

ribs are nearly obsolete. The form of their spires is also not pupæform. The shell measures without canal .017, canal only .022.

*Distribution.*—Gault of Folkestone, where it is rare.

I should perhaps have named this *A. pupæformis*, and have thereby implied the form and character of the shell; but this name was appropriated by D'Archiac in 1847 for a little-known Oolitic species. I have named it in compliment to John Griffiths, the well-known collector at Folkestone, who has furnished me with the great majority of my specimens. A comparison of specimens in cabinets supplied by him with figures of Folkestone fossils of twenty or thirty years ago, shows the useful, and let us hope not unprofitable, work he has devoted himself to.

#### EXPLANATION OF PLATE III.

FIG. 1.—*Aporrhais retusa*, J. Sby. Natural size, showing ventral side. The posterior digit is slightly lengthened from a specimen lent me by Mr. Price.

FIG. 2.—Showing dorsal side.

FIG. 3.—Specimen showing dilated lip.

FIG. 4.—Part of a shell, to show dilated node. Enlarged.

FIG. 5.—A young shell, to show mode of growth.

FIG. 6.—A young shell, illustrating the same, from the British Museum.

FIG. 7.—*Aporrhais cingulata*, Pictet and Roux, showing arrangement and relative position of digits and canal.

FIG. 8.—Specimen showing development of wing.

FIG. 9.—Another, with dorsal view.

FIG. 10.—Specimen showing aperture and middle digit.

By tracing and reversing Fig. 7 and Fig. 8 an illustration can be obtained of the relative length and position of the wing and canal, showing general appearance of the shell.

FIGS. 11 to 14.—*Aporrhais Griffithsii*, Gardner, from Folkestone.

All in the author's cabinet, save Fig. 6.

FIG. 15.—*Aporrhais pes-carbonis*, Recent.

(To be continued.)

## II.—CONTRIBUTIONS TO THE STUDY OF VOLCANOS.

By J. W. JUDD, F.G.S.

(Continued from page 16.)

### THE LIPARI ISLANDS (continued).

#### 3. Third Period of Volcanic Activity in the Lipari Islands.

Although, as we have already seen, the older volcanic formations of the Liparis present us with features of no little interest, yet it is on account of the cones and lava-streams, composed of rocks of singular beauty and almost unique character,—which are the product of the latest developments of igneous action in these islands, that the attention of geologists is most frequently directed to them.

Lofty cinder-cones, composed of snowy pumice, their vast craters breached by lava-streams of solid glass, seemingly fresh as when the fiery flood leaped from the volcano's throat, and poured with slow and tortuous current down its flanks; wide-spreading lava-fields, their horrid bristling surfaces coated by a reddish-brown crust, but exposing in grand cliff-sections the most marvellous combinations of variegated rocks;—these seen rising amidst the bright blue waters of the Mediterranean, and displayed in that clearness of

outline and that vividness of colouring which only the brilliancy of an almost tropical sky can impart, constitute scenery of startling novelty and wondrous beauty—the impressions produced by which it is as hopeless to convey as it is impossible to forget. Nor is the geologist disappointed by a nearer approach to these remarkable scenes; every blow of his hammer revealing fresh examples of singular rock-structure, novel groupings of crystallized minerals, and lively illustrations of the multiform products which result from the action on rock-masses of the ever-varying combinations of many forces,—such as heat, chemical affinity, crystallization, pressure, tension, and the disengagement of imprisoned vapour and gas.

But before entering on a description of some of these remarkably interesting volcanic cones and lava-streams, composed of pumice and glass respectively, it will be well to pause in order to notice the very striking *linear arrangement* affected by the volcanic vents belonging to both the second and the third periods of igneous action in these islands. For nowhere, perhaps, is this constant feature of the development of volcanic forces—so unmistakably suggestive of the existence of subterranean fissures—more admirably and clearly illustrated than in the Lipari Islands.

Commencing with the southern part of the Island of Vulcano (see map, p. 7), the observer, standing on the summit of the Monte Saraceno, will have no difficulty in perceiving that there lie before him the remains of at least four different volcanic cones and craters, which have been successively formed through the continued shifting of the eruptive vent to more northerly positions. The great central cone of Vulcano, with its magnificent active crater, is evidently thrown up on a continuation of the same line. But an attentive study of this cone and crater-ring clearly indicates to the geologist that they are not the product of a stationary vent; on the contrary, we find clear evidence that the cone has been more than once partially destroyed by explosion and its crater re-formed. Indeed, portions of at least three successive crater-rings, which must have been clearly excentric with one another, can be easily traced. It is interesting to notice that the last eruption of this volcano (which, as will be described in a future chapter, took place only a year ago) threw up cinder-cones at the bottom of its great crater, not, however, at its centre, but at its extreme northern limit.

