Journal of Research and Didactics in Geography (J-READING), 2, 3, Dec., 2014, pp. 33-41
DOI: 10.4458/4403-03

J - READING
JOURNAL OF RESEARCH AND DIDACTICS IN
GEOGRAPHY
homepage: www.j-reading.org

Vesuvius, Pompei, Herculaneum: a lesson in natural history

Roberto Scandone[a], Lisetta Giacomelli[a]
[a] Dipartimento di Matematica e Fisica, University of "Roma Tre", Rome, Italy
Email: scandone@uniroma3.it

Received: October 2014 – Accepted: October 2014

Abstract

The eruption of Mount Vesuvius of 79 AD destroyed the cities of Pompeii and Herculaneum, but preserved them from the deterioration of time. A large patrimony of knowledge was obtained with the development of new techniques of archeological excavation, which began in these areas in 1700. At the same time, the persistent activity of the volcano stimulated the birth of modern volcanology with the building of the first volcanological observatory in the world in 1841. The effects of the different volcanic phenomena during the eruption of 79 AD also made it possible to investigate the causes of death during an explosive eruption. Overall the volcano and its activity have stimulated the advancement of different branches of human knowledge and the preservation of a cultural patrimony unrivaled in the world. This information can be used to develop interdisciplinary projects in schools aimed at better understanding the nature of volcanic hazard.

Keywords: Hazard, Herculaneum, Interdisciplinary Projects in Schools, Pompei, Vesuvius, Volcanic Eruptions

1. Introduction

Vesuvius is the best known volcano in the world because a peculiar set of different reasons (Scandone et al., 1993):

- the first written account of an explosive eruption in 79 AD to hit the densely inhabited cities of Pompeii and Herculaneum. The term Plinian, used to define the large explosive eruptions, derives from the description of Pliny the Younger of that very eruption;
- a 2000 year long historical eruptive record;
- a volcano that was particularly active during the Enlightenment, when new theories on physical nature were developed;
- the discovery, at the beginning of 1700, of the buried cities of Pompeii and Herculaneum led to the birth of a new discipline, archaeology;
- its activity and the presence of the Roman ruins made it one of main places to be visited, when Naples was an important European capital during the Grand Tour made by European scholars;

- it entered a prolonged repose period after the 1944 eruption, and since then there has been a large increase in the density of the population at its base, making it a case study for the Civil Protection to face possible future eruptions.

Because of these peculiarities, Vesuvius came to be known as the archetype volcano where many new theories were developed.

In this paper we will examine all these different peculiarities, trying to provide an example of multidisciplinary study of natural and social phenomena.

2. Volcanology

Vesuvius is a strato-volcano located in Southern Italy near the city of Naples, whose summit elevation is 1281 m asl, with the diameter of the base approximately 10 km. It is formed by the superposition of different edifices formed by growth during effusive phases and destruction during major explosive eruptions. This feature is recognized by the occurrence of the so-called Somma rim, which represents the overlapping of at least four major caldera collapses (Cioni et al., 1999). On the side of one of these collapses was emplaced the present volcanic cone (Gran Cono), which has been active since 79 AD (Figure 1).

Figure 1. The Gran Cono of Vesuvius formed after the eruption of 79 AD with the large crater resulted from the last eruption of 1944. In the background the rim of the Somma and the lava flow of the last eruption of 1944. Photo: R. Scandone.

The activity of Somma-Vesuvius spans the entire spectrum of volcanic eruptions, from mild effusive emissions of degassed lava to violent explosive eruptions (Scandone et al., 1993). Eruptions began between 39000 and 25000 years ago with the emission of lava flows, which built the mountain called Somma. The first products of an explosive activity are dated at the end of this phase, about 25000 years ago (Delibrias et al., 1979).

The most significant explosive eruption occurred about 17000 years ago and is called the "Pomici Basali or Sarno eruption". A long series of different explosive events took place after that one, the last three of which occurred in 79 AD, (the eruption which destroyed Pompeii and Herculaneum), in 472 and 1631.

