ANNALI DI GEOFISICA, VOL. 41, N. 4, October 1998

Some considerations on the state of Vesuvius in the Middle Ages and the precursors of the 1631 eruption

Antonio Nazzaro
Osservatorio Vesuviano, Ercolano, Napoli, Italy

Abstract
The volcanologic literature concerning Vesuvius and its activity, since the great eruption of 1631, is particularly abundant and helpful in order to investigate topics of remarkable interest on the eruptive history of the Neapolitan volcano. One of these topics relates to the precursory phenomena of the eruption of 1631. This problem it is of great importance for a better knowledge of the eruptive trends of the volcano since the 1631 eruption is the reference for any Civil Defence plan regarding the Vesuvius volcano. In addition, knowledge of the medieval activity of Vesuvius is important because it furnishes useful data for research into some unfamiliar aspects of the volcano's history, *e.g.*, the existence of a 1500 eruption and consequently the duration of the inactivity period before 1631. It is generally assumed that the precursors of this eruption occurred less than one month before its beginning. In particular, the earthquakes would have come about 10 days before the eruption. Moreover a soil uplift is reported about 20 days beforehand. On the basis of a careful analysis of some important sources, books and manuscripts, we will see that the outline of the phenomena was much more complex.

Key words *Vesuvius 1631 eruption – precursors of eruptions – medieval activity*

1. General considerations on the precursors of the 1631 Vesuvius eruption

Volcanic eruptions are generally preceded by a succession of phenomena which are connected by complicated relations. The records, study and, especially, the interpretation of precursory phenomena of eruptions form an important field of research. They suppose a good knowledge of geology and volcano structure, the characteristics of its magma, its eruptive mechanism and, finally, an accurate and reliable historical study of its eruptions (Swanson *et al.*, 1985; Scandone and Gasparini, 1994; Tilling, 1995).

In geology, we generally talk of Precursory Phenomena (PP) when considering a cluster of events in which it is possible to identify a sequence characterized by obvious genetic, geographical, and chronological relations, in comparison with an event of a very high energy which we call *catastrophic* or *main event*, which usually ends the sequence. In this case, it is possible to attribute a value of prediction to the former weaker events in comparison with the main event. This attribution can be based on historical memory and experience both of which are particularly important for Vesuvius. Modern research moreover tries not only to identify the PP, but, chiefly, to fix the quantitative relations that connect them to the

Mailing address: Dr. Antonio Nazzaro, Osservatorio Vesuviano, 80056 Ercolano, Napoli, Italy; e-mail: nazzaro@osve.unina.it

catastrophic phenomenon they related to. It is evident that the study of relations between precursory and the highest energy phenomenon makes the value of prediction more reliable. The primary purpose is to determine *a priori* the chronological relation between PP and a possible catastrophic event. This can be helpful in order to distinguish the PP that greatly anticipate the main phenomenon (called *long term PP*, like for example the Pompei earthquake of 63 A.D. in connection with the 79 A.D. Vesuvius plinian eruption) from *short term* precursors that slightly anticipate the eruptive events when the volcano is in a state of open conduit.

A practical aim of this studies is to be able to start a sort of countdown through a sequence of natural events, becoming more and more violent and numerous, which ultimately lead to the catastrophic event. Therefore, it is important to reckon the *point of no return*, that is the moment the PP fade into the main event and mingle with the phenomena that join it (Fournier d'Albe, 1979).

In the case of the PP of the 1631 Vesuvius eruption, it is opportune to outline some general considerations. First of all, the precursors are usually quoted only *post eventum*; moreover we realize that the impressiveness of the catastrophic phenomenon often dominates nearly all the information, with scant references to the PP. There are references only to the ones nearest to the *main event*, when they become one and the same thing. In other words, the stress put on the dramatic event can monopolize all narration. Hence it is possible that the historical records (Riccio, 1889) would ignore the PP because too weak or remote in the past or, also, because people were not able to realize any connection between these phenomena and the one that would have been afterwards identified as a catastrophic phenomenon.

Many of these difficulties can be overcome expanding research into historical records concerning not necessarily the main event. Research into the PP of Vesuvius' ancient eruptive events, like the 1631 eruption requires a study of archive documents dealing with public or private works, indemnity or finance measures, harbors and road works, industrial mining, handicrafts, agricultural activities on Vesuvius' territory, canalization works, waterworks and their maintenance, and so on. The great difference between conditions of life in past times compared with the present, the different relation we have with the territory, the great development of techniques and the possibility to record even the smallest phenomena with sophisticated instruments, are all elements to bear in mind when researching the precursors of this eruption. We also have to stress that, contrary to what happens today, at that time possible signs of eruptions tended to be underestimated in order to avoid the abandonment of countryside and the fall in productivity of important agricultural and pastoral activities, with the consequent famine risk. Another important difference is that the earthquakes recorded by literature were obviously only those once felt by people, so they were of considerable intensity. In addition to earthquakes, the variations of sea level were also deemed PP – in the past people thought the sea penetrated into caverns under the volcano, triggering the eruption (Nazzaro, 1995) – as well as variations of water level inside wells (De Bottis, 1786; Guarini *et al.*, 1855).

We relate some quotations on the subject:

«So that earthquakes always precede the eruptions or, at least, they usually follow them.» (Mecatti, 1761).

«Earthquakes always precede big eruptions.» (Monticelli, 1841).

