow, through a small channel, into the earthen mould, which was at a little distance under the pavement. But at the moment the melted metal reached the mould, such a violent explosion took place, that the metal, the mould, and a great quantity of earth, were thrown up with inconceivable violence. The furnace was blown in pieces ; the portico, walls, and beams of the roof torn up and broken in many places ; a large opening made in the roof, the tiles scattered about, and a wide and deep hole sunk in the ground. Some of the bystanders were killed, others severely wounded and hurt, and all overwhelmed with dread and consternation. Such dreadful effects were produced by a little moisture being left in the earthen mould, through the inattention of the workmen. We may hence conclude

what terrible and destructive explosions may be caused in volcanos by a large quantity of water entering among the subterranean fires.

Here a question naturally arises, which it may not be unuseful to discuss. It can admit of no doubt, that water insinuating itself under the burning matter, and suddenly reduced to vapour by the extreme heat, if it can obtain no passage, will cause the most terrible eruptions. But what effect will it produce should it fall upon the fire, supposing it either sea-water or rain; for the latter may easily penetrate, through the pores and fissures of the earth, to the volcanic furnaces? If we attend to some experiments, we shall be inclined to suppose that the evaporation of the water in the latter case will produce the same effect as in the former. Thus, if we throw drops of water on an oily and boiling matter, such as butter, fat, or oil, the water, by its violent expansion in evaporation, will force out the oily particles with a kind of explosion

explosion and shaking of the containing vessels.

But other facts, more consentaneous to the nature of volcanos, prove the contrary. It is well known to all mineralogists, that, if water be dropped upon melted copper or silver, the abundant vapours which arise will produce a kind of noise, but no explosion.

The elegant experiments of Deslandes, relative to the effects of water poured upon melted glass contained in capacious crucibles, in a glass-furnace, are equally deserving attention in themselves, and applicable to the present question. I shall give a brief abstract of them. A glass of water having been thrown on a quantity of melted glass, the water suddenly formed a globule without producing the least sound: it assumed, or seemed to assume, a red colour, similar to that of the crucible and the melted glass. It rolled on the surface of the glass; and, nearly in the same manner as lead

is consumed in the cupel, its volume gradually diminished, until in three minutes it was entirely evaporated, without emitting any apparent fume. In another experiment the vitreous matter was poured upon a table, and made to flow, before the water was entirely evaporated: no detonation, however, followed.

The convenience of access to a glass-furnace incited me to repeat these easy experiments, which have not, to my knowledge, been verified by any other person. Before I proceeded to make them, I spoke to one of the workmen on the subject, whom I found so well acquainted with the fact that he offered to pour as much water on melted glass as I pleased, assuring me that not the smallest ill effect was to be apprehended. I perceived, therefore, that this was one of those phenomena which are published to the world as new, and which, in fact, are so to the learned, but have been long well known to many of the vulgar,

I began

I began my experiments with pouring six ounces of well-water into a cylindrical clay vessel, about two feet in diameter, which had for fifteen days been nearly full of melted factitious crystal-glass. The water immediately dispersed itself into a number of globules, in the same manner as mercury divides when thrown upon a plain surface. These globules rolled about, gradually diminishing in size, and, in less than two minutes, disappeared. All this time not the least detonating sound was to be heard ; but, attentively observing the larger globules by the bright light of the furnace, I could perceive them in a state of scarcely discernible ebullition. I repeated this experiment by emptying into the vessel a pot containing eight-and-forty ounces of the same water, which now dividing into larger globules, enabled me to observe the appearances which took place in them with greater precision. At first the globules, moving as usual on the surface of the melted glass, showed no sign of ebullition ; but this, a few instants afterwards, became visible, in those,

those, at least, that were nearest to me; whence it may be concluded that the same happened in those at a greater distance. They boiled and swelled perceptibly, but did not cause the least sound; the water being in a space, if not deprived of air, at least containing only such as must be highly rarefied. They, however, as in the former experiment, continually diminished in size, and, after about four minutes, entirely disappeared. During their ebullition, no sign of any vapour was discoverable around them.

It would be superfluous prolixity to describe several other experiments which I made with still greater quantities of water, no difference being discernible in the results. I very attentively observed whether the water assumed a red colour, but saw nothing like it: this mistake must have been occasioned by the redness of the hot glass surrounding the water.