The eruption of 1631 was a violent explosive event, although one order of magnitude lesser than the 79 AD one. It is however important for different reasons:

- it occurred after a long repose period of about 400 years;
- it started a period of semi-continuous activity with frequent effusive or mildly explosive eruptions which lasted till 1944;
- it is considered as the type eruption which may occur in case of a renewal of activity.

The period of permanent activity between 1631 and 1944 coincided with the development of a scientific approach to volcanoes and from 1700 onwards Vesuvius became the model to test new geological theories on. In 1841, the first volcano observatory in the world was built on its flanks. Among its directors there was Giuseppe Palmieri who devised a seismoscope to study the eruptions, and Giuseppe Mercalli, famous for the invention of the scale to measure the intensity of earthquakes.

Nowadays, the Vesuvius Observatory is a section of the National Institute of Geophysics and Volcanology, and maintains a comprehend-sive monitoring program with a seismic and deformation network, and measures of gravity and chemistry of fumaroles. Along with the nearby area of Campi Flegrei, Vesuvius is one of the best monitored, quiescent volcanoes.

3. The 79 AD eruption

The only testimony of the eruption of 79 AD are two letters written by Pliny the Younger to Tacitus nineteen years after the event, describing the death of his uncle, Pliny the Elder, when rescuing the people endangered by the eruption. Several other descriptions like that of Dio Cassius are of a later age and less reliable. Contemporary Latin poets like Statius and Martial recalled the effects of the eruption in some of their poems.

Pliny the Younger's letters to Tacitus have been frequently recalled as the first vivid description of an explosive eruption. In the first letter there is the classical depiction of the eruptive column that has been termed by volcanologists "Plinian eruption column": "It resembled a pine [Mediterranean pine] more than any other tree. Like a very high tree, the cloud went high and expanded in different branches. I believe, because it was first driven by a sudden gust of air (*recenti spiritu eiecta)*, then, with its diminution or because of the weight, the cloud expanded laterally, sometimes white, sometimes dark and stained by the sustained sand and ash *(pondere suo victa in latitudinem vanescebat, candida interdum, interdum sordida et maculosa prout terram cineremque sustulerat)*".

According to Pliny's description, and the analysis of erupted products, from the column white pumices fell for over 12 hours, followed by the fall of grey pumices. The height of the eruption plume is estimated at 24 kilometers in the first phase, reaching over 30 km during the phase of grey pumices. The pumices were dispersed to the SE of Vesuvius because of the dominant winds, thus covering everything downwind, including the city of Pompeii (Sigurdsson et al., 1985).

The increase of the eruption vigor led to the collapse of the eruptive plume and the flow along the flank of the volcano of the eruptive products as hot avalanches (pyroclastic flows) that destroyed everything in a radius of 10 km (Figure 2).

The earlier pyroclastic flows reached Herculaneum which was not affected by the pumice fall as it was upwind. When the valley along the slopes of the volcano had been filled up, the flows expanded on the flattened surface to Pompei already buried by the pumice.

Figure 2. The deposit of the pumice fall at Pompei and the overlaying pyroclastic flow deposits.
Photo: L. Giacomelli.

The thickness of the pyroclastic flow deposits is in the order of 20 m in Herculaneum and 4 m in Pompeii, but their passage was fatal everywhere. The eruption lasted little more than 24 hours but its products sealed fields, people and cities under a deep cover for more than seventeen centuries (Figure 3).

4. Archeology

In 1592, the building of an aqueduct from the Sarno river to Torre Annunziata, passing through a small hill called "Civita", cut some ancient walls belonging to the buried city of Pompeii. Only in 1607 did the Neapolitan historian Capaccio report the findings of the ruins of an old city called Civita. The burying of most of the Vesuvius area during the eruption of 1631 delayed a systematic study of these discovered places for more than a century. The first excavations were thanks to the Austrian viceroy, prince D'Elboeuf, who owned a villa in Portici, where he started accumulating the statues and findings of the first sporadic excavations made in correspondence with the theater of Herculaneum (Giacomelli and Scandone, 2001).