The meaning of prediction attached to earthquakes had been well known for sometime, and this is why two scholars, Ascanio Filomarino in 1795 and Luigi Palmieri in 1856, invented and constructed their seismographs (Nazzaro and Tramma, 1985). They write that:

«I gave the description of this machine so that in the Capital, as well as in the villages close to the volcano, they will use it together with a precise atmospheric electrometer. Examining the earthquakes in concert with the outer signs of volcano it is possible, at times, if not to foresee clearly a new eruption at least to presume it.» (Filomarino, 1797).

«I believe that the seismograph set in the area corresponding to the earthquake focus, ought to act like a seismograph close to a volcano. As the former forebode the fires, the latter, maybe, could give the signs of a great earthquake showing the small agitation of soil that precedes the big shocks.» (Palmieri, 1873).

It is to be noted that from 1856, Luigi Palmieri began to record and study volcano earthquakes at the Osservatorio Vesuviano by means of his seismograph (Nazzaro and Tramma, 1985).

«When Vesuvius was about to burn, at 10 o'clock, along the sea coast of Naples, the sea water withdrawn for the length of a stone throw, so that the Neapolitans who were there caught the fish run a ground.» (Sorrentino, 1734).

«On the 17th of May, somebody told me that all along the marina of Arso at Torre Annunziata, the sea suddenly withdrawn for about 15-20 steps; after a few minutes the pristine level impetuously came back.» (Monticelli, 1841).

King Charles of Bourbon in 1740 had two tide gauges installed along the gulf coast (at Granatello and Darsena) in order to measure the variations of sea level connected with eruptions. The first scholar to show that it was not the sea which subsided, but the soil which was raised, was Luigi Palmieri (Palmieri *et al.*, 1862), who calculated this uplift during the 1861 Vesuvius eccentric eruption. The studies on Pozzuoli bradyseismic phenomena witnessed by the columns of the celebrated Serapis Temple, had already demolished the old Aristotelian concept of *terra firma*; in any case, it was Palmieri who first related the folding of soil to a volcanic eruption (Nazzaro, 1997).

Finally research on precursory phenomena must consider a kind of *factor of conversion* between today's precursors and the ones connected with a past event, that allows for the respective technological, cultural and economic context, so that these PP can be compared and have the same predictive meaning.

2. An outline of Vesuvius' morphology and activity during the Middle Ages and the problem of the 1500 eruption

It is generally assumed that the eruption of 1631 had occurred after a long period of inactivity. In particular, some scholars think that a previous eruption was in 1139, and afterwards the volcano had no activity. Besides recent authors (Rolandi *et al.*, 1993; Rosi *et al.*, 1993; Scandone *et al.*, 1993), others (Braccini, 1632; Volpe, 1632; Bulifon, 1701) also suggest 1139 as the year of a former eruption. This does not mean, of course, that during the interval Vesuvius had been completely inactive, at least for a certain period of time. As matter of fact, some evidence vouched that Vesuvius remained with an open conduit for a certain period and eruptions of comparatively less energy occurred, at least till the beginning of the 14th century (Alfano, 1924). Moreover, it is not possible to exclude that in this period a strong eccentric eruption occurred, as represented unequivocally in a painting of the time (fig. 1).

A useful guiding principle to tackle these still not very well known aspects of the eruptive history of Vesuvius, can be the study of the volcano's morphology before the 1631 eruption considering that the shape and activity of the volcano are intimately and reciprocally linked.

On the shape of Vesuvius around 79 A.D. (von Buch, 1836; Palmieri, 1879; Mercalli, 1883; Cocchia, 1901; Catalano, 1975; Scherillo, 1982), we think that, when inside Mt. Somma caldera the big central cone (*Great Cone)* of Vesuvius did not exist, as it was before (von Buch, 1836; Palmieri, 1880; Mercalli, 1883) and immediately after the 79 A.D. eruption (Nazzaro, 1997), it is obvious that the term *crater* could not indicate the structure on the top of the Vesuvius central cone. Therefore we must infer that ancient authors like Strabo (63 B.C-19 A.D.) are actually referring to the Somma caldera when described the crater of the volcano.

«Above this locality Mount Vesuvius stretches. It is entirely occupied by beautiful fields, except for the