On comparing these facts with those observed

served by Deslandes, I find them perfectly accord, except that the ebullition, which certainly takes place, was not observed by him. When we proceed to apply them to volcanos, with respect to the falling of water on their burning mouths, we shall be ready to conclude that water so falling cannot cause eruptions. To enable myself, however, if not to decide this question, at least somewhat more to elucidate it, I made some other experiments, both on different metals and lavas in fusion. I made use of iron, copper, tin, and lead. With respect to the first, I employed filings of it, to facilitate its fusion; as I have already remarked in the Introduction to this work, that, by this means, a decisive principle of fusion may be obtained in this metal in the furnace. The crucibles for these experiments were wide at the top, narrow at the bottom, and of considerable capacity; and I never entirely filled them with metal, that there might be room to pour on it a sufficient quantity of water.

After

After the iron had remained twenty-four hours in the furnace, and was semi-fused, I let fall a few drops of water on it. They at first remained motionless, without apparently diminishing in bulk; but they soon after began to leap about and boil, wasting away, till, in less than a minute, they disappeared. When I poured on more water the effects were the same, only the ebullition was more sensible, because it was proportioned to the greater quantity of water.

Leaving the iron in the furnace, I, after seven hours more, repeated the experiment, having first removed the crucible into the cold air. I threw on the iron a slight sprinkling of water; but this in an instant disappeared without the least sound. I then poured the quantity of an ounce on it. For a moment the water remained quiet; it then divided into globules, and began to boil with some slight noise. In a short time it entirely evaporated.

The

The redness of the iron was now somewhat obscured ; and I availed myself of the circumstance to drop more water on it ; but here the result changed its appearance. At the moment the water touched the metal it began to boil, and an undulating vapour arose, with noise, which continued till the entire dispersion of the liquor. The heat of the iron continued sufficient for me to repeat this experiment twice more with the same effect.

Copper in the furnace was completely fused. I made the same experiments on it, and with the same circumstances as on the iron. I omit describing the results, as that would only be to repeat exactly what I have said relative to the former metal.

To make the same experiments on tin and lead, the furnace was not necessary, a much less heat being sufficient for the fusion of these metals. But I soon perceived that the confidence with which I had made my trials on the iron and copper, must
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not be continued with the lead, and still less with the tin, on account of the violent explosions excited by their touching the water. I made a great number of different experiments on both these metals; but, for the sake of brevity, I shall only mention the principal.

When water was let fall, drop by drop, on melted tin in the crucible, it exploded with a loud noise, and pieces of the metal were thrown to the distance of two, three and four feet. If so much water was poured as to form a thin covering over a part of the surface of the tin, the detonation increased in proportion, and a great part of the metal was thrown out, with a loud explosion, to a considerable distance from the crucible. Not the least appearance of any vaporous fume was observable.

Approaching as near as this dangerous experiment would permit me, and attentively watching the progress of it, I observed, that as often as the drop of water touched
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the metal, the latter, by its fluidity, became in motion. I likewise remarked that, at the same time, a momentary cavity was produced in its surface, from the fall of the drop, especially if it fell from any height. It then occurred to me, that it might be possible that the explosion and detonation might be the effect of the water sinking into the cavity, and being in part confined in the melted metal; where, passing suddenly into the state of vapour, and finding no room for its dilatation, it impetuously forced out the metal. But this supposition did not accord with the fact. Had this been the case, if the drop had touched the melted tin without sinking the small cavity, it would have caused no explosion; which must have been the louder and more violent the deeper the cavity, which would then have contained more water. I, therefore, first let fall the drops of water on the tin from a very small height, and afterwards from one of five or six feet; but I found no sensible difference, either in the explosion

sion or ejections. The effect described, it may, consequently, be concluded, was produced merely by the simple contact of the water and the tin.

I had, besides, sufficient proof that the water, when included within this melted metal, causes ejections much stronger and with a louder report. Having taken a crucible containing melted tin from the fire, the surface soon began to cool. I then with the point of a nail made a perforation through the crust that had gathered over it, which was still thin and soft, and poured on it half an ounce of water, a part of which entered the perforation, when immediately the crust was forced up with an unusual explosion, almost all the melted metal violently thrown out, and the earthen crucible broken to pieces. The cooling and consequent contraction of the crust had produced a vacuity between it and the melted metal, which admitted the water, but was much too confined for its expansion

sion when reduced to vapour, which, by its elasticity, caused the violent effects that followed.

