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"Volcanic travels" and the Development of Volcanology in 18th Century Europe

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The aim of this paper is to provide an overview of the different ways of travelling through a volcanic region and studying a volcano - in order to describe its lithological, mineralogical and geological features - particularly in the second half of the 18th century. The early descriptions of Italian volcanoes were included in different kinds of printed works: "theories of the Earth" or theoretical interpretations of the "subterranean world", chronological repertoires of eruptions, publications based on travel of which geological observations were part and later fieldwork specifically undertaken in order to study the volcanoes. The increasing amount of data collected in the field during these travels in the Mediterranean region, as well as the changing methods of interpretations of the volcanic phenomena, also contributed to the European debate on the formation and on the age of the Earth's surface.

In the late 18th century, the development of volcanology as a scientific discipline was strongly influenced by the increase of the travels to the active Mediterranean volcanoes such as Vesuvius, Mt. Etna and the volcanoes of the Aeolian Islands. This research work followed the early studies on the so called 'ancient' or extinct volcanoes located in France, Italy, Bohemia and in other parts of Central Europe since the middle of the 18th century, but it was also the starting point of a larger series of explorations on the volcanic regions of Northern Europe, Southern America and Asia.[1] Several scientists and travellers gave a significant contribution to the studies of the Mediterranean volcanic phenomena in the late 18th and in the early 19th century: in particular, the names of William Hamilton (1730–1803), Déodat de Dolomieu (1750–1801), Lazzaro Spallanzani (1729–1799), Patrick Brydone (1743–1818), Michel-Jean comte de Borch (1751–1810), Scipione Breislak (1748–1826), Giovanni Battista Brocchi (1772–1826) and Leopold von Buch (1774–1853) may be recalled.[2]

The activity of volcanoes had attracted the interest of scholars since classical times. In the Mediterranean region, the first ideas of the ancient Greek and Romans on volcanic action were influenced by memories of the colossal 'Minoan eruption' of Santorini island (Thera) in the Aegean Sea, as well as by the long-standing activity of Mt. Etna and some of the Aeolian Islands (Vulcano and Stromboli) near Sicily, well before the catastrophic eruption of Vesuvius in 79 A.D.[3]

Later, the theory of the Earth proposed by Athanasius Kircher (1602–1680) in the second half of the 17th century provided some suggestions as to the role of volcanoes as one of the main elements for the functioning of the "geocosm" presented in the *Mundus Subterraneus*:[4] According to this theory, a central fire was connected to various fire filled chambers by numerous channels and the volcanic eruptions were regarded as safety valves against over-heating.[5] It was a theoretical system, but also based on the results of some travels in southern Italy, when Kircher had directly observed Stromboli and Etna in 1637, as well as Vesuvius in 1638 (Fig. 1). Moreover, the great catastrophic eruptions of Vesuvius (1631) and Mt. Etna (1669), although they did not motivate long-distance travels, stimulated several scientific observations by local scholars. These works marked the beginning of a specific literature which continued to be very rich in the following centuries, including descriptions of the volcanoes, histories of their eruptions, but also interpretations of the volcanic phenomena and their dynamics.[6] In particular, the 1670 treatise *Historia et Meteorologia incendii Aetnaei anni 1669* (Fig. 2) by Giovanni Alfonso Borelli (1608–1679) was a fundamental step toward the birth of volcanology: volcanoes were still considered as safety valves, but Borelli recognized that local combustion inside the mountains melt rocks and sand in order to produce vitrified lava.[7]

FIGURE 1. Athanasius Kircher, Vesuvius observed in 1638 (in *Mundus Subterraneus*, Biblioteca Nazionale Centrale Roma, Fondo Gesuitico, Ms. 562, f. 509).

Descriptions of the eruptions of Vesuvius and Etna indeed represented the most considerable part of the 'volcanological' primary sources still in the early 18th century, but, after the works by Kircher and Borelli, theoretical explanations of the volcanic phenomena were also more often included in learned treatises about the 'subterranean world', such as for example the *Fisica Sotterranea* (1730) by the abbot Giacinto Gimma (1668–1735). He adopted the ancient theory of the earth 'as a sponge' with many subterranean caves and tunnels crossed by rivers of water or rivers of fire (as already illustrated by Kircher in the *Mundus Subterraneus*). This system of communicating rivers of fire was fed by combustible matter ("materie combustibili") and when one of these rivers arrived at the surface of the earth through an opening like the crater of a volcano, it caused an eruption. The *Fisica Sotterranea* was a detailed scholarly work, but clearly not based on travels or fieldwork.[8]