Again, we have proofs of the opening of a vent, still a little farther to the north, in the actual walls of the great cone, in the beautiful little crater called the Fossa Antico. The Faraglione, situated between Vulcano and Vulcanello, is a mass of volcanic agglomerates, in which mineral deposits of great beauty and value have been developed, in consequence of the permeation of the mass by acid gases and vapours; it is now burrowed over, like a rabbit warren, by the excavations which serve as houses for the workmen employed in the chemical works in the adjoining great crater; this mass of tuffs is clearly the greatly denuded and ruined vestige of a cinder-cone. Thus we find that in the island of Vulcano there exists evidence of the opening, along a single line, of at least *nine* different

vents, which have given rise to eruptions differing very greatly in violence and duration.

On a continuation of the same line, we find in Vulcanello, now joined to Vulcano by a bank of cinders, three other well-marked craters. The features presented by Vulcanello are illustrated in the accompanying sketch (Fig. 6). Of these craters the newest is

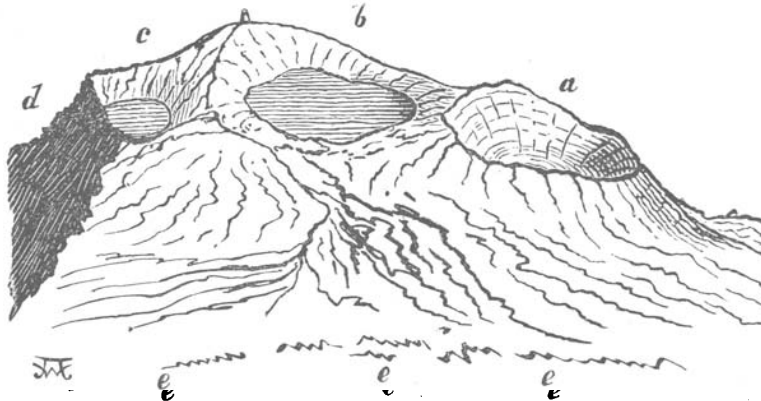


FIG. 6.—Vulcanello with its three craters as seen from the south end of the Island of Lipari. *a*. Most modern crater. *b*. Central, largest, and oldest crater. *c*. Portion of third crater. *d*. Section of cone in sea-cliff. *e*. Lava-stream.

clearly that which occupies the most southern position, and which was in all probability due to an eruption during the historical period. The most northern of the three craters of Vulcanello has had one-half of its periphery removed by the encroachments of the sea, and here we actually find a clear section of one of these small volcanic cones, as represented in Fig. 7. The central crater of Vulcanello is the largest, most ruined, and probably the oldest of the three.

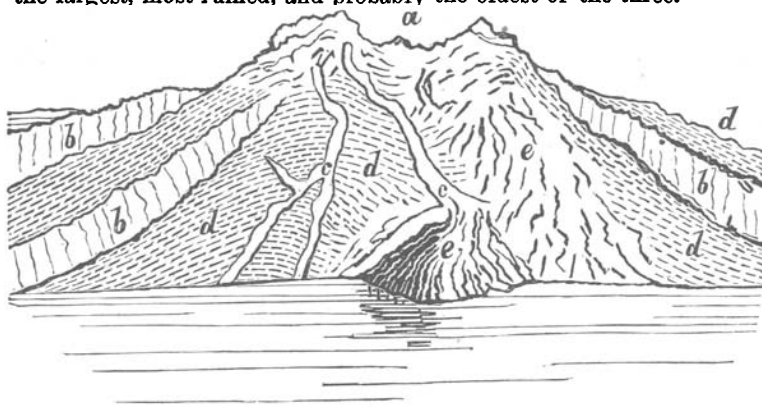


FIG. 7.—Section of cone of Vulcanello in sea-cliff (*d* in Fig. 6). *a*. Crater. *b, b*. Lava-streams. *c*. Dykes which have clearly formed the ducts through which lava has risen to the crater. *d, d*. Stratified volcanic tuffs and agglomerates, exhibiting the characteristic arrangement of the interior of volcanic cones. *e*. Portions of cliff concealed by taluses of fallen fragments.

The island of Lipari must be looked upon as only accidentally separated from that of Vulcano and Vulcanello; the same line of volcanic cones and craters which we have described in the latter being clearly continued in the former. In the southern part of the island of Lipari we find at Punta Capparo, Formiche, Monte della Guardia, and Fossa del Monte, weathered and unmistakable craters and lava-streams, composed of materials of highly acid or siliceous character, namely, pumice and quartz-trachyte (Liparite), passing into obsidian, perlite, retinite, etc., and evidently belonging to the latest period of volcanic eruption. The central parts of the island of Lipari are entirely composed of the tuffs and lavas of the second period; these are, however, as we have already seen, much altered by the gaseous emanations, still represented by the hot mineral springs of San Calogero and the stufe of Bagno Secco, which must be assigned to the third period. The great central crater of Monte Sant' Angelo (see Fig. 3, page 14) is thrown up on the same great line of fissure which we have been tracing to the southwards; but on the west and east sides of it respectively we find the smaller lateral craters of Mazza Carusæ and Monte Ferrara or Forgia Vecchia, the latter belonging to the latest period of eruption.

The northern part of the island of Lipari, like its southern extremity, exhibits a fine series of pumice cinder-cones and lava-streams of volcanic glass graduating into Liparite, evidently of recent origin, and forming a continuation of the same north and south line of vents. These we shall presently describe in greater detail.