When the surface of the tin was cooled and consolidated so that the water could not penetrate to the part which still remained fluid, the latter only boiled, and resolved into a small vaporous cloud which rose in the air.

In these explosions, however, irregularities happen for which it is not easy to assign a reason. For example : after five or six explosions had been produced by letting fall drops of water on the tin in fusion, they would suddenly cease, though I continued the fall of the drops, which, when they reached the metal, only boiled and evaporated. But what must appear most extraordinary was, that after three or four drops had produced no explosion, others which fell immediately after again caused it. Nor must we imagine that the failure was occasioned by the water falling not im-

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diately on the tin, but on the pulverulent pellicle with which it is invested by oxydation, since I carefully removed it as often as it was formed.

Melted lead exhibited the same appearances with the tin, and similar irregularities, except that its explosions with water were not so frequent, nor, as it appeared to me, so strong.

I shall not here enquire why the water in the furnace exhibits no evaporation of any kind, nor boils till after some instants ; whereas, when the experiment is made in the open air, the ebullition and evaporation follow immediately that the water touches these two metals, now somewhat cooler : nor why, when the water falls on lead and tin, it explodes with a loud noise, while no such explosion happens with copper and iron. Such researches, to be properly made, require other experiments, which would lead me too far from my subject. It appears to me preferable to proceed immediately

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diately to relate what I observed in lavas in fusion, contained in crucibles of the form and size before described, and tried by the same experiments which I had made on glafs and metals.

The first I used were of that species which in the furnace become but little porous. The water, when poured upon these in a state of fusion, for some instants remained motionless; afterwards it began to boil, and the ebullition continued until it was entirely dissipated. I repeated the experiment on the same lavas, after having taken them out of the furnace, and when they had in part lost their glowing redness. The water, on touching them, arose in noisy bubbles, producing a profusion of vapours; and, as the lavas became cooler, the quantity of vapours became more abundant, at least to a certain degree of coolness. These lavas, therefore, did not differ from glafs, copper, and iron, with respect to their causing no explosion with water.

I next proceeded to the lavas filled with pores and bubbles ; but here more caution was necessary. In one of them, two large bubbles appeared perforated on one side. On pouring the water into the crucible, it exploded with a noise equal to the report of a small pistol, and forced out the lava in scattered fragments. I was then convinced that this explosion had not been produced by the water that had merely touched the surface of the lava, but by that which had penetrated into the two open bubbles. I had recourse, therefore, to a proof which could not but be decisive, which was, to repeat the experiment on the same kind of lava, but on such as contained no fracture of any bubble, which may frequently be obtained among fused lavas of this species. When this lava was liquefied I let fall into the crucible the same quantity of water, which produced only a simple ebullition ; and the same happened on repeated trials, which convinced me I was not mistaken in my opinion.

I concluded these experiments with the following : Having fused a lava in a capacious receiver of clay, I perforated it obliquely from the top to the bottom by immersing in it a pointed iron wire three lines and a half in diameter. We shall see in Chap. XXIII. that the lavas which are most easily fusible, and which are inflated and overflow the crucible, forming a stream down the sides, retain, nevertheless, so great a tenacity in their parts, that they are with difficulty pierced, and that the cavity made by such perforation remains entire but a very short time. I resolved to introduce water into this cavity ; but as the experiment was dangerous, I removed the receiver from the furnace into a court-yard, and poured in the water by means of a long tube of iron, which reached the vessel through a hole in the door that shut in the court-yard. As soon as the water entered the cavity, the pieces of the receiver and of the lava were forced violently to the distance of many feet, with a detonation equal to the report of a musket.

While making these experiments, I wished to satisfy my curiosity relative to another particular. Hitherto I had used fresh water from a well : and I wished to ascertain whether there was any difference in the effects produced by water from the sea ; since it appears highly probable that this water, by entering among the fires of volcanos, is the cause of their most terrible eruptions. I, therefore, caused some to be brought, in closed vessels, from the neighbouring gulph of Genoa ; but, when I made use of it in similar experiments on the fused lavas, I found the results perfectly the same with those already described.