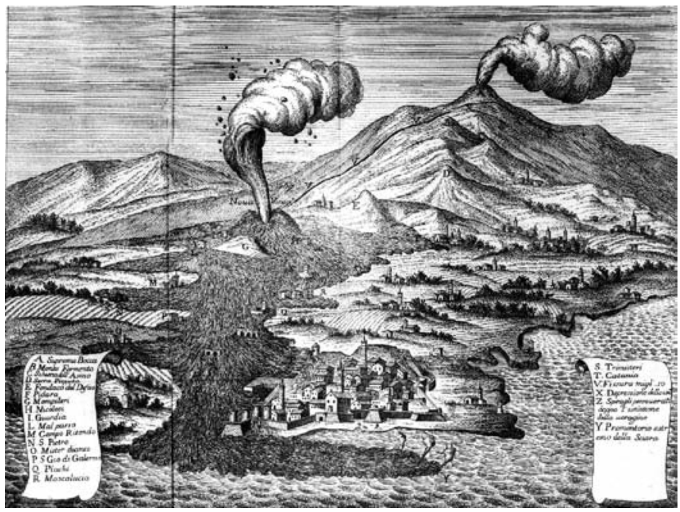

FIGURE 2. Mt. Etna after the 1669 eruption (from Borelli 1670; reproduced in Spallanzani 1792–97, vol. 1, plate I).

Ten years later, Anton Lazzaro Moro's (1687–1764) original theory of mountain building was expressed in the book *De' Crostacei*,[9] originally inspired by the impressive reports on the emergence in May 1707 of a new volcanic island near Santorini in the Aegean sea.[10] According to Moro, the 'primary' mountains were pushed up from the sea bottom by underground heat, like submarine volcanoes, and were composed of massive unstratified stone. The 'secondary' mountains, instead, were formed by strata deposited on the terrestrial surface by volcanic eruptions of the primary mountains during different ages. Consequently, all the mountains were products of the Earth's volcanic activity. This "volcanic" orogenesis had therefore essentially taken place within a great primitive ocean and was probably repeated during the Deluge and other floods. It is important to point out that Moro had not accumulated much data collected in the field (and he never visited a 'volcanic' region), but he had instead expressed a precise theoric conviction based above all on the study of printed sources relative to various volcanic phenomena of the past and of the present, as according to him nature was uniform and always acted in a constant manner. This theory had an interesting diffusion within the Italian scientific community of the second half of the 18th century, but the limits of its excessive generalization were gradually emphasized by the geological results of the regional researches in the field, which in Italy drastically increased from the 1760s.

It seems therefore evident that from the late 17th to the middle of the 18th century, volcanoes were not usually the central subject of specific travels, but were included in general theories of the Earth without much fieldwork, studied by local scholars because of some catastrophic eruptions or casually observed during non-scientific travels. The latter case is well represented by the letter sent to King Charles II of England by Heneage Finch, 3rd Earl of Winchilsea (d. 1689), "late ambassador at Constantinople, who in his return from there, visiting Catania and the Island of Sicily, was an eye-witness of the dreadful spectacle", that is to say the Mt. Etna 1669 eruption (Fig. 3).[11]

Around the middle of the 18th century, more scientists began to examine those burnt rocks that resembled volcanic lavas and were sometimes found near to hills with conic shapes and crater-like tops, similar to small volcanoes. In the 1750s and 1760s, after several excursions in the south-eastern French region of Auvergne, Jean-Étienne Guettard (1715–1786) and later Nicolas Desmarest (1725–1815) announced that they had found traces of ancient extinct volcanoes, the evidence for which was the presence of rocks considered to be of igneous origin (formed by solidification from a molten state, like volcanic lavas), such as basalt.[12] The question of the origin of this latter type of rock had often puzzled geologists, especially because of the amazing regularity of the shape of the columnar basalts, which were large prismatic columns like those to be seen at the famous Giant's Causeway in the north of Ireland.[13]

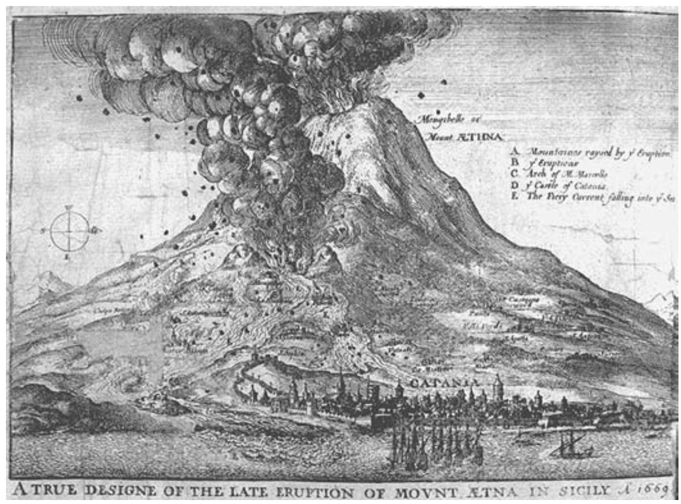

FIGURE 3. The eruption of Mt. Etna in 1669 (in Winchilsea 1669).