Thus we have clear evidence that along a line, directed towards the earliest and great central volcano of the Lipari group, at least *twenty* distinct vents, giving rise to volcanic cones and craters of varying size, have been formed. It seems probable, as suggested by Hoffmann, that the volcanic products of Capo di Milazzo may be regarded as a continuation of the same line.

The twin volcanos of Salina (the Didyma of the ancients) with those of Filiudi and Alicudi are evidently situated on another line, which may perhaps be produced to Ustica. This line also radiates from the same central volcanic mountain.

Lastly, in Stromboli, with its linear arrangement of old and recent craters, and in Stromboluzzo, doubtless the last relic of another volcanic pile, we see evidence of a third string of volcanic vents, the direction of which points to the same great centre of igneous activity.

That the linear arrangement of volcanos, such as we have described as so well exemplified in the Lipari Islands, points clearly to the existence of great fissures in the earth's crust, along different parts of which eruptions have successively taken place, has been recognized by all geologists. Indeed, in the fissures produced at Etna during the recent eruption (1874), as described by Professor Silvestri, of Catania, in the earlier eruptions of the same mountain in 1669, 1811, and 1819, and in many analogous cases, we have had ocular demonstration that such is the case. Fresh proofs of the correctness of

this conclusion are afforded by the great fissures filled with volcanic materials, with which all geologists are familiar, as traversing older rock-masses where exposed by denudation.

Nor must we forget that the volcanic band, which has been indicated as passing through the great central vent of the Liparis and Stromboli, would, if produced, strike the great earthquake-shaken tract of Calabria, and by a slight deflection pass through the volcanic districts of Southern and Central Italy; while the southern continuation of the same, passing through Lipari, Vulcanello, and Vulcano, points to Etna, the Val di Noto, and the volcanic islands lying south of Sicily. These facts are interesting, as indicating that Von Buch's classification of volcanos, according to their mode of arrangement, in linear systems and groups, cannot be sustained. All volcanic action appears to be developed along lines of fissure, though these may present very varied relations and connexions with one another, I shall take occasion, hereafter, to show that the principal of these combinations assumed by volcanic lines of fissure may be classified as radial and parallel series.

The fissures of the Lipari group afford an interesting example of the radial arrangement, with some illustration of the production of lateral or branching fractures on either side of the principal ones. The whole, however, being probably a subordinate part of a great band of subterranean volcanic action.

It is a most interesting circumstance, and one by no means devoid of suggestiveness to the geologist, that the two active volcanic vents of the Lipari Islands are situated at distant, almost indeed extreme, points of the group; and that while one of them, Stromboli, ejects materials of the most highly *basic* character—dolerite and basalt—the other produces rocks of extremely *acid* composition, quartz-trachyte (Liparite) and obsidian. The striking differences in the specific gravities of these two classes of rocks has been commented on by many geologists. As every great volcanic area may fairly be supposed to have beneath it a reservoir of materials in either an actually or potentially<sup>1</sup> liquefied state, we may, without adopting Durocher's notions of *universal acid* and basic magmas, suggest a possible explanation of the peculiarities of the existing volcanic phenomena of the Lipari Islands. If we imagine the area to be underlaid by a reservoir of liquefied materials which is of intermediate composition, this might have supplied the products of all the earlier eruptions of the district; and it is only necessary to suppose that, by the action of gravity, the materials (magmas) of different densities were in process of time separated from one another, while distinct fissures were opened connecting the upper and lower portions of the mass, respectively, with different parts of the surface,—to see that just such phenomena as now take place would be called into play.

<sup>1</sup> By a rock in a *potentially* liquefied state, I of course mean one which, either from its elevated temperature or its condition of internal tension from imprisoned volatile constituents, would assume a liquid form on being relieved from the pressure which maintains it in a solid state.

Reserving for a future occasion, when some other volcanic districts have been described, all general remarks upon the classification of the products of volcanic action, we may notice that the modern lavas of the *northern* fissure (Stromboli and Stromboluzzo) produce rocks of the most typical basic character, namely, basalts and dolerites. Abich's analyses of these lavas gave the following results—their specific gravity being between 2.86 and 2.96.

	Lava of Stromboli.	Lava of Stromboluzzo.
Silica ... ..	50.25	53.88
Alumina ... ..	13.09	12.04
Oxide of Iron ... ..	10.55	9.25
Oxide of Manganese... ..	0.38	—
Lime ... ..	11.16	7.96
Magnesia ... ..	9.43	8.83
Soda (with some Potash)... ..	4.92	4.76
Loss ... ..	—	2.78

The second of these rocks appears to have undergone a certain amount of alteration.

These doleritic lavas appear to consist mainly of an aggregation of nearly equal proportions of crystals of Labradorite felspar and augite, to which variable quantities of magnetite and olivine are added in different examples.