From this series of experiments I think we are authorised to conclude, that when a quantity of water falls on the burning crater of a volcano, it has not the power of producing explosions ; but that the latter on the contrary are very violent when the water, penetrating below, reaches the conflagration ; when suddenly reduced to vapour by the heat, it finds no room for its dilatation ;

dilatation ; or when it insinuates itself laterally among the liquefied matters ; of which we have a satisfactory proof in the explosion of the lava, violently forced from the containing vessel, on the introduction of water into a cavity made in it.

Though, from the facts now adduced, there is the utmost reason to believe, that water changed to vapour, by the incredible power it acquires, is extremely well adapted to produce the great volcanic eruptions ; and, by the sudden sinkings of the sea, which frequently happen on such occasions, it is nearly certain that they are to be ascribed to this most powerful agent ; it is not necessary to recur to it for the cause of the more moderate and smaller ejections ; as, to produce these, the different permanent gases mentioned above are sufficient ; and it is, in fact, beyond doubt, that they are the causes of such eruptions in some volcanos, as, for instance, that of Stromboli. In Chap. X. we have seen that the symptoms of that volcano consist in an ebullition

of the liquid lava within the crater, by which it rose to a certain height, inflating with multiplied tumors, which burst at the moment the detonation and ejection took place; that this was immediately followed by a sinking of the lava to a certain depth, to which succeeded a new rising of the same, with like inflations and tumors that burst with similar ejections and explosion; and that in this alternation consisted the action of that volcano.

I have already supposed that these tumors are caused by an elastic fluid imprisoned within them, which endeavours to obtain a passage, and at length finds one, by bursting the tumors and forcing up their fragments to a considerable height; and this conjecture I then thought extremely well-founded, and am still of the same opinion. It only remained to enquire what might be the nature of this fluid; which enquiry I reserved to be made in the present chapter, in which I treat of the nature of the gases of volcanos. From the observations I made

on the spot, I was sufficiently convinced that the fluid contained in the tumors could not be derived from the evaporation of the lava, since this evaporation (which, from the facts adduced, cannot be denied) was, indeed, sufficient to burst them, but not to produce the ejections continually observable. Nor can we attribute them to evaporated water, as this would not have deferred its detonation when included in those bubbles till it had reached the surface of the lava ; but the explosion and ejection would have taken place at the moment the water had come in contact with the burning lava, and, consequently, at a much greater depth. Besides, had that multitude of capacious tumors been filled with water which had passed into the state of vapour, it must be manifest that every eruption would be much more violent and loud. We must therefore conclude that the fluid in question is a permanent gas, and probably one of those which are discoverable in volcanos when, in a state of tranquillity, they are accessible,

cessible, such as the carbonic acid gas, hydrogenous gas, oxygenous gas, &c.

In fact, M. Dolomieu, though he did not approach so near to the crater of Stromboli as I did, yet, from the observations he made, conjectured that its action was caused by hydrogenous gas. He supposed that the internal fire might disengage this gas from the matters existing near, but not immediately touching, the volcanic furnace; and that this gas, by subterranean passages, might reach the principal cavity in which the conflagration rages, and there suddenly take fire.

This hypothesis, which that judicious naturalist has proposed only in the shape of a doubt or conjecture, is extremely plausible, nor do I hesitate to believe that it is frequently the true explanation of what takes place in burning volcanos; though, with respect to Stromboli, it cannot be maintained when we compare it with the facts

facts observed. For, in the first place, though this gas has the property of rising in flame, it has also that of extinguishing fire placed within its atmosphere. How then can the lava melted in the cavern of Stromboli be penetrated, put in motion, and rarefied by this gas, without the diminution, not to say the entire loss, of that ardent redness which I observed in it during the night? Secondly, though, in this volcano, the detonation is always inseparable from the explosion, we cannot suppose the former occasioned by hydrogenous gas, unless we would admit an effect incomparably less than the cause. In the repeated visits I made to that volcano, I observed that the strongest detonations were not louder than the sound of a very short hollow thunder; and that, at the moment they are heard, the tumors which cover the lake of fiery lava, many of which are several feet in diameter, burst. Is it not then evident that the superabundant quantity of this gas, contained in so great a number of tumors, and fulminating almost at one instant, must
cause

cause a much stronger detonation? But the proof that admits of no reply, or rather the absolute demonstration of the insufficiency of this hypothesis, is the following: When these tumors burst by the force of the imprisoned fluid at the time it disengages itself, were this fluid hydrogenous gas, it would take fire at the same moment, and cover with flame the surface of the lava; but it is certain that not the least appearance of the feeblest flame is discoverable in the lava in any eruption; as I can affirm from the various observations I have made, at a very short distance, of the most minute accidents that take place within the crater.