It is well known that toward the end of the century, the question of the origin of basalt became one of the main elements of the controversy between the so-called Neptunists and Plutonists.[14] However, this controversy was preceded by a series of detailed field investigations that resulted in the discovery of extinct volcanoes and volcanic rocks in various regions of Europe, within a growing interest for the volcanic phenomena, although these were considered mainly as 'accidental' for the formation of the Earth's surface.[15] In Italy, for example, several important studies were carried out in the Venetian region between the 1750s and the 1770s by Giovanni Arduino (1714–1795) and by Alberto Fortis (1741–1803), as well as by the Briton John Strange (1732–1799).[16] In Tuscany similar studies were undertaken by Giovanni Targioni Tozzetti (1712–1783), on the footsteps of Pier Antonio Micheli (1679–1737), and later by Giorgio Santi (1746–1822), who travelled in the area of Monte Amiata, clearly recognized as being of volcanic origin.[17] These and other 'vulcanistic' researches were promoted in Europe by influential scientists particularly involved in mineralogy, such as the German Rudolf Erich Raspe (1737–1794), the Austrian Ignaz von Born (1742–1791) and the Swedish Johann Jakob Ferber (1743–1790), who also travelled extensively in several countries of central and southern Europe.

In Italy, Giovanni Targioni Tozzetti was one of the main authors of an interesting collection of essays, *Dei Vulcani o Monti ignivomi più noti, e distintamente del Vesuvio*.[18] This work (Fig. 4) collected papers both about extinct and active volcanoes (with the exception of Mt. Etna) being studied in Italy by various 18th century scholars: it included several writings concerning Vesuvius, but also the extinct volcanoes in Tuscany and in Veneto. It was a significant example of a growing trend among the Italian scientists interested in the "volcanic" mountains and rocks where the comparison between lithological and morfological data collected in the field around active volcanoes and similar observations made in the places of supposed extinct volcanoes became gradually indispensable.


DEI VULCANI
O MONTI IGNIVOMI
PIU' NOTI, E DISTINTAMENTE
DEL
VESUVIO
OSSERVAZIONI FISICHE
E NOTIZIE ISTORICHE
Di Uomini Insigni di varj tempi, raccolte con diligenza.
Divise in due Tomi.
TOMO I.
LIVORNO 1779.
Per Calderoni e Faina,
All' Insegna di PALLADE in Via Verrazzana. *Con Approvazione.*

FIGURE 4. Title page of Targioni Tozzetti, 1779.

Lithological and chemical observations determined the recognition of old volcanic craters, such as the Solfatara of Pozzuoli,[19] or supported the idea that ancient volcanic activity had significantly changed the local geomorphology and had often altered the rock composition of some alpine and pre-alpine areas in the north-east of Italy[20] and in the Roman region called "Campagna Romana".[21] The rocks of the "colline vulcaniche" (volcanic hills) recognized in these areas were compared, for example, with those erupted by Vesuvius or found as part of the structure of an active volcano: in fact the demonstration of a melting process undergone by certain rocks was the proof of an ancient volcanicity.

As a consequence of these researches, several scientists at the end of the 18th century thought it necessary to describe in detail all the rock material found in the volcanic areas. Besides the well known works by Barthélemy Faujas de Saint-Fond (1741–1819),[22] the *Litologia Vesuviana* by Giuseppe Gioeni (1747–1822) was an interesting attempt to classify the volcanic rocks systematically in four units.[23] During the last thirty years of the 18th century, volcanoes became the subject of specific mineralogical and lithological studies**,** while travels to active volcanoes such as Vesuvius, Mt. Etna and the Aeolian Islands were undertaken by an increasing significant number of scholars and scientists. The establishment of a new kind of specific fieldwork linked to a travelling practice focused on the Earth sciences was also a consequence of a growing awareness about the existence of "empirical evidence related to the *rates* at which various natural processes could be seen operating; […] Volcanoes provided some of the best evidence for such natural rates, and the most intensely discussed".[24] Southern Italy in particular, also with its region of ancient volcanoes (the Roman region, the Vesuvian region and some parts of Sicily) attracted several 'volcanic' travellers: among them William Hamilton (1730–1803), Déodat de Dolomieu (1750–1801) and Lazzaro Spallanzani (1729–1799) significantly contributed to establish and define the style of 'volcanic' travelling in the 1780s.[25]

FIGURE 5. William Hamilton (1755–1797).