As is usually the case with igneous rocks of basic composition, the lavas of Stromboli only very rarely assume the vitreous condition. The scoriæ which are ejected from the active crater of Stromboli, at intervals of a few minutes only, sometimes fall so near to the observer that he can approach them while still in a soft and plastic condition, and thrust coins or other hard objects into them. These cinders are found on examination to be perfectly stony in character; but they are completely full of vesicles, formed by the escape of volatile materials from their midst, and they usually inclose nearly perfect and very beautifully formed crystals of augite—sometimes of considerable size. But besides the scoriæ, showers of volcanic sand also fall around the observer standing beside the crater of Stromboli. This volcanic sand proves on examination to be, like the similar materials ejected from Mount Klut in Java in 1864, and from the volcano of Georg in the Gulf of Santorin in 1866, both of which were submitted to microscopical examination by Vogelsang, an aggregate of more or less broken and rubbed crystals of augite, felspar, olivine, and magnetite, with comminuted fragments of scoriæ.

Around the sides of the crater of Stromboli crystals of augite can be collected in great abundance; they are usually macle, and sometimes form beautiful stellar groups and other interesting combinations. These are doubtless in part ejected directly from the crater, but in other cases result from the breaking up of the light cindery fragments in the midst of which they were inclosed at the time of their ejection. That these crystals were actually formed *within* the volcanic vent there is not the smallest room for doubt.

That Stromboli has in comparatively recent times given forth streams of basaltic lava of very considerable magnitude is clear to any geologist who studies the fresh and undecomposed fields of lava



(Sciaras) which surround the island. Sometimes this lava assumes the finely columnar structure so common in rocks of this class. Thus, a very fine series of columns is exhibited at Punta Labronzo, the northern point of Stromboli, and ruder ones at Punta del Uomo, on the south-east of the island. On the extremest verge of this latter lava-stream is situated one of those little shrines, which, in spite of the apparent inaccessibility of its position, has its burning lamp constantly replenished. The voyager in these seas is startled when, on reaching these spots, the wild cries and strange songs of the boatmen are suddenly hushed, all engaging for a few moments in silent devotion to the saint who is supposed to warn, by means of this primitive and not very efficient lighthouse, the mariner who approaches these inhospitable shores.

The products of the modern eruptions along the *southern* line of fissure—that, namely, which extends beneath the islands of Lipari and Vulcano—offer, as we have already remarked, the most striking contrast to those of Stromboli. These lavas belong to that highly silicated class so well illustrated in the Ponza Islands, the Euganean Hills, and Hungary. The highly acid lavas, to which the name of quartz-trachyte is usually applied, but which by Roth were called “Liparite,” and by Richtofen “Rhyolite,” are in their ultimate composition almost identical with the granites; and when highly crystalline, are seen to be composed of precisely the same constituent minerals—namely, several species of felspar, orthoclase being always predominant, free quartz, and variable quantities of hornblende or mica. By the peculiar *arrangement* of their materials, however, the highly silicated lavas are well characterized; and in their internal structure they present features which almost always serve to distinguish them from the granites, with which they were by early geologists so frequently confounded.

In illustration of the ultimate composition of these highly acid lavas of Lipari, we give the following analyses of Abich, with which others by Berthier and Klaproth closely agree:

	Obsidian of Lipari.	Pumice of Lipari.
Silica ... ..	74.05	73.70
Alumina ... ..	12.97	12.27
Oxide of Iron ... ..	2.73	2.31
Lime ... ..	0.12	0.65
Magnesia ... ..	0.28	0.29
Soda ... ..	4.15	4.52
Potash ... ..	5.11	4.73
Water ... ..	0.22	1.22
Chlorine ... ..	0.31	0.31

The specific gravity of the obsidian is 2.3702, and of the pumice 2.3771. When in its most completely stony condition, the rock has a specific gravity of 2.53, and consists almost entirely of orthoclase felspar, quartz, and hornblende, in about the following proportions:

Felspar ... ..	77 per cent.
Quartz ... ..	18
Hornblende or Mica ... ..	5

In the less compact or stony and more cavernous varieties of

Liparite, the ordinary hornblende and mica crystals do not appear; but instead of them, we find in the mass grains of magnetite with groups of acicular, filiform, or capillary crystals, which we should at first sight refer to *Breislakite*, but which, considering their association, may probably be regarded as a variety of *hornblende*, bearing the same relation to the Amphibole series which *Breislakite* does to the Pyroxene series.

In striking contrast to the basic lavas of Stromboli, the highly acid lavas of the Lipari and Vulcano constantly tend to assume the vitreous condition; some of the lava-streams being, indeed, composed of solid volcanic glass. These glasses in turn frequently assume a more or less puniceous structure, through the inflation of their materials with blisters and bubbles, as a consequence of the disengagement of those volatile constituents which the researches of many chemists show that obsidians so abundantly contain. The cones formed of the ejected fragments of these newer volcanos of Lipari and Vulcano consist of fragments of typical pumice. So excellent and abundant is the pumice of Campo Bianco in Lipari, that it is sent to all parts of the world; and its collection, preparation by drying, and exportation, constitute one of the most important sources of wealth to the islanders.

Mingled with the white pumice, which constitutes fragments of every conceivable size, there occur numerous volcanic bombs, in which every stage of the transition from obsidian to pumice can be admirably studied. The exterior surface of these bombs is covered with a crust of solid obsidian, which is usually cracked into a number of polygonal fragments; but, as we pass towards the centre of the bomb, blisters gradually increase in number, till the centre is found to be composed of a mass as light and porous as a sponge. Bombs of this character, sometimes many feet in diameter, and which have been usually broken by their fall, are found scattered around the active cone of Vulcano, and are in all probability the product of its last grand eruption in 1786.