In 1734, the kingdom of Naples became part of the Bourbon heritage and given to Charles, son of Philip V of Spain and Elisabeth Farnese. The young king and his wife, Mary Amaly Cristine of Polony, gave a strong impulse to the excavations of Herculaneum (Figure 4). An engineer of the Bourbon army, Roche Joachim Alcubierre, was nominated for the direction of the excavations.

Figures 3 and 4. Above, the excavation area of Pompeii with Vesuvius in the background. Below, the excavations of Herculaneum, surrounded by the modern town of Ercolano, lay at 20 m below the present ground level. The green area at the upper part of the picture is the garden of the royal palace of Portici (the yellow building on the left side). Photos: R. Scandone.

The city of Herculaneum, buried under more than 20 meters of hard pyroclastic deposits, required a special process consisting in the digging of deep wells and lateral excavations starting from the central shaft. Large holes in the walls of the buildings were made when they prevented further advancement. The holes are still visible nowadays. Precious belongings and decorations were taken away and transported to the royal palace. The less important ones were destroyed or thrown away. At the end, the excavations were filled up again with the volcanic material to prevent collapse and to avoid a large accumulation of volcanic materials (Figure 5).

Figure 5. Example of a hole dug during the first excavations in the wall of a house to explore the buried edifices.
Photo: L. Giacomelli.

Archeology as a science did not yet exist and the excavations were only made to collect objects to adorn the royal palaces. These were the first steps in the development of a more formal investigation, which later on was to become a proper science.

The collection of objects, first in Portici and then in Naples, although in a primitive way represents the first example of a Museum that, according to the King, was to be a patrimony of the State. The public character of the enterprise was also enhanced by the assignment of royal financial support, and the sporadic publication of journals on the excavations. On his departure from Naples to become King of Spain, Charles (Figure 6), left everything found in the excavations as patrimony of the Kingdom of Naples.

Figure 6. Two bronze (Runners) and marble statues recovered from Villa dei Papiri at Herculaneum in the National Archaeological Museum of Naples.
Photo: L. Giacomelli.

The difficulty of digging in Herculaneum and the rarefaction of important findings led the attention to Pompeii, where the excavations were easier because the city was covered by 8 meters of almost soft pumice and ash. On the 1 April 1748, 12 workers, sent to dig on the hill of Civita, set out on the astonishing enterprise of uncovering a city buried for centuries under the products of Vesuvius.

Since the middle of the nineteenth century the archeologists Fiorelli and then in 1900, Maiuri, improved new research methods. Fiorelli developed the ingenious method of dripping liquid chalk into the holes in the ashes thus obtaining the cast of the corpses and artifacts, which had been consumed following their burial. At Herculaneum the method was not possible

because the lack of pumice below the ashes did not permit the slow degradation of bodies (Figure 7). Maiuri made great advances by uncovering large parts of Pompeii by selling the accumulated pumice as construction material for the new highway between Napoles and Salerno. However, his efforts of completely removing the eruption product, prevented a full understanding of the mechanism of deposition and the circumstances of the burial of the two cities.

Figure 7. Cast of a victim in a repository of Pompeii. Photo: L. Giacomelli.

The archeological areas of Pompeii and Herculaneum make it possible to understand the slow and difficult development of archeology since the early attempts in 1700 with rough reconstruction work and removal of frescos and mosaics to the more difficult restoration and preservation of later excavations.

A full understanding of the crucial steps of archaeology and Roman history could be better obtained by the reading of the excavation journals written by the different archeologists and by visiting the Archeological Museum of Naples where most of the artifacts are conserved.

5. Gran Tour

During 1700 and 1800, Italy was the country where intellectuals, aristocrats and scholars from all over Europe came to visit its arts cities, enjoy the climate and the natural beauties. Vesuvius and its fuming craters with its scenic eruptions, and the nearby Campi Flegrei with hot springs and baths, were among the most attractive places to be visited. The discovery of the buried cities of Pompeii and Herculaneum added relevance to the new independent reign of Naples and its enlightened court.