Sir William Hamilton (Fig. 5) was a scientist, antiquarian, collector and British envoy to the court of Naples:[26] in his successful book *Observation on Mount Vesuvius, Mount Etna and other volcanos* — published for the first time in 1772, then reprinted in 1773 and 1774 — he stated that "it was to establish a system, it would be, that Mountains are produced by Volcanoes, and not Volcanoes by Moun-

FIGURE 6. Hamilton, 1774, p. 42, plate I.

FIGURE 7. View of Stromboli drawn by Pietro Fabris (in Hamilton, 1776).

tains".[27] Hamilton travelled extensively in the Vesuvian area, climbed Vesuvius over 70 times, described some eruptions (such as that of 1767) (Fig. 6), visited Mt. Etna, and explored especially that large complex of craters and fumaroles located west of Naples, called the Phlegraean fields (Monte Nuovo and Solfatara). His collection of original papers and letters addressed to the Royal Society was published in the beautiful *in folio* volume *Campi Phlegraei*, enriched by a precious volume of coloured plates (Fig. 7).[28] Hamilton also realized that the historic recorded eruptions of an active and "so very ancient" volcano, such as Vesuvius or Etna, were just a small part of a much longer history: consequently, as Martin Rudwick has pointed out, "if the volcano had been built up by a succession of eruptions similar to those recorded through the centuries of human history, its total age must be vast beyond comprehension".[29]

FIGURE 8. Déodat Gratet de Dolomieu (1750–1801)

Dolomieu (Fig. 8), well known as a great geologist of the Alps,[30] travelled for the first time in southern Italy and visited the Vesuvian region in 1776, although his travel of 1781 was more distinctively volcanological, as he climbed Mt. Etna, explored the Aeolian islands and most of Sicily, including the extinct volcanoes of the Val di Noto.[31] Dolomieu's interest in Italian volcanoes determined the enlargement of his scientific correspondence and the establishment of personal relationships with Italian scientists such as Giuseppe Gioeni, Giovanni Arduino and Alberto Fortis. Moreover, Dolomieu's studies on active and extinct volcanoes were strictly linked to his original work on the structure of mountains within the 18th century debate on the 'classification' of mountain and rocks, according to the chronology of their formation.[32] For example, in the *Voyage aux Iles de Lipari*, Dolomieu described in detail the lithology of the Sicilian mountains called "*montes Neptunei*" (Péloritani mountains) in order to show the difference between the lavas of Etna (considered a mountain with a base of schists and granits) and the Aeolian islands (regarded as built on a base of granite) because "the study of mountains which are the base of volcanoes may be very useful for the theory of subterranean fires as well as the study of volcanoes themselves, and this aspect has been too much neglected in the past".[33]

Dolomieu did not believe that the volcanic mountains were formed only by strata of superimposed lavas, as theorized by Anton Lazzaro Moro and later by William Hamilton and Lazzaro Spallanzani. According to the French scientist, these were mainly primitive mountains deformed by volcanic forces which had mixed the erupted material (i.e. porphyry) with the rocks on the surface.[34] Consequently, according to Dolomieu the volcanic activity was a very important geological phenomenon which had modified the orography made of primitive and secondary mountains, but could not be regarded as a complete orogenetic phenomenon. Moreover Dolomieu considered the action of fire as essential for the formation of basalts studied on the Italian volcanic terrains and defined as products of a cooling process in the sea-waters,[35] while some years later Spallanzani stated that the basaltic lavas could acquire the prismatic shape either because they condensed in the water or in the air: for example, some prismatic basalts observed on top of Vulcano in the Aeolian Islands were considered by Spallanzani the result of a process of cooling in the air of pieces of lava attached to the sides of a crater.[36]

Concerning the classification of volcanic products, in the *Mémoire sur les îles Ponces* (1788), Dolomieu published a *Tableau méthodique des productions de l'Etna*, according to the Linnean nomenclature, where rocks and minerals were subdivided in four classes ("productions" found during the eruptions; found during the calm periods; not modified by fire; other non volcanic products, but part of Etna's history), 12 genera, 40 species and several varieties. Finally Dolomieu stated that the quantity and complexity of Vesuvius' rock material was even greater than that from Etna. Consequently, volcanic productions were regarded in general as extremely varied and numerous, according to the different times and conditions of their formation. Moreover the volcanic activity was not considered a superficial fire, but instead a phenomenon which occurred in the deep structure of the terracqueous globe.