The wonderful variety of the acid rocks of the Liparis arises from the fact that every possible gradation between the stony, vitreous, and puniceous characters, may be observed in them. The liquefied material may, according to the conditions of its consolidation, assume one of three forms, Liparite, Obsidian, or Pumice, or it may form a material in which the diverse characters of these three products are united in the most singular and unexpected combinations.

Some of these remarkable and interesting varieties, which may be well studied at Rocche Rosse, Monte Perrara, Monte della Guardia, Fossa del Monte, Punta Capparo and many other points in Lipari, and in the great modern lava stream of Vulcano, it will be necessary briefly to notice.

*First Series.*—The most perfect glass is found passing by insensible gradations into rocks of less strikingly vitreous lustre—pitchstones or retinites—and thence through materials of pearly or porcellanous appearance into the most perfectly stony and crystalline, almost indeed granitic, masses. This series of changes is effected



without the appearance in the mass of any definite arrangements of crystallites.<sup>1</sup>

*Second Series.*—Much more frequently, however, the passage from the vitreous to the stony series takes place by the appearance in the mass of scattered “sphaerulites,” composed of radiating crystals of felspar, entangling others of quartz, magnetite, and other minerals. Occasionally these sphaerulites are found scattered in a promiscuous manner through the vitreous matrix; but, far oftener, they assume very striking and definite arrangements; these are clearly seen to be the result of the conditions of pressure, tension, and slow-dragging movements to which the slowly consolidating mass was subjected. Sometimes the alternate laminae of vitreous or colloid and stony or crystallized materials have assumed a parallel arrangement, and the rock is almost as perfectly *cleaved* as a piece of slate; at others they assume all the beautiful wrinklins and corrugations so characteristic of metamorphic *foliated* schists. The light which these remarkable products throw upon the mode of formation of many of the older rocks will be illustrated on a future occasion.

*Third Series.*—At times the obsidian base of the rock is porphyritic, that is to say, it has crystals, often large and well formed, most commonly of brilliant sanidine, but not unfrequently of quartz, hornblende, or black-mica, floating through its mass. It then assumes the characters of an “obsidian-porphry” (porphyritic obsidian). No one can study this rock, as exhibited in Lipari, without being convinced that the crystals which it contains were ejected, ready-formed, with the lava as it issued from the volcanic vent. Not only is there no trace of crystals in various stages of formation, as in the case of the sphaerulites, etc., but sometimes pumiceous masses, evidently blown out of a volcanic vent, may be found entangling just such perfect crystals. We shall not at present enter on the discussion of those interesting problems which the phenomena of these perfect crystals of minerals of such different degrees of fusibility, floating in the same liquefied highly siliceous magma, must suggest to every geologist. We shall only notice, in this place, that the combinations of these ejected crystals with those gradually developed in the mass by the growth of crystallites, the whole modified by the peculiar mechanical conditions to which the masses have been subjected, result in the formation of rocks of wonderful diversity, exquisite beauty, and remarkable suggestiveness to the petrologist.

*Fourth Series.*—Fresh complexities of rock structure are originated and new varieties of lava produced, when, in either of the kinds already noticed, disengagement of volatile materials in the midst of the mass began to take place. The vesicular cavities thus originated were variously modified by the strains and movements to which the plastic mass was subjected. The most stony and highly crystalline, as well as the most vitreous varieties of these lavas, are thus affected

<sup>1</sup> The exceedingly beautiful and clear obsidian of Lipari, like that of Mexico, has been employed by the ancient inhabitants of the island for cutting instruments and weapons.

by the more or less complete disengagement of their volatile constituents; and while in the former, cavities originate which are occasionally lined with the most beautifully developed crystals of the component minerals of the rock,—in the latter, a laminated structure is produced, the planes of which sometimes coincide with, but not unfrequently cross, those produced by the devitrification of the mass under pressure.

But this attempt at a classification is far from exhausting the varieties of the beautiful quartz-trachytes of Lipari. New forms are originated through masses of obsidian being broken up and entangled in a stony matrix, or by glassy streams enveloping stony or perlite fragments, or, as is not unfrequently the case, by their catching up in their flow angular fragments of lavas of different composition, and belonging to earlier periods of eruption. Thus are originated the most singular brecciated structures, and rocks of very peculiar and, at first sight, puzzling character are produced.

When, however, these rocks are studied by the aid of the microscope, new features of interest continually make their appearance, only a very few of which it will be possible to notice in this place.

In the most clear and translucent volcanic glasses which have yet been examined, the beginnings of the process of *devitrification* can always be detected. Minute acicular crystals of felspar (Belonites) are seen, which, in a later stage of development, assume rectangular forms and ruin-like terminations, and thus gradually approximate to the ordinary characters of sanidine crystals. Other acicular or filiform crystals of hornblende (Trichites) appear and combine into radiating groups or tree-like masses of marvellous beauty. Where these crystals reach the surface of a cavity in the lava, free development of them often takes place, and we are enabled to study their nature and characters with the greatest facility.