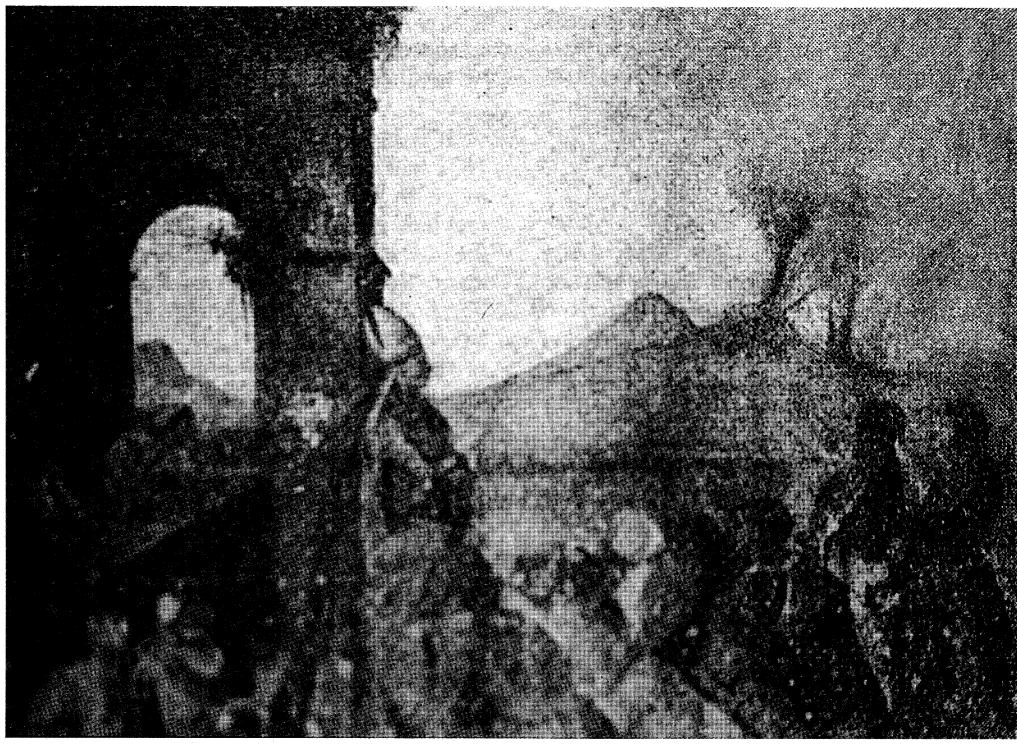

Fig. 1. Fresco of 15th or beginning of 16th century, in the arcade court of the Church of Saint Gennaro Extramoenia in Naples. Today it is no longer visible, but Alfano (1924) luckily published this very important photograph of it. It represents a very evident eccentric eruption of the volcano by vents in the southern area.

top. The top itself is almost completely flat, but it is quite barren, the land having a cinereous appearance; there are cracked cavities, opening on rocks sooty as if consumed by fire. We could suppose that this place previously burnt, and later its fire craters died out as the material burnt completely.» (Strabo, Geography, V, 4, 8).

Subsequently the big central cone was formed with its crater on the top and consequently the crater of Strabo, that is the caldera of Somma, was reduced to the so-called Atrio, becoming in that way an anular surface surrounding the big central cone. As a consequence, the morphological evolution of Vesuvius in more than 1500 years, from the times of Strabo until 1631, made the meaning of the term crater ambiguous. This may be why the authors of 16th and 17th centuries misinterpreted the passage written by Strabo, which describes Vesuvius as before 79 A.D. They in fact wrongly thought that, when Strabo wrote about the crater, he referred to the crater existing on the top of the big central cone present in their times, *i.e.* in 16th or 17th centuries. I think that the medieval large central cone could not have formed as a consequence of the 79 A.D. eruption, both for its presumable stratovolcanic structure, and for the eruptive mechanisms, as well as the very violent explosions of the same one. If the medieval central cone was formed after 79 A.D., then it was almost certainly destroyed by the 472 very strong eruption (Pollena eruption; Rosi and Santacroce, 1983) whose huge amounts of lahar and pyroclastic flows observed in the geologi-

cal section give us the certainty of its destructive and catastrophic effects on a possible central cone. It is to be added that, if Saint Gennaro's image kept in the Catacombs of Naples really depicts a 6th century Great Cone of Vesuvius (Fasola, 1975), probably the unknown artist's memory retained the recollection of a double-headed possible form of the volcano existing before 472. Therefore, owing to the activity corresponding to the powerful thickness of strombolian scoriae observed in geological sections above the products of the 472 eruption, as well as the imposing lava effusion of the 10th and 11th centuries, we think that the formation of the large central cone existing before 1631 (fig. 3) dates back to around the 11th century. It is difficult to be more precise, as Vesuvius' activity between 79 and 1631 is not well known (Alfano, 1924; Figliuolo and Marturano, 1997). From a stratigraphic point of view, this activity is proved by pyroclastic products, layers of strombolian scoriae, lava fountains possibly caused by the great eruptions of 685 and 787; but also by lava flows, observed in particular on the western coast of the volcano and southward (*Villa Inglese* and *Pozzelle* quarries) connected with the southern cut of the caldera (Nazzaro, 1997). Finally, the large central cone (Great Cone) which we see nowadays is not the one that existed before 1631. Indeed, only recently has it been demonstrated that the 1631 eruption lowered the volcano more than 450 m (Nazzaro, 1985, 1989), causing the destruction of the former Great Cone, that is a much more significant lowering of the volcano than the ones considered of 168 m (Imbò, 1984) or 211 m (Santacroce, 1987). As a consequence, it is estimated that between 1631 and 1944 the volcano erupted about 5 km^3 of eruptive materials inside Somma caldera, corresponding to an average eruptive rate of $16 \cdot 10^6$ of m^3 a year (Nazzaro, 1989, 1997).

2.1. *1500 eruption*

We shall see that these arguments are useful with regard to the question of the 1500 Vesuvius eruption. The main source of this eruptive event is represented by work of Ambrogio Leone (1514), who writes about an eruption which for three days darkened the air and caused a rain of reddish ashes:

«We have been seeing the air very dark for three days until everybody, amazed, started tremble. When the eruptive violence finished, covering everywhere with material thrown out by the volcano, then it rained reddish ashes very abundantly; it seemed that every thing was covered by a slender snow. The fire is not burned out completely; in fact on the top of the mountain they excavated hollows into the rocks to produce vaporization, so that in the month of August many sick persons can have their articulation diseases healed by means of plentiful exudations.». (A. Leone, 1514).