As Giovanni Arduino had stated some years earlier, Dolomieu believed that the combined action of fire and water was very important, if not essential, in the geological history of the Earth. Thus, at the beginning of the *Mémoire sur les volcans éteints du Val Noto en Sicile* we read that: "the two great agents of nature have worked in the mineral kingdom during the same times and in the same places in order to build the mountains; they have mixed their products and they have left certains proofs of their simultaneous action".[37]

The scientific methodology of Dolomieu, expressed through his researches on Italian volcanoes, adopted the essential elements of the late 18th century geology: the scientific travel and detailed fieldwork; the mineralogical skills and the practical knowledge of mining; the comparative study of mountains and volcanoes: "the study of mountains can spread more light on volcanoes, and the volcanoes themselves can be of great help for knowing the materials which are abundant in the center of the Earth. The excavations made by man for the exploitation of minerals are only small scratches on the surface of the globe and cannot be compared with the enormous cavities made by volcanoes".[38] The perception of the great complexity, number and variety of geological phenomena had moved Dolomieu away from the general theories of the Earth. He searched for the solution to the geological problems through travelling. This is the reason why, instead of referring to general theoretical models, he constantly introduced questions about problems that emerged from the fieldwork.

FIGURE 9. Johann Wolfgang Goethe (1749–1832).

FIGURE 10. Johann Wolfgang Goethe, The eruption of Vesuvius in 1787 (watercolour: Schloss-Museum, Weimar).

The same careful attitude toward the theoretical 'systems' in geology was adopted by a different kind of scholar, but also scientist and traveller, such as Johann Wolfgang Goethe (1749–1832) (Fig. 9). In the *Italienische Reise*, the diary of the long Italian Journey undertaken between September 1786 and April 1788, published in two stages in 1817 and 1829, the observations on volcanoes and volcanic terrains throughout Italy, did not determine a substantial change in Goethe's neptunistic views and instead confirmed his idea that volcanoes were local phenomena whose fire was not linked to a common igneous source within the earth.[39] However, if, while exploring the Vesuvian area and climbing Vesuvius (Fig. 10) while in eruption, he had stated his familiarity with the rock-types (lava) observed at the flanks of the volcano, when in Sicily, he examined the remains of the 1669 lava flow of Mount Etna and noted that "remembering what passions had been aroused before I left Germany by the dispute over the volcanic nature of basalt, I chipped off a piece: it is a piece coming from a fusion without any doubt".[40]

Concerning the remains of extinct volcanoes, the Venetian area was only briefly mentioned by Goethe, who instead dedicated some pages to the "volcanic hills", "volcanic terrains" and "volcanic tufa" of the region of Rome, at that time less known and little investigated also by the Italian geologists. Compared to the Apennines, "these volcanic areas [near Rome] lie much lower, and it is only the water tearing across them which has carved them into extremely pictoresque shapes, overhanging cliffs and other accidental features".[41] In his Italian Journey, as well as in other scientific writings, Goethe often preferred to adopt a careful attitude of collecting and evaluating geological data, more than attempting general statements: on the other hand, he believed that in the history of naturalistic research, many observers had moved too quickly from the single phenomenon to the theory, which had often become insufficient and too hypothetical.

The most significant results of Lazzaro Spallanzani's (Fig. 11) geological researches were included in the *Viaggi alle Due Sicilie e in alcune parti dell'Appennino*, printed in Pavia from 1792 to 1797.[42] This impressive work in six volumes contains the reports of several travels in southern Italy and in the northern Apennines during the summer and autumn of the years 1788, 1789 and 1790. The entire second volume (1792) and about half of the third (1793) were devoted to the analysis of the geological and volcanological feautures of Lipari, Stromboli, Vulcano and other parts of the Aeolian Islands.[43] The reports on Mount Etna, Vesuvius and the Vesuvian area of Campi Flegrei were confined to the first volume (1792). The *Viaggi* soon also became available to non-Italian readers through various translations into French, German and English.[44]

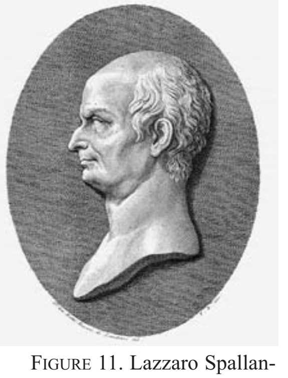

FIGURE 11. Lazzaro Spallanzani (1729-1799)