Compelled, therefore, to abandon this explanation, it occurred to me whether atmospheric air might not possibly produce the phenomena in question. I considered, however, that, before this hypothesis was admitted, it would be necessary to show that the atmospheric air had free access from without the mountain to the volcano; that

that it insinuated itself into the body of the lava ; and issued out upwards, causing the inflations, ejections, and detonations. As to the possibility of its entrance to the most internal recesses, containing the melted lava ; it seemed to admit of easy proof from the cavernous structure of volcanic mountains. But how this air could be sufficiently powerful to insinuate itself into the great mass of lava, traverse it to the top, and there occasion the explosions, I could not conceive, from the two following, in my opinion, insuperable obstacles. First, it is undeniable that the atmospheric air which might penetrate through the cavities of the mountain, till it approached the immense mass of melted and burning lava, would be extremely dilated, and make its way where it found the easiest passage, which would be by the caverns that had admitted it ; but it could never penetrate the lava, from its too great resistance. Secondly, even granting for a moment that it might penetrate the lava, from the dilatation it must suffer, it would penetrate it extremely rarefied, and
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be incapable of producing the explosions continually observed at Stromboli. I omit several other objections, as I think these two are sufficient to demonstrate that this second hypothesis, likewise, cannot be maintained.

Shall I venture to propose a third, which, in my opinion, is not contemptible, though I offer it merely as conjectural? May not the phenomena of this volcano be attributed to the action of oxygenous gas? On the one side, it is well known that the sulphate of iron and the sulphate of alumine afford this gas in abundance, when acted on by a strong fire; and, on the other, it is equally certain that these two salts are copiously produced in volcanos. They may, therefore, in the profound recesses of Stromboli, furnish a rich and inexhaustible mine of oxygenous gas, which, mixing with the lava, and ascending through it by its levity, may collect, in a considerable quantity, in the narrow neck of the crater, and producing inflations and bubbles in the lava, force
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its way out with detonation, bursting and throwing up the fragments of the lava, from its expansive force being greatly increased by heat. The ejections will be great, small, or moderate, according to the different quantities of this gas collected and disengaged.

Against this hypothesis two objections may certainly be made ; the one, that, admitting it, the ignited lava would be so bright that the eye could not bear to look on it ; as we know that it is with difficulty we can bear to look on a small flame animated by oxygenous gas ; whereas, on the contrary, the redness of this lava is not greater than that of melted glass or metal. The other objection is, that the burning lavas acted on by this gas would be converted into a glass, or homogeneous enamel ; whereas the lavas continually thrown out by Stromboli, besides that the base of the primitive rock is sufficiently recognizable in them, still preserve their shoerls and felspars in their original state of crystallization.

Both

Both these objections, however, will, in my opinion, be found to have little weight, when we consider that this gas in burning volcanos can never be pure, but must necessarily be mixed with some mephitic gas, and, especially, with carbonic acid gas, which, in volcanic countries, is rarely wanting. By this mixture the vivid brightness which pure oxygenous gas would produce in the ignited lava, will be greatly weakened, and the action of the fire be prevented from being so violent as to destroy the characters of the primitive rock.

This hypothesis, however, as I have said, I offer only for examination, and shall be very ready to reject it should it be found defective. The impossibility of collecting the fluid that escapes with detonation from this volcano, prevented me from ascertaining its nature accurately. I am, therefore, obliged to seek it by conjecture, having recourse to that elastic fluid, the existence of which in the volcano of Stromboli I believe certain, and which, in some measure,

measure, at least, may explain the phenomena.

At the same time it is to be observed, that we know not but that in those immense laboratories of Nature which we call volcanos, certain gaseous substances, hitherto unknown to us, may be produced or developed by the means of fire, and act a considerable part in their eruptions and explosions. Of the existence and nature of these substances, perhaps, we may not always remain ignorant.