Most frequently, however, the crystals unite in radiating masses, giving rise to those globular concretions known as *sphærolites*. In some cases the formation of these sphærolites has been determined by the liberation, in the midst of the vitreous mass, of an infinitesimal bubble of volatile matter. By the development of these crystalline globules with such exquisitely beautiful concentric and radiated internal structures, the peculiar forms and distinctive opalescent lustre of “perlite” is originated.

Nowhere, perhaps, can better materials be found for illustrating the development of these peculiarly interesting structures in vitreous rocks than in Lipari. Some of the pearlstones of this island, as, for instance, that of the lava-stream above Canneto, contain sphærolites of the size of peas. To attempt anything like an adequate account of the varieties assumed by the crystalline interiors and semi-vitreous envelopes of these, would require numerous figures and an amount of detailed description which would be out of place in these sketches.

It is in the northern part of Lipari that we find the best examples of the volcanic cones, craters, and lava-streams of the latest period of eruption in the Lipari Islands.

Supposing a furnace containing many millions of tons of liquefied

glass were allowed to pour forth its contents in a stream extending to a length of some miles, and to a thickness of hundreds of feet, what would be the nature of the phenomena attending its outburst, and of the products which would result from its gradual solidification?

This is no idle problem; for the solution of it may be found by the geologist at Campo Bianco and Rocche Rosse.

Campo Bianco or Monte Pelato is a volcanic mountain (see Fig. 8), composed entirely of the whitest fragmentary pumice, the highest portion of the crater-ring of which rises to the height of more than 1500 feet above the sea-level. This is partially embraced (as is Vesuvius by Somma) by the relics of an older and far larger cone of the same materials, which culminates in Monte Chirien, having an elevation of nearly 2000 feet. The soft white pumice tuffs of the flanks of both these cones have suffered greatly from denuding forces, acting on their light and incoherent materials, and giving rise to those long furrows producing the "umbrella form" which is admirably exemplified in them. The crater of Campo Bianco presents at its bottom a flat plain, covered with comminuted pumice-tuffs, and now forming a most productive vineyard at a level of 892 feet above the sea; its walls rising almost vertically around it to heights of from 400 to 600 feet on the northern, western, and southern sides. On the north-eastern margin of this crater, however, a petrified cascade of vitreous lava rises 100 feet above the crater-floor, and, sweeping away all that side of crater-wall, has poured with a current, half a mile in breadth, down to the sea. This lava-stream, now covered with a reddish-brown coating from the oxidation of its iron, is the Rocche Rosse. Near the point where it issues from the crater, a deep "bocca" exists, once evidently the place of discharge of powerful steam-jets—now an awful pitfall, which the islanders avoid and speak of with terror. The surface of the lava presents a most striking example of those rugged cooled surfaces, like the *Cheires* of the Auvergne, and presents one of the wildest and most desolate scenes which it is possible to imagine. The traversing of it is in many places a very difficult task.

Other similar cones, craters, and lava-streams abound in Lipari. On the western side of Monte Chirien, at an elevation of more than 1700 feet, is a second crater, much ruined, that of the Piano dell'altra Pecora; and on the south side of Campo Bianco is another, that of Forgia Vecchia, or Monte Perrara, at an elevation of 968 feet, from which another stream of vitreous lava flows to the sea. At the head of this lava-stream no less than three mouths communicating with abysses of unknown depth, similar to that of the Rocche Rosse, are seen. They doubtless mark the sites of explosive discharges of steam. At Canneto is an older stream of perlite, which probably flowed before the present crater of Campo Bianco was formed.

The craters of the southern part of the island of Lipari give rise to lavas similar in composition to those of the north end of the island. In the former, however, the stony characters predominate