The first of these travels started in June 1788. During the following months Spallanzani paid particular attention to volcanic phenomena, as he had the possibility to observe Vesuvius and the Vesuvian area directly, to climb Mount Etna, and to study in detail the Aeolian Islands. Volcanoes are a constant presence in the first four volumes of the *Viaggi*, which contain all the geological observations carried out in southern Italy. Spallanzani himself had called this travel a "vulcanico viaggio" (volcanic journey) although its official purpose was to collect volcanic specimens for the Museum of Natural History of the University of Pavia.[45] In reality, Spallanzani's travel was also undertaken for pure research purposes, as demonstrated by his method of research in three successive stages, clearly inspired by Dolomieu's style of scientific travelling. Spallanzani's method included firstly the collection of information about previous literature on the subject of study; then a series of long, repeated and detailed observations in the field, with the compilation of lists of specimens; and finally several chemical experiments and analysis in the laboratory on the specimens collected (especially on the fusion of lavas or other volcanic rocks, also using glass furnaces). There is however a substantial difference between Spallanzani's and Dolomieu's views, as the latter did not believe it possible to recreate in the laboratory the real temperatures and the real conditions of a volcanic fusion because "we do not have any measure in order to know the degree of the fire we want to reproduce; its original intensity and activity is influenced by an infinity of circumstances which we cannot calculate".[46]

The content of the *Viaggi* shows Spallanzani's methodological approach in the vivid descriptions of the volcanic phenomena, in the detailed analyses of the observed lithological features, and in the reports of the experiments consequent to the travels made in the laboratories in Pavia, especially for determining the nature of lavas and the processes of melting and vitrification ("vetrificazione"). In fact, according to Spallanzani, the naturalist involved in the study of the rocks also needed an excellent chemical knowledge, because "the natural history of fossils[47] is so closely connected with modern chemistry, and the rapid and prodigious progress of the one so exactly keeps pace with that of the other, that we cannot separate them without great injury to both».[48]

Spallanzani was particularly interested in the geological and lithological structure of volcanoes. In the Introduction of the *Viaggi* he clearly stated the aim to study the volcanoes as mountains were generally studied by the "careful lithologists", that is to say with the investigation of the rock masses, including the position and the direction of the strata. This 'lithological' approach determined the insertion of many detailed descriptions of different kinds of rock and mineral specimens, as long digressions which often interrupted the main narration. For this reason Spallanzani was conscious that his *Viaggi* could not have been easy to read: nevertheless, he pointed out the need of the "circumstantial descriptions, which, in fact, form the basis of all solid science",[49] because the previous literature on the volcanic areas of southern Italy had rarely provided systematic lithological and mineralogical analyses. Moreover, Spallanzani considered both the exploration of the craters at the top of the volcanoes and the observation of the coastal features of the islands, where the erosion by the sea could have uncovered the internal lithological structure of the volcanic mountains, to be of equal importance.

According to Spallanzani, the orientation of the Aeolian Islands, in a straight line from east to west, showed a typical direction of the volcanic mountains, already noted for example in the little islands raised from the sea after the eruption of Santorini in 1707 or in the line of volcanic hills, which appeared during the eruption of Vesuvius in 1760. In this matter Spallanzani was probably also influenced by Dolomieu's hypothesis on a subterranean link between the volcanoes of the Aeolian Islands, Vesuvius, and Etna, as well as Dolomieu's interpretation that the volcanic arc of the islands near Ponza (with Ischia and Procida) was the connection between the region of active volcanism (Vesuvius and Campi Flegrei) and the region of the extinct volcanoes near Rome.[50] Consequently, the Italian scientist suggested that all the Aeolian Islands were probably raised contemporaneously from the sea and not in different ages.