CHAP. XXII.

DISCOVERY THAT VARIOUS VOLCANIC
 PRODUCTS CONTAIN MURIATIC ACID
 —ENQUIRY HOW THIS ACID HAS BEEN
 PRODUCED, AND MIXED WITH THEM.

*An acid liquor extracted from the spotted
 glass of Lipari, during ignition—Proofs
 that this acid is muriatic—The same re-
 sult followed on a repetition of the experi-
 ment—A similar acid liquor produced from
 the black glass of Lipari—Factitious
 glasses do not furnish it—Proof, both by the
 dry and humid way, that the muriatic acid
 is not combined with these two glasses, but
 only mechanically united to their parts—
 Seven other volcanic products subjected to
 the same experiments, from some of which
 the same acid liquor was obtained, and
 from others not—Discovery that this acid
 does not exist in volcanic products when in
 a state*

a state of fusion or ignition, but is introduced afterwards—This muriatic acid not derived from the muriate of ammoniac—It is probable that it proceeds either from subterranean places, or from the decomposition of the muriate of soda.

NEAR the beginning of the former chapter, it has been observed that, when we enquired whether volcanic products, placed in matraffes and exposed to the fire, afforded any gas, and of what nature, a method there described was adopted to ascertain whether any liquor was produced from the same. It was also mentioned that such was obtained, which was found to be of a very singular character, and of which a description was reserved for another place, as we were then occupied in the details of the gasifications of the said products, and other particulars of the same nature. It is now proper to proceed to a more full description of this liquor, and the circumstances that accompanied it.

I shall begin by describing the manner in which it was obtained from two species of the glasses of Lipari, the spotted and the black.

With respect to the former of these, when the fire began to heat considerably the matrafs, there appeared in the receiver a white cloud, which increased till it filled the whole cavity ; and then gradually dispersed, adhering to the internal sides of the glass in the form of drops ; and, after two hours and three quarters, entirely disappeared, leaving at the bottom of the receiver a small quantity of limpid liquor.

This liquor, on examination, manifested the following characters : Its weight was 144 grains ; and its taste was that of diluted muriatic acid.

The ferruginous prussiate of pot-ash, not saturated, and the tincture of galls made with spirit of wine, do not show any sign of iron.

The

The ammoniacal carbonate, in like manner, exhibits no appearance of earth.

The tincture of turnsole becoming red, shows that this acid is disengaged :

Its effervescence with the ammoniacal carbonate, that it is not a weak acid.

Its not precipitating with the muriate of barytes, shows that this acid is not the sulphuric.

The copious white fleeces produced with the nitrate of silver, prove that this acid is the muriatic.

Eighty grains of this liquor remained after I had made these experiments, and on this I poured nitrate of silver several times till no precipitation followed. This precipitate beingedulcorated, dried, and weighed, was found to be eight grains : whence, the muriatic acid, according to the calculations of Bergmann, composing the fourth part

of the muriate of silver, the eighty grains of liquor must have contained two grains of this acid.

It is not easy to express the surprise I felt at the presence of this salt, and this water, within a stony substance which had not only been fused, but even vitrified by subterranean fires. It could not be suspected that they had both adhered to the matrafs, since, besides that it was a new one, like all the others employed in these experiments, this was the first time I had made use of it.

The extraordinary nature of the fact determined me to repeat the experiment with the same spotted glass. As I had several large pieces of it, I reduced a part of them to powder, which I put into another matrafs, and proceeded in the same manner as before. But, in this case, after half an hour's continuance in the fire, the white cloud began to appear in the receiver, which, at length, it entirely filled; and, afterwards dispersing, covered the sides with
a water

a water which, falling down, produced at the bottom a tolerable quantity of liquor. I found its weight $77\frac{1}{2}$ grains. It had the usual taste of the muriatic acid; and the presence of this and no other was confirmed by the re-agents I had applied to the other liquor. It was now, therefore, proved that this acid, united to water, was really contained in the volcanic glass. The appearance of white vapours in the glass receiver was thus explained; as they proceeded from the water mixed with the muriatic acid, it being well known that this acid, when it comes in contact with any humidity, produces such vapours. The water reduced to vapour was condensed by the cold of the receiver, and fell to the bottom; and the acid in question, from its great affinity with it, was absorbed by it.