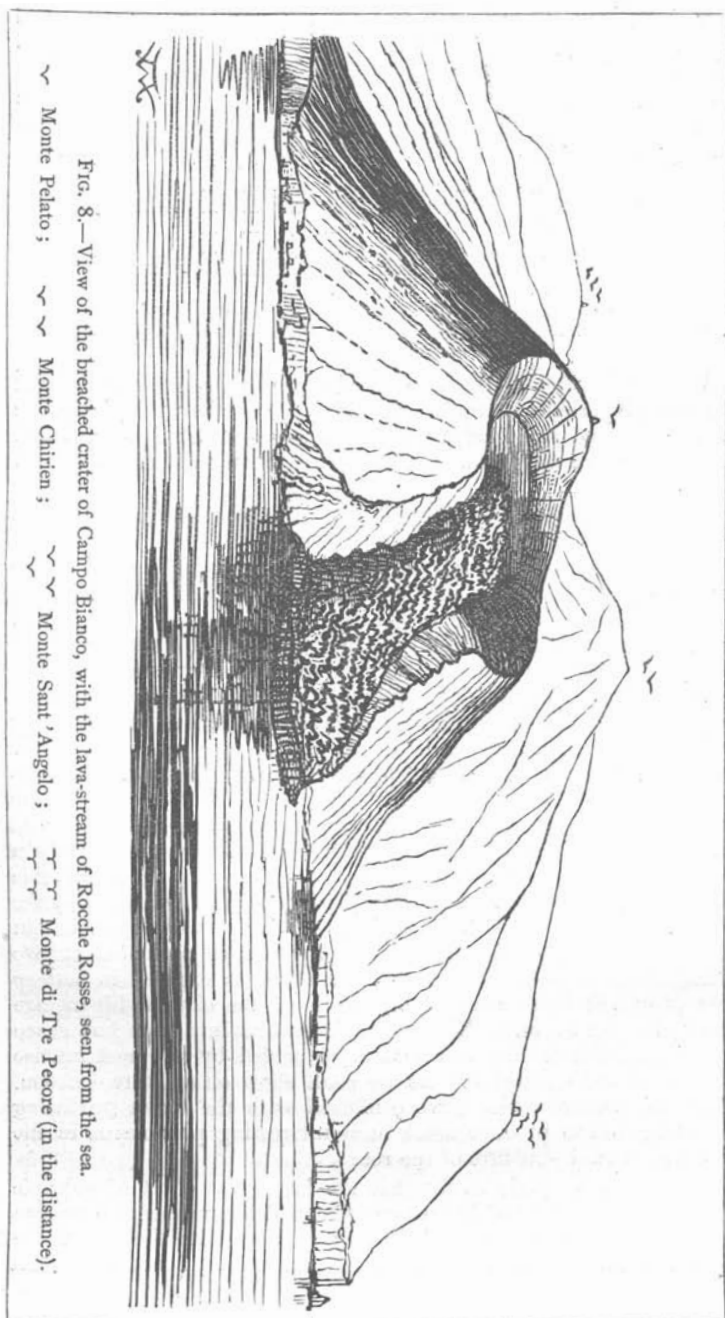


FIG. 8.—View of the breached crater of Campo Bianco, with the lava-stream of Rocche Rosse, seen from the sea.

~ Monte Pelato ; ~ Monte Chirien ; ~ Monte Sant' Angelo ; ~ Monte di Tre Pecore (in the distance).

over the glassy, while in the latter the reverse is the case. Old craters can be traced at Fossa del Monte, Monte della Guardia, and other points in the district.

Some of these lavas have undergone a certain amount of alteration from the passage through them of acid gases, as is shown by the following analysis by Abich of a Liparite from Monte della Guardia :

Silica	...	...	...	...	...	...	...	...	68.35
Alumina	...	...	...	...	...	...	...	...	13.92
Oxide of Iron	...	...	...	...	...	...	...	...	2.28
Lime	...	...	...	...	...	...	...	...	0.84
Magnesia	...	...	...	...	...	...	...	...	2.20
Potash	...	...	...	...	...	...	...	...	3.24
Soda	...	...	...	...	...	...	...	...	4.29
Volatile materials, principally Sulphur and Sulphuric Acid									4.64

While the action of the acid gases upon the ordinary trachytes of the second period of eruption in Lipari gives rise to the formation of selenite and basic sulphates of iron,—sulphate of alumina and free sulphur are the products of the same action on the later formed quartz-trachytes.

To those who regard the fluidity of lava as the result of simple fusion, nothing can be more startling than the behaviour of these obsidian currents of Lipari. While, as is well known, some of the highly crystalline lavas of Vesuvius have flowed with the most astonishing rapidity, these glassy masses have evidently possessed only the most imperfect fluidity. In proof of their viscosity I may point to the manner in which the modern obsidian stream of Vulcano is confined to the steep slope of the cone, at the bottom of which it has piled itself up in great hummocky masses, instead of spreading out in a fan-shaped manner, or continuing to flow in a stream over the smaller slopes. The same fact is more or less strikingly illustrated by all the glassy lava-streams. But even more decisive evidence of this slow movement of the obsidian lavas, and of the vast amount of tension and pressure to which their masses have been subjected, is afforded by their *internal structure*. Every conceivable condition of plication, crumpling and puckering, is illustrated by the sections afforded either in sea-cliffs or the ravines cut by mountain torrents in these obsidian lavas. The appearance presented at two different portions of the same lava-streams, as exposed in a steep escarpment at Porto delle Genti, south of the city of Lipari, are shown in Fig. 9: in A the mass has been bent into large but sharp folds; in B the folding has been accompanied by the most intense crumpling and puckering. As we shall show on a future occasion, these mechanical forces have combined with the forces producing devitrification to produce some most interesting phenomena in the minute internal structure of the rocks.

There can be little doubt that the last great effort of volcanic activity in the island of Lipari was that which produced the present crater of Campo Bianco, and the lava-stream of Rocche Rosse. In spite of traditions and obscure historical allusions, I find it difficult

to believe, so much have the hard masses of lava suffered in places both from marine and subaerial denudation, that any record of this great eruption can have survived.