Furthermore, the researches made in the Aeolian Islands confirmed Spallanzani's theory that the fire of volcanoes was probably caused by an enormous quantity of underground sulphur ("sulfuri di ferro") that was ignited by the presence of oxygen ("gaz ossigeno"); these investigations also contributed to reinforcing his conviction that volcanoes had gradually grown eruption after eruption until they became large mountains made of strata, such as Vesuvius or Etna (Fig. 12). Spallanzani concluded that "this certainly is the structure [origin] of almost all volcanic mountains. Their beginning is but small, and proportionate to the quantity of the first eruption; but as the succeeding eruptions increase in number and extent, they augment in size and solidity, till in time they acquire considerable dimensions".[51]

FIGURE 12. The main crater of Mt. Etna (in Spallanzani, 1792–97, vol. 1, plate II)

With the writings by Dolomieu and Spallanzani, the urgency of a new method of travelling and observing the volcanic terrains in the field in a different way from other mountain areas, became definitively evident to the scientific community of the late 18th century. It is therefore significant that in his famous *Agenda* of instructions for making geological observations in the field, the Swiss scientist Horace Bénédict de Saussure (1740–1799), dedicated a full chapter to the study of volcanoes, where he recalled the difference between observations made during an eruption, on dormant and on possible extinct volcanoes.[52] Better known as an alpine traveller and geologist, Saussure had also travelled in the volcanic regions of southern Italy during the years 1772–73, while Hamilton was studying the Vesuvian area.[53]

At the turn of the century, within the geological controversy between Neptunists and Plutonists, not only new significant geochemical and lithological researches emerged,[54] but also the results of the 'volcanic' travels in the Mediterranean region had a great impact. The development of Italian geology and volcanology, for example, benefited greatly from the debate between Vulcanists and Neptunists or "Wernerians" at least up to the 1830s.[55] In the early decades of the 19th century, some former students of Werner at the Mining Academy of Freiberg such as Leopold von Buch, Alexander von Humboldt (1769–1859) and Jean-François d'Aubuisson de Voisins (1769–1841), as well as other less known European geologists, after some travels through the volcanic regions of southern Europe and South America began to revise their Wernerian ideas and accepted vulcanistic views that were more similar to those of the Plutonists.[56]

The 18th century heritage was recovered, discussed and analyzed in the light of the new theoretical positions on the study of volcanoes. New fieldwork was stimulated, mainly by the need to verify the range of applications of the emerging science of geology. When Charles Lyell (1797–1875) visited Mount Etna in 1828,[57] the 'volcanic travel' was certainly considered an indispensable part of the scientific study of the Earth's surface, but it was also becoming a significant tool for evaluating the great question of geological time.

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NOTES

1 Morello, 1998a.

2 On the wide literature on this topic, between the 17th and 19th century, see Ashworth, 2004.

3 Sigurdsson, 1999:21–50.

4 Kircher, 1664–65.

5 On Kircher's *Mundus Subterraneus*, see Morello, 2001 and Nummedal, 2001.

6 See in particular Bulifon, 1701; Sorrentino, 1734; Della Torre, 1768, De Bottis, 1786; Recupero, 1815; Gemmellaro, 1858; Palmieri, 1880. More references in Cerbai & Principe, 1996.

7 Borelli, 1670 (also published, with Italian translation and notes by N. Morello, in Borelli, 2001). For a complete analysis of this work, see Morello, 1998b.

8 Gimma, 1730. On this Italian scholar, see Vasoli, 1970.

9 Moro, 1740. On Moro, see Baldini et al., 1988.

10 See in particular Goree, 1711.

11 Winchilsea, 1669. On this author see Dean, 1998:105–107.

12 Ellenberger, 1994:218–245: on Desmarest see also Taylor, 1969, and Rudwick, 2005:203–214. On the geological travellers in Auvergne during the second half of the 18th century, see Taylor, 2007.

13 On this debate, see Den Tex, 1996.

14 Ellenberger, 1994:265–267.

15 This interpretation has been proposed by Taylor, 1998.

16 On these scientists, see Vaccari, 1993 and Ciancio, 1995.

17 Targioni Tozzetti, 1768–79; Santi, 1795: on Targioni Tozzetti, see Arrigoni, 1987.

18 See his paper in Targioni Tozzetti, 1779.

19 Ferber, 1773.

20 Arduino, 1775, 1792 and Fortis, 1765.

21 Breislak, 1786.

22 See in particular Faujas de Saint-Fond, 1778, 1784.

23 Gioeni, 1790.

24 Rudwick, 2005:118–119. Rudwick also well defines the importance of "firsthand outdoor fieldwork" for the late 18th century geologists (see pages 41–44).

25 Principe, 1999.

26 On this scholar see Fothergill, 1969; Sleep, 1969 and Knight, 1990.

27 Hamilton, 1774:161.

28 Hamilton, 1776; 1779: on this work see Moore, 1994. On Hamilton's ideas on Vesuvius and Etna, see Rudwick, 2005:119–122.

29 Rudwick, 2005:120–121.

30 Besides the classic biography by Lacroix, 1921, see the recent studies by Zanzi, 2003; Gaudant, 2005; Rudwick, 2005:317–325.