This testimony is strengthened by the account of a certain Gonzalo Hernandez de Oviedo y Valdes (1532) who ascended Vesuvius in 1501 and found a vent of about 9 m of diameter from which flowed out a continuous shining jet of smoke:

«I ascended Vesuvius and I saw there a hole of about 25-30 spans of diameter from which smoke came out (...). Some people claim that this smoke, that you can see in the daylight, during the night becomes a very bright flame.» (in Gasparini and Musella, 1991).

This is credited also by many writers like Roth (1857) and Riccio (1889). In addition, this eruption is believed possible by Alfano (1924) on the basis of the several historical records he checked. Henry Stephen Washington too, the famous American petrographer, published in 1918 an extraordinary ichonographic document which probably represents the eruption on the back of a medal dating back to the beginning of the 16th century (fig. 2).

The 1500 eruption could not have been very strong, and it consisted of one or more phreatic explosions with vulcanian – type phases. It must be considered a very important one, because it can be explained as caused by magma which tried to rise again through the eruptive conduit after a long period of quiescence. After 131 years, this ascent would lead to a dreadful eruption, preceded by a long period of hyper-

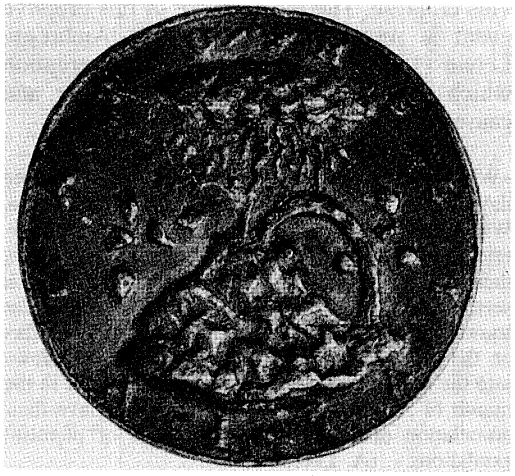

Fig. 2. Probable representation of the 1500 Vesuvius eruption in an early XVI century medal according to Henry Stephen Washington (Washington, 1918).

thermicity in the area of the big central cone and a sequence of important PP. This eruption has not left any stratigraphic deposits, may be because they were so thin as to be eliminated by lahar and post eruptive rains, apart from the intense farming of the inhabitants of the area.

This eruption nevertheless is doubted by some:

1) The testimony of Ambrogio Leone would be unfounded, as he was in Venice in 1507 and it is likely he had been there in 1500 also, then could not be considered a reliable eye witness. It is a very weak objection, in contrast with the authority of Leone. Furthermore in a manuscript of a certain Passero, a chronicler, who describes the events that occurred in that region, there is no mention of the eruption. But he wrote of great rains and floods which could be connected with the eruptive event (Alfano, 1924).

2) Some think that in 1500 no eruption occurred following an opinion, going back to Giulio Cesare Braccini (1632), based on his interpretation of Pighio's excerpt concerning the presence of big trees inside the crater.

«The edge of the crater, which looks like an amphitheater, *there is plenty of firs and big trees* growing gorgeously along the slopes as far as sun heat and rains can reach.» (Pighio, 1587; italics are mine).

But we believe that really Pighio referred to the caldera of Somma, that is the Atrio of its times. As a matter of fact, if we admit the semantic sliding crater-caldera, this objection has no reason to exist. In this case, the verdant crater the author mentions is actually the Somma caldera or, rather, what remained of it, *i.e.* the Atrio: it was not the crater of Pighio's time but the one of Strabo, Floro and Procopius, who were considered models, according to a widespread rhetorical canon. Consequently, it was the Atrio which was verdant with high trees, haunted by shepherds, hunters, woodcutters, druggists picking simple, pilgrims, students and people who went to the *sudatorium* to recover their health (Bacci, 1571; Braccini, 1632; Eliseo, 1634).

My interpretation, founded on the likeness between the Strabo crater and Atrio, is enhanced by the apparent contradiction of Braccini himself when he clearly makes reference to a crater of the large central cone being almost impracticable. In fact he writes of a certain Giovanni Domenico Magliocco who descended into the crater in 1619 after having been encouraged by some monks of Camaldoli who accompanied him, and it is strange you need to be encouraged to walk along a path that was commonly used by people. In another passage, Braccini mention an analogous episode, when he writes that 20 years before he himself ascended the top of Vesuvius, but he did not want to descend into it, although his guide told him that it was possible. Once again, we see a place not very attractive for woodcutters, shepherds and pilgrims. Other authors also clearly allude to the inaccessibility of the crater.

«The fire was so great that the mountain itself lowered and reduced to ashes (...) *in the past having been inaccessible, because of its height, even to the animals*». (Oliva, 1632; italics are mine).