But is this fact confined to this particular species of volcanic product, or does it extend to others? To ascertain this was of some importance. I, therefore, made the same experiments on the black glass of the

same island. The result was not different. From twelve ounces of this glass I obtained 104 grains of a liquor which accumulated at the bottom of the glass receiver, by the condensation of the white vapours, and the liquor manifested to the taste the same muriatic acid, the presence of which was confirmed by the same proofs as before.

Notwithstanding the equality of the weight of the two glasses, the liquor obtained from the present weighed 40 grains less than that extracted from the other, but, when touched with the point of the tongue, tasted somewhat more acid. In fact, from 80 grains of this latter I obtained 10 grains of muriate of silver, in which there was, consequently, $2\frac{1}{2}$ grains of muriatic acid, while the other only contained 2.

I afterwards made the same experiment on factitious glass; but, in this case, not more than a grain of water was collected in the receiver, and that was perfectly insipid. It appears, therefore, that this acid apper-
tains

pains to the two volcanic glasses, exclusively of artificial glasses.

It remained to attempt the solution of an important question. Is the muriatic acid combined with these two volcanic substances, or only mechanically united? I conceived that some elucidation of this doubt might be obtained by exposing one of these two glasses to a fire not sufficiently strong to cause fusion. I put six ounces of the spotted glass, reduced to powder, in a glass retort with a luted belly; joining to it the glass receiver, communicating as before with the mercurial apparatus. This I heated in a sand-bath for twelve hours successively. At the end of an hour and a half there appeared, in the neck of the retort, a large drop of limpid liquor, which soon after fell into the receiver. Afterwards a second formed in the same place, which remained adhesive, no other humidity arising to increase it. No vapour of any kind was visible in the retort or the glass receiver, and it was not till after the first two hours that
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the neck of the retort began to be covered with a white veil, which afterwards became more dense. No kind of gas was formed on the mercury.

Having broken the retort, I found that this veil was only the more subtile part of the pulverized glass, sublimed by the heat, and remaining adhesive to the retort. No fusion followed in the glass. The two drops of water, which might amount in quantity to nine or ten grains, were extremely acid to the taste, and it appeared from the application of re-agents that the acid was purely muriatic.

The glass remaining untouched, this experiment showed that the water and the muriatic acid were not in combination with the parts of the glass, but only adhesive to them; it appeared, likewise, that the quantity of acidulous water produced was not equal to that obtained in the matrasses, because the heat was not so great.

The

The humid way afforded a still further elucidation. Having reduced to powder twelve ounces of the black, and twelve of the spotted glass of Lipari, they were left separately during twelve hours in digestion with heat in distilled water. The water, when filtrated, did not in the least change the colour of the tincture of turnsole; a proof that in it there either existed no acid disengaged, or that it was extremely weak. On trying the same water with nitrate of silver, a slight turbidness was produced; and, after four-and-twenty hours, an extremely small sediment.

As I knew that the muriatic acid, though weak, always produces white fleeces or streaks in the solution of the nitrate of silver, I entertained some doubt whether this turbidness might be the effect of this acid; and, to remove it, I resolved to try whether a similar turbidness, but without fleeces or streaks, might not be produced by nitrate of silver in distilled water in which a drop of muriatic acid had been infused. On
making

making this experiment I found that the fleeces, on increasing the quantity of water, became less sensible in the infusion of solution of silver ; and, adding still more water, a slight turbidness was at length produced without fleeces or streaks : whence it appeared evident that the turbidness in question was the effect of a very slight portion of the muriatic acid, which had passed from the volcanic glasses into the water.

I took twelve ounces of each of the glasses, the spotted and the black, reduced them to powder, and boiled them separately in distilled water four successive times, fifteen hours each time ; then straining off the water, I evaporated it to dryness, and found at the bottom of the vessel a residue of fine glass-powder. On this I poured a little distilled water, and tried one part of this water with the tincture of turnsole, and the other with nitrate of silver. In the former arose a thin reddish fume, and in the latter a slight turbidness, not without a few white fleeces.