31 See Dolomieu, 1783, 1784a, 1784b, 1785a and 1785b. Dolomieu's unpublished notes on this travel have been studied by Lacroix, 1918. On Dolomieu's studies of Italian volcanoes, see Vaccari, 2005a.

32 On this subject see Vaccari, 2006.

33 Dolomieu, 1783:127. "L'étude des montagnes sur la base desquelles reposent les volcans, peut instruire le

Naturaliste sur la théorie des feux souterrains, autant que l'étude des volcans eux-mêmes; ce point de vue a été trop negligé jusqu'à present."

[34] Dolomieu, 1783:130.

[35] Dolomieu 1790:198.

[36] Spallanzani, 1792–97: vol. 2, 192; vol. 3, 182–192.

[37] Dolomieu 1784:191. "Les deux grands agents de la Nature dans le règne minéral y ont travaillé dans le même temps et dans les mêmes lieux à la formation des montagnes; ils ont melé leurs produits et y ont laissé des preuves certaines de leur action simultanée."

[38] Dolomieu, 1783:130–131. "Mais l'étude des montagnes peut répandre beaucoup de lumières sur les volcans, les volcans eux-mêmes peuvent être d'un très-grand secours pour connoître les matières qui se trouvent les plus abondamment dans le centre de la terre. Les excavations et les approfondissemens que les hommes font pour l'extraction des minéraux, ne sont que des égratignures sur la surface du globe, lorsqu'on les compare aux cavités immenses qu'ont formées les volcans, en élevant des masses aussi enormes que le sont les montagnes qu'ils ont produites".

[39] On Goethe's geological studies see Vaccari, 2005b and Hamm, 1991.

[40] Goethe, 1947:158. "Ich schlug ein unbezweifeltes Stück des Geschmolzenen herunter, bedekend, dass vor meiner Abreise aus Deutschland schon der Streit über die Vulkanität der Basalte sich entzündet hatte".

[41] Goethe, 1947:137. "Die vulkanischen Strecken sind viel niedriger als die Apenninen und nur das durch-reisende Wasser hat sie zu Bergen und Felsen gemacht; da sind aber schöne gegenstände, überhägende Klippen".

[42] Spallanzani,1792–97: now reprinted in Spallanzani, 2006–07. On Spallanzani's geological studies, see Vaccari, 1999, 2000.

[43] Vaccari, 1998a.

[44] See the English translation in Spallanzani, 1798.

[45] Spallanzani, 1792–97, vol. 1:XI–XII.

[46] Dolomieu, 1783:127–128. "Nous n'avons aucune mesure pour connoître le degré du feu que nous employons; son intensité et son activité tiennent à une infinité de circonstances que nous ne pouvons calculer".

[47] At the end of the 18th century this term were still used for indicating all the inorganic objects which were found within the Earth's surface.

[48] Spallanzani, 1798, vol. 1:XXV, translation of Spallanzani, 1792–97, vol. 1:XXXI: "la Storia naturale dei Fossili è sì strettamente legata alla Chimica d'oggigiorno, e i rapidi e prodigiosi avvanzamenti dell'una camminano sì del pari, e sì concordemente cospirano con quelli dell'altra, che separar non possiamo la prima dalla seconda senza notabile danno di entrambe".

[49] Spallanzani, 1798, vol. 1:XVII, translation of Spallanzani, 1792–97, vol. 1:XX–XXII: "particolarizzate descrizioni, le quali infine formano la base d'ogni solido sapere".

[50] Dolomieu, 1783:139–141: *Communication des volcans de Lipari avec l'Ethna et le Vésuve*.

[51] Spallanzani, 1798, vol. 2:152, translation of Spallanzani, 1792–97, vol. 2:137–138: "Questa certamente è la genesi di quasi tutti i Monti vulcanici. Da principio sono tenue cosa, proporzionati cioè alla mole della prima eruzione. In ragione poi del numero, e dell'estensione di queste, si aumentan di massa e di volume, e a capo di tempo aquistano considerabile ampiezza". It must be noted that the Italian word "genesi" (genesis, birth, origin) has been not properly translated in English with the word "structure".

[52] Saussure, 1796: § 2322. On this work and its role for the development of the geological travel, see Vaccari, 2007:10–12. On Saussure, see Sigrist, 2001.

[53] Saussure, 1776.

[54] As demonstrated by Fritscher, 1991.

[55] See Vaccari, 1998b, 2003.

[56] Greene, 1982:62–68. See also the case of the Italian Giambattista Brocchi, analyzed in Ciancio, 1998.

[57] Rudwick, 1969.