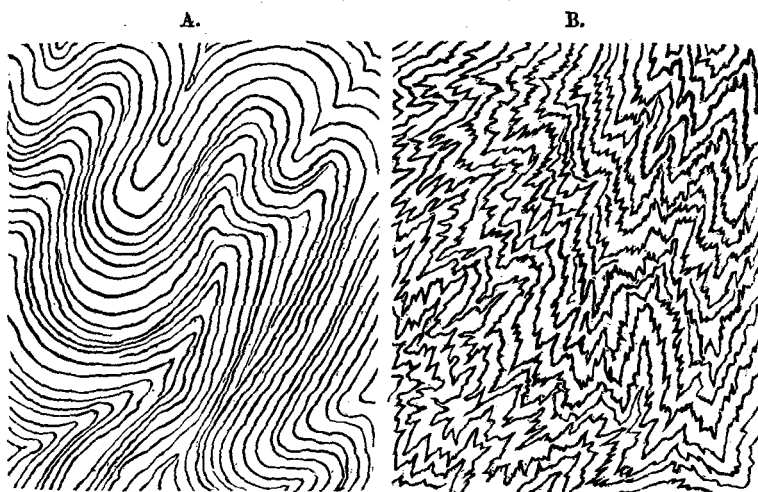


FIG. 9.—Sections of quartz-trachyte (Liparite) lava-streams at Porto delle Genti, illustrating the folding and crumpling of their interior portions, produced by the slow movement of the viscous mass. A. Exhibits a series of broad folds. B. A series of most complicated puckerings, exactly like that seen in many gneissose rocks.

To their permeation by gases and vapours, probably during the latest period of eruption, the altered trachytes and tuffs, with their veins of selenite and other minerals, are probably due. Only two vents, constituting the dying efforts of volcanic activity, once so powerful in this island, still remain, being situated on its western side; one of these is at Bagno, or la Fonte di San Calogero, and gives rise to a hot mineral spring; the other is at Bagno Secco, a little to the northward, and only dry stream, charged with hydrochloric and sulphurous acid gases, is evolved from it.

The hot spring of San Calogero has long been celebrated for its curative properties, having been mentioned by Diodorus Siculus; in 1870 a bath-house and hotel were erected here by the municipality of Lipari. In a medical tract by Dr. Guiseppe Eincotta, the use of these waters in various rheumatic and cutaneous affections is stated to be attended with the most beneficial results.

The water, which has a temperature of 198° F., that of the surrounding atmosphere being 77°, has been analyzed by Dr. Ferdinando Rodriguez, and also by Prof. Guiseppe Arrosto, of the University of Messina. It contains free carbonic acid and sulphuretted hydrogen, with the carbonates of lime and magnesia, and chlorides of calcium and sodium, and a little organic matter.

The following is the result of Prof. Arrosto's analysis :



Oxygen ... ..	0.0037
Nitrogen ... ..	0.0126
Carbonic Acid ... ..	0.2758
Sulphuric Acid ... ..	1.8842
Silicic Acid... ..	0.0082
Chlorine ... ..	3.8630
Lime ... ..	0.5286
Magnesia ... ..	0.3219
Potash... ..	0.1092
Soda ... ..	2.7629
Iron, Organic substances, and Alumina ...	traces.
Total solid and gaseous substances ... ..	9.7701
Water ... ..	990.2299
Total ... ..	1000.0000

The water deposits upon the walls and pipes of the bath-house a thick white incrustation.

Of the more active and very striking manifestations of volcanic activity at the present time in the Lipari Islands we shall treat in succeeding chapters, which we propose to devote to the description of the remarkable active volcanos of Vulcano and Stromboli.

(To be continued in our next Number.)

### III.—A CHAPTER IN THE HISTORY OF METEORITES.

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(Continued from page 30.)

1870, January 23rd.—Nidigullam, near Parvatypore, Vizagapatam District, Madras. [Lat. 18° 41' 20" N.; Long. 83° 28' 30" E.]<sup>1</sup>

A meteoric iron, weighing 407 tolas (about 10 lbs.), fell at Nidigullam, and penetrated the ground to the depth of twenty inches. Those who saw the meteor describe it as very large and beautiful, and as exhibiting increased brilliance when it burst. The explosion was followed by a series of rumbling noises. The meteorite passed over Parvatypore from N. to S.; the people of the village were greatly alarmed, and one man, near whom it fell, was stunned. The villagers "carried it off to their temple, and, much alarmed, were found making pūja to it." The author of the notice in the *Proceedings* considers that this aerolite contains no stony matter, and he states that it is marked with striæ lying obliquely to its greatest length, which is 6½ inches. The lamented Dr. Stoliczka, however, was of opinion, from the description of the striation, that it is a stone containing much iron, "like the Mooltan aerolite which fell some short time ago."<sup>2</sup> If it be metallic throughout, as Saxton asserts, it is the third<sup>3</sup> iron recorded to have fallen in India, and one of the very few

<sup>1</sup> G. H. Saxton. *Proc. Asiat. Soc. Bengal*, 1870, 64.—This fall is stated by Mr. Greg, in the *Report Brit. Assoc.*, 1870, to have taken place December 26th, 1869.

<sup>2</sup> This is probably the meteorite of Lodran which fell 1st October, 1868 (see Part II.).

<sup>3</sup> The second is that found at Prambanan, Soerakarta, Java, in 1865; if we include