On the other hand, in the pictures of the time

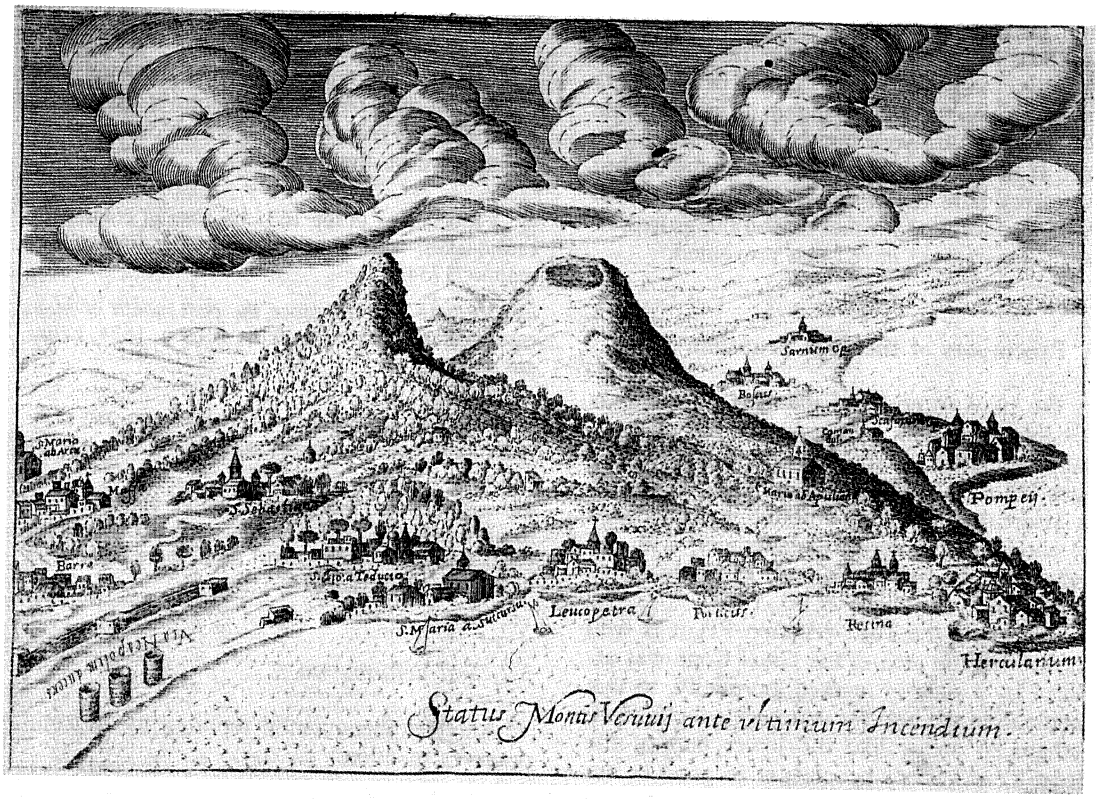

Fig. 3. Vesuvius volcano before the 1631 eruption (Masculo, 1633). We can see the whole Great Cone and crater rim completely devoid of trees.

depicting Vesuvius, the large central cone (Great Cone), on the contrary, appears absolutely without any vegetation (*in vertice nudatus*, De Arminio, 1632). There grew rare herbs and some bushes of broom or rare saplings, pasture for agile flocks * (fig. 3).

These considerations can help to clarify another question concerning Vesuvius' medieval lava. According to careful reconstructions of the 1631 event both from stratigraphic and historical points of view (Santacroce, 1987; Nazzaro, 1989), there were no discharges of lava flows: as a consequence, the lava flows previously considered to be erupted during this eruption (Le Hon, 1865; Scacchi, 1883; Burri and Girolamo, 1975; Imbò, 1984; Rolandi *et al.*, 1993) were actually ejected during the Middle Ages.

What we have depicted agrees much better with the environmental situation represented by Atrio with the bottom made up of ashes, lapilli and other pyroclastic materials. This would explain the presence of secular vegeta-

* As Giovan Battista Marino (1569-1625) wrote: «Even if I, a shepherd, am not so excellent, may condition is not, anyway, derelict. I have got so many sheep that the top of Vesuviu's seems white like snow: they are so prolific that, as good mothers, they carry with pain their own heavy weight: twice a day I milk them, and yet, their breast is full of milk».

tion present inside the volcano, otherwise in contrast with continuous lava flows. Consequently, the lava flows erupted before 1631 most probably were emitted from parasitic vents formed on very low sides of volcano. In fact, if those lavas were erupted by the central vent very hard rocks should have covered the Atrio surface, and for that reason the growth of large trees would have been prevented.

3. Precursors of the 1631 eruption

We have to consider the 1500 eruption as possible important symptom of the changed thermodynamic conditions, which later would have led to the 1631 great eruption. It is hard to assert that the 1631 eruption was preceded by about five centuries of inactivity, with the exception of 10-15 days of PP only (Rosi *et al.*, 1993; Scandone *et al.*, 1993).

Regarding the 1631 eruption PP, it is well known that the area of the Great Cone was affected by a state of marked thermicity, so that people used the heat for therapeutical purposes, perhaps in areas, like the lower part of the Great Cone, where people not in good health could easily go. Among the many authors who mention this fact, we quote here Bacci's words:

«In some places the heat comes out of fractures; here the people who live in the Vesuvius area dig holes in order to make exudations to heal affections like bronchitis, swellings, trembles, pouldagras and so on.» (Bacci, 1571).

As we know, Giulio Cesare Braccini reports that, before the eruption, on the bottom of the crater there were three little pools of hot and mineral water: this is also a very significant condition whose precursory meaning has already been pointed out (Gasparini and Musella, 1991).

We also recall the lowering of water into the wells and its turbidity at the end of November of that year and the fact that some eastern hotsprings started to warm a few months before the eruption (Varone, 1634).