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I took 19 ounces, 2 drams, and $7\frac{1}{2}$ grains of black glass of Lipari, broke it into six pieces, put them in distilled water, and left them during forty hours in a sand-bath, but without boiling. I did the same by a quantity of the spotted glass, broken into seven pieces, and weighing 20 ounces, 2 drams, and $1\frac{1}{2}$ grain. Having dried the two glasses in the air and the sun, I found them of the same weight. Into these two waters, diminished by evaporation, I poured the nitrate of silver, which caused a slight turbidness, and a proportionate sediment.

By all these facts I think it is incontestably proved that the muriatic acid, in these two volcanic glasses, is not combined with them so as to enter into them as a constituent principle; but is only mechanically attached to their parts.

Besides these two glasses, the black and the spotted of Lipari, I made experiments, as I have mentioned in the preceding chapter, on six other volcanic products. The
gaseous

gaseous substances obtained from them have been already described. It now remains to state the results relative to the present enquiry.

From the lava of Vesuvius, containing garnets, was obtained in the receiver two grains of water, which did not in the least change the tincture of turnsole, but produced a light-blue milkiness by the mixture of nitrate of silver. It could not, therefore, be said that this lava was entirely destitute of muriatic acid.

The lava of Vesuvius which had flowed a short time before I visited that volcano, left at the bottom of the receiver four grains of water, which, when tried by the re-agents, was found not to differ from the distilled water.

From the lava of Vulcano, which is externally an enamel, I obtained $4\frac{1}{2}$ grains of water, which was without odour, but somewhat acidulous; and the precipitation in white fleeces, caused by the nitrate of silver,

ver, proved the presence of the muriatic acid.

The lava of Stromboli, thrown out of its crater, furnished two grains of pure water.

Another lava of Stromboli, of the same species, but which, from its being found buried deep beneath other lavas, must evidently have been thrown out before they were, produced $7\frac{1}{4}$ grains of water in which was contained a portion of muriatic acid; as was discoverable by touching it with the tongue, and still more decisively by the fleecy streaks produced by the nitrate of silver.

The lava which issued from Etna in the year 1787, and which, like that of Stromboli, was still warm when I collected it, gave water to the amount of 6 grains, which in every respect resembled distilled water.

From a solid pumice of Lipari I obtained $24\frac{3}{4}$ grains of water, which was acid to the taste, changed the tincture of turnsole to red,

red, and the acid of which was manifestly muriatic, from the fleecy turbidness produced by mixing it with the nitrate of silver.

On comparing all these facts, it appears that, of nine volcanic products exposed to the action of the fire and fused, six manifested the presence of the muriatic acid, and in three not the least sign of it appeared. From a comparison of the local circumstances of these nine products, we must be convinced that the muriatic acid does not exist in these products when they are either fused, or heated to redness; but that it unites with them afterwards, since the three lavas, one from Vesuvius, another from Stromboli, and a third from Etna, which had been recently ejected from the subterranean furnaces, contained none, though they afforded a small portion of water; while the six others which had ceased to burn for a longer or shorter time, gave a greater or less quantity of this acid. It is also a confirmation of this fact, and merits attention, that the same lava of Stromboli

was destitute of it when first ejected ; but, after some time was elapsed, began to acquire it.

The idea occurred to me whether this acid might not be derived from the ammoniacal muriate, as this salt is almost always found in volcanos. I, therefore, poured a small quantity of the acid liquors obtained from the two glasses upon lime without making use of the carbonate of pot-ash ; but I did not perceive any thing of the strong odour of ammoniac ; an evident proof that it was not the ammoniacal muriate.

I rather incline to suppose that this acid originates either from the subterranean places in which we know that it is sometimes found, or rather perhaps from the sea penetrating beneath the volcanic mountains ; that it is generated from the decomposition of the muriate of soda, by the means of sulphureous acids in which volcanos abound ; and that, absorbed by the humidity of the

air, it is introduced with it into the volcanic products. I cannot, however, deny but that it must appear surprising that this salt in conjunction with water should have been able to find an entrance into the two glasses of Lipari; and especially the black species, as it is extremely compact, and has not the least appearance of any cleft or crack. But we know that water can subtilize itself in such a manner as to penetrate other bodies equally solid and compact, in which our eyes, though assisted by a lens of a strong magnifying power, cannot discover the smallest fissure or minutest pore.

END OF THE THIRD VOLUME.

Front View of Campo Bianco.

Side View of Campo Bianco.