Now I shall discuss seismicity and the observation of anomalous phenomena connected with soil deformation.

3.1. *Earthquakes*

First of all, contrary to what is usually reported on the basis of Braccini's chronicle, some sources record seisms which occurred six months before the event.

«(...) It occurred in the 1631 because of continuous earthquakes, six months before the fire.» (Sorrentino, 1734).

«In Vesuvio caverns, since *the past month of May*, earthquakes started to be felt.» (Eliseo, 1634; italics are mine).

Also the appearance of snakes we can consider connected to earthquakes:

«It was remarked that the time before vintage, at the locality called Li Galliti in Francesco Buon Groanne (who was called delli Quint) farm, there came a lot of snakes.» (Viola, 1649).

3.2. *Soil deformation*

Another phenomenon reported by Braccini deserves mention:

«A trustworthy person from Ottaviano told me that one month ago he ascended the mountain at the mouth of the Abyss. He let himself down the Abyss, and so he did once again 15 days later. He found the soil had risen so much that he could pass from one side to another without going down.» (Braccini, 1632).

Recupito also relates that the crater (*vorago*) was obstructed and its edges seemed rejoined.

«Few days before the eruption, the crater abyss was obstructed by rocks. All the hunters told us that on the top of the mountain everything was flat.» (Recupito, 1632).

These testimonies are important because they reveal another classic precursory phenomenon of eruptions, *i.e.* soil deformation. The same testimonies are commonly explained (Rosi *et al.*, 1993; Gasparini, 1995) in the sense that magma which is about to erupt is

pushed upward the bottom of the crater, allowing the passage from one side of the crater to the other. Or else, the magma itself had filled the crater, almost springing up from the bottom. Arcangelo Scacchi, also, thought on this subject that a mass of fluid and incandescent magma had been coming out from the central crater filling it slowly without showing signs of its subterranean origin, explaining this silent uprising by the fact that magma did not find a phreatic layer, therefore it did not explode (Scacchi, 1883).

As a matter of fact, this interpretation of Braccini's passage dates back to about two centuries ago, exactly to Leopold von Buch who quoted the same circumstances explaining it within his theory of Craters of Elevation (von Buch, 1836):

«Here is the general formula of each eruption (...). The bottom of the crater rises a little before the eruption till the top of the mountain, *i.e.* till the edge of the crater itself. It is a precursory phenomenon, so necessary to an eruption that it is incredible it has not yet been duly considered (...). Braccini writes that a person ascended the top of the mountain some months before the eruption, *finding that the soil had risen so much that one could pass from one side to another without going down.*» (Italics are by von Buch, who quotes the words of Braccini in Italian. von Buch, 1801).

It is surprising that this peculiar circumstance of presumed upheaval of the crater, already deemed impossible by Teodoro Monticelli (Monticelli, 1841), is today believed possible from a physics point of view: magma rose through a completely solidified conduit, after a rest of some centuries, pushed the crater up, or perforated it, and later filled the top of the crater. Moreover this happened in a state of seismic stillness, since we deem that earthquakes started only afterwards, *i.e.* a week before the eruption (Rosi *et al.*, 1993; Scandone *et al.*, 1993). But I think that Braccini's testimony can be better explained by the landslides caused by the volcano upheavals, in particular in its apical part. These landslides would have filled the bottom of the crater so that it was possible to cross it from one side to another.

Incidentally, we can compare an autograph, unpublished manuscript of a certain Silvestro Viola, kept at *Società Napoletana di Storia Patria*, in which you can read:

«But it began to be felt since *last year 1630, in the month of January*, because in the mouth of the ancient abyss, in the locality *called Ciammella, fell down more than one hectare*, as some villagers reported to me.» (Viola, 1649; italics are mine).

And again, in a footnote, we can read:

«In the year 1630 much *ground fell down* into the mouth of Vesuvio.»

Here a substantial phenomenon due to landslide was recorded 23 months before the eruption. It had an extension of more than one hectare, *i.e.* a surface of more than 10000 m^2. This evidence was missed by Arcangelo Scacchi, although he himself had written a note on the title page of the Viola manuscript. Noteworthy also is mention of the locality called Ciammella. It harmonizes with what Gianbernardino Giuliani writes: according to him, in a locality with the same name, at dawn on December 16th 1631, eruptive vents opened:

«Mount Vesuvio opened from the side facing the sea, commonly *called Ciammella* by the villagers.» (Giuliani, 1632; italics are mine).

Therefore the Viola passage must be interpreted in the sense that the Vesuvius' Great Cone was subjected to pre-eruptive landslides for two years before the eruption, caused by deformations which concerned the structure. The part of Atrio called Ciammella is, moreover, particularly important for the pre-eruptive and eruptive scenery. This landslide fell from the top of the cone towards the outer side. We ought to think, however, that other landslides occurred, particularly inside the crater so that the bottom was filled to permit the crossing, as Braccini reported. A preliminary verification of some sources will confirm this circumstance. For example, Masculo clearly writes that a few months before the eruption several jugers of ground fell into the crater (*abyss*) together with the animals grazing along the edge.

«Few months before the eruption, several jugers of ground with rocks, together with some herd, fell down in the abyss.» (Masculo, 1633).

Besides, Varone writes about a big rock that slid down at the calends of December, *i.e.* just before the eruption, terrifying shepherds and sheep (Varone, 1634).

Therefore, we have records of landslides two years (according to Viola) some months (according to Masculo) and about 15 days before (according to Varone and Braccini) the eruption. Consequently, the deformation must have been remarkable, as well as the earthquakes which had their role in helping to detach the rocky masses raised by deformation.

Acknowledgements

This research, developed within the History of Volcanology Section of Osservatorio Vesuviano, has been partly supported by *Gruppo Nazionale di Vulcanologia* of Italian CNR, that I would like to thank. I am very grateful to Profs. Renato Funiciello and Bruno D'Argenio for their critical reading of the manuscript. I am also indebted for assistance to the staff of Biblioteca della Società di Storia Patria of Naples and to Dr. Salvatore Broda of Credito di Cicciano Bank.

REFERENCES

ALFANO, G.B. (1924): *Le Eruzioni del Vesuvio tra il 79 e il 1631*, Valle di Pompei.

BACCI, A. (1571): *De Thermis*, Venezia.

BRACCINI, G.C. (1632): *Dell'Incendio Fattosi nel Vesuvio a XVI di Dicembre MDCXXXI e delle sue Cause ed Effetti*, Napoli.

BUCH VON, L. (1801): Lettre de Mr. Léopold Buch à M.A. Pictet, l'un des Rédacteurs de la Bibliothéque Britannique; sur les volcans, *Bibliothéque Brittannique*, Genève, Nos. 125-126, 227-249.

BUCH VON, L. (1836): *Description Physique des Iles Canaries*, Paris.

BULIFON, A. (1701): *Compendio Istorico degli Incendi del M. Vesuvio fino all'Ultima Eruzione Accaduta nel Mese di Giugno 1698*, Napoli.

BURRI, C. and P. DI GIROLAMO (1975): Contributo alla conoscenza delle lave della grande eruzione del Vesuvio del 1631, *Rend. Soc. Ital. Mineral. Petrol.*, **30** (194), 705-739.

CATALANO, V. (1975): Contributo alla morfologia del Somma-Vesuvio, *Rend. Acc. Sci. Fis. Mat., Naples*, **52**, 32-58.

COCCHIA, E. (1901): La forma del Vesuvio nelle pitture e descrizioni antiche, *Atti R. Accad. Archeol., Lett. Belle Arti*, Napoli, **21**, 1-66.

DE ARMINIO, J.D. (1632): *De Terremotibus et Incendiis Eorumque Causis et Signis item de Flagratione Vesuvii*, Napoli.

DE BOTTIS, G. (1786): *Istoria di Vari Incendi del Monte Vesuvio*, Napoli.

DE OVIEDO Y VALDES, G.H. (1532): *Histoire du Nicaragues*, reprinted by H. TERNAUX-CAMPAUS: *Voyage, Relations et Mémoires Originaux pour Servir a l'Histoire de la Découverte de l'Amérique*, Paris, 1840.

ELISEO, N.A. (1634): *Rationales Methodus Curandi Febres Flagrante Vaesuvio Subortas*, Napoli.

FASOLA, U.M. (1975): *Le Catacombe di S. Gennaro a Capodimonte*, Roma.

FIGLIUOLO, B. and A. MARTURANO (1997): Catalogo delle eruzioni vesuviane in età medioevale (secoli VII-XV), in *Mons Vesuvius*, edited by G. LUONGO, Napoli, 77-90.

FILOMARINO, A. (1797): *Gabinetto Vesuviano del Duca della Torre*, Napoli.

FOURNIER D'ALBE, E.M. (1979): Objectives of volcanic monitoring and prediction. *J. Geol. Soc. London*, **136**, 142-151.

GASPARINI, P. (1995): Storia di un laboratorio naturale, in *Vesuvio*, edited by A. MOZZILLO (Franco Di Mauro, Napoli), 15-45.

GASPARINI, P. and M. MUSELLA (1991): *Un Viaggio al Vesuvio* (Liguori, Napoli), pp. 307.

GIULIANI, G. (1632): *Trattato del Monte Vesuvio e de' suoi Incendi*, Napoli.

GUARINI, G., L. PALMIERI and A. SCACCHI (1855): Memoria sullo incendio vesuviano del mese di maggio 1855 per incarico della Reale Accademia delle Scienze preceduta dalla relazione dell'altro incendio del 1850 fatta da Arcangelo Scacchi, Napoli, 1-203.

IMBÒ, G. (1984): *Il Vesuvio e la sua Storia* (Edizioni Scientifiche Italiane, Napoli), pp. 233.

LE HON, H.S. (1865): Histoire complète de la grande eruption du Vesuve de 1631, *Bull. Acad. R. Med. Belg.*, 2.me serie, tome XX, No. 8. Bruxelles.

LEONE, A. (1514): *De Nola. Lions Club*, Nola and *Credito di Cicciano*, Nola, 1993.

MASCULO, G.B. (1633): *De Incendio Vesuvio Libri X*, Napoli.

MECATTI, G.M. (1761): *Continuazione delle Osservazioni Sopra Diverse Eruzioni del Vesuvio*, Napoli.

MERCALLI, G. (1883): *Vulcani e Fenomeni Vulcanici in Italia*, Milano.

MONTICELLI, T. (1841): *Opere*, vols. I and II, Napoli.

NAZZARO, A. (1985): Il Vesuvio: storia naturale dal 1631 al 1944, *Boll. Soc. Nat. Napoli*, **94**, 19-55.

NAZZARO, A. (1989): L'eruzione del 1631 ed il collasso del Vesuvio in base all'analisi delle fonti coeve, *Rend. Soc. It. Mineral. Petrol.*, **43** (3), 725-732.

NAZZARO, A. (1995): Vesuvius and volcanologists, 1734-1860, in *Rocks, Fossils and History, Proceedings of the 13th INHIGEO Symposium, Pisa-Padova, 1988*, Firenze, 129-140.

NAZZARO, A. (1997): *Il Vesuvio. Storia Eruttiva e Teorie Vulcanologiche* (Liguori, Napoli), pp. 390.

NAZZARO, A. and B. TRAMMA (1985): Il sismografo di Luigi Palmieri, *Boll. Soc. Nat. Napoli*, **94**, 1-18.

OLIVA, N.M. (1632): *Lettera del Signor – Scritta all'Illustriss. Signor Abbate Don Flavio Ruffo*, Napoli.

PALMIERI, L. (1873): La conflagrazione vesuviana del 26 aprile del 1872, *Atti R. Accad. Sci. Fis. Mat.*, Napoli, **5**, 280-287.

PALMIERI, L. (1879): *Del Vesuvio dei Tempi di Spartaco e di Strabone*, Napoli.

PALMIERI, L. (1880): *Il Vesuvio e la sua Storia*, Milano.

PALMIERI, L., E. CAPOCCI, G. GIORDANO, F. SCHIAVONI, R. CAPPA and G. GUISCARDI (1862): Intorno all'incendio del Vesuvio cominciato il di 8 dicembre 1861, *Rend. Acc. Pontaniana*, **20**, 1-23.

PIGHIO, S.V. (1587): *Hercules Prodicius seu Principis Iuventutis Vita et Peregrinatio*, Antverpiae.

RECUPITO, G.C. (1632): *De Vesuviano Incendio Nuntius*, Napoli.

RICCIO, L. (1889): Nuovi documenti sull'incendio vesuviano dell'anno 1631 e bibliografia di quella eruzione, *Archivio Storico per le Province Napoletane*, Napoli, anno XIV, fascicolo III, 1-69.

ROLANDI, G., A.M. BARRELLA and A. BORRELLI (1993): The 1631 eruption of Vesuvius, *J. Volcanol. Geotherm. Res.*, **58**, 183-201.

ROSI, M. and R. SANTACROCE (1983): The A.D. 472 Pollena eruption: volcanological and petrological data for this poorly-known, plinian-type event at Vesuvius, *J. Volcanol. Geotherm. Res.*, **17**, 32-42.

ROSI, M., C. PRINCIPE and R. VECCI (1993): The 1631 Vesuvius eruption. A reconstruction based on historical and stratigraphical data, *J. Volcanol. Geotherm. Res.*, **58**, 151-182.

ROTH, J. (1857): *Der Vesuv und die umgebung von Neapel*, Berlin.

SANTACROCE, R. (Editor) (1987): Somma-Vesuvius, *Quad. Ric. Sci.*, CNR, Roma, **114**.

SCACCHI, A. (1883): Della lava vesuviana dell'anno 1631, *Mem. R. Acc. Sci. Fis. Mat.*, tomo IV, Napoli.

SCANDONE, R. and P. GASPARINI (1994): Geophysical precursors of renewal of activity of oversleeping volcanoes, in *Proceedings of Large Explosive Eruptions Meetings*, Accademia Nazionale dei Lincei, Roma, 161-184.

SCANDONE, R., L. GIACOMELLI and P. GASPARINI (1993): Mount Vesuvius: 2000 years of volcanological observations, *J. Volcanol. Geotherm. Res.*, **58**, 5-26.

SCHERILLO, A. (1982): La regione sotterrata dal Vesuvio, *Atti del Convegno Internazionale Università degli Studi di Napoli, 11-15 novembre 1979*, Università di Napoli, 945-953.

SORRENTINO, I. (1734): *Istoria del Monte Vesuvio*, Napoli.

SWANSON, D.A., T.J. CASADEVALL, D. DZURISIN, R.T. HOLCOMB, C.G. NEWHALL, S.D. MALONE and C.S. WEAVER (1985): Forecasts and predictions of eruptive activity at Mount St Helens, USA: 1975-1984, *J. Geodyn.*, **3**, 397-423.

TILLING, R.I. (1995): The role of monitoring in forecasting volcanic events, in *Monitoring Active Volcanoes*, edited by B. MC GUIRE, C. KILBURN and J. MURRAY (UCL, London), 369-397.

VARONE, S. (1634): *Vesuviani Incendii Historiae Libri Tres*, Napoli.

VIOLA, S. (1649): *Historia del Monte Vesuvio nella quale Diffusamente si Tratta di Tutto lo che è Occorso in Esso dal Principio del Mondo Sino al Anno 1636 et 1649. Con Occasione del Ultima Eruttazione di Fuoco Fatta dal Detto Monte a 16 di Dicembre 1631 a 28 di Dicembre 1649*, Napoli.

VOLPE, C. (1632): *Breve Discorso dell'Incendio del Monte Vesuvio*, Napoli.

WASHINGTON, H.S. (1918): The representation of a volcano on an italian renaissance medal, *Art Archaeol.*, the Octagon, Washington, DC, **7** (7), 256-263.

(received February 18, 1998;
accepted September 21, 1998)