Several narratives of these travelers of the "Tour d'Italie" became classical accounts of sociology and science. The English plenipotentiary minister to the Kingdom of Naples, Hamilton reports, that "*without a detached, Scottish point of view, it would be difficult to live in such suggestive and difficult country*". In spite of this opinion, he enjoyed the natural environment of the country and left a lifelong description of the activity of Vesuvius and the other volcanoes of Southern Italy in a series of letters to the Royal Society of London, which were later collected in an elegant book "Campi Phlegraei, observations of the volcanoes of the Two Sicilies" illustrated by 54 color drawings by Pietro Fabris.

In 1764 the kingdom was governed by a thirteen year old king, defined by Hamilton as "*one of the divine damnations of the Bible*". Later, most of the day to day routine was to be governed by his brilliant wife Caroline, daughter of Mary Therese of Austria and sister of Mary Antoinette of France. The queen loved to be surrounded by Enlightenment intellectuals, until the revolutionary turmoil of France, which rapidly spread to the whole of Europe and the death of her sister.

One of the most famous *tourists*, J.W. Goethe, wrote his "Travels to Italy" with a romantic attitude. Dining on the riverside of Torre Annunziata, on 13 March 1787, he wrote: "*It is sufficient that this image remains in my spirit*" and visiting the Pompeii excavations added that the eruption of Vesuvius of 79 AD had been the major disaster that caused "*so much joy to posterity*". He climbed the volcano several times leaving detailed accounts of its activity.

The great number of people visiting the volcano brought about the proliferation of artists, who developed a new fast painting technique, called gouache that permitted them to catch the eruptive activity of the volcano like photographic pictures, which then became a true visual archive of the record of activity of the volcano (Figure 8).

Figure 8. A gouache (by Camillo De Vito) of the 1822 eruption of Vesuvius.

Local guides accompanied the tourists to the top of the volcano. The most frequent travelers had their own personal guides, with whom they developed a true friendship even in a period of rigid class separation. The temporary friendship added a further concern to the perilous ascent to the crater.

The guides used multiple tricks to extort money from the tourists, but rewarded them with *their wild, sweet national music*, as wrote the poet Shelley in 1818. Often, they carried ladies and gentlemen unable to continue the ascent on their shoulders, or appeared suddenly with drinks in the middle of lava flows when thirst became unbearable. *For a glass of wine, I paid three liras*, but the same boys, *broke their back with reverence*, wrote in 1895 Vincente Blasco Ibanez. The guides were however necessary to reach the volcano without being assailed by robbers on the way up. The use of guides and their fees were ruled by a prefect's decree in 1840 and then in 1855. The maximum fee was ten carlini for the day, twelve for the night, four ducats for a chair brought by eight people, and eight carlini for a mule, horse or donkey (Figure 9).

Figure 9. Gouache (by Camillo De Vito) of tourists observing an active vent on top of Vesuvius (1829).

On arrival at the top, the show of the fire of the volcano, and the landscape from the Apennine to the sea, and the islands of Capri, Procida and Ischia in the background, cancelled every trace of unpleasantness or tiredness. The experience remained fixed in the mind as the adventure of a lifetime, which compared the smallness of men to the power of Nature. As Chateaubriand wrote, "*what are the famous revolutions of empires in comparison with the accidents of nature that change the face of earth and seas*".

6. The Lessons

In Pompei, 394 corpses were found in the pumice fall deposit and 650 in the pyroclastic deposit, with a total of 1044 victims being recovered inside 2/3 of the city of Pompeii (the excavated part) (Giacomelli et al., 2003). Most of the corpses within the pumice fall deposit were found inside buildings (88%), whereas, of the 650 corpses recovered in the pyroclastic flow deposit, 334 were found inside buildings and 316 outdoors.

The relative proportion of people died because of the high pumice fall in comparison to the known statistics, which report less than 4% in many historical eruptions (Tanguy et al., 1998). It is probably related to the unawareness of the people about the very presence of a volcano (Vesuvius was inactive for many centuries before 79) and to the belief that they could save their lives inside the buildings that later collapsed under the load of pumice or because the pyroclastic flow action.

Such information is relevant to minimize loss of human lives during an explosive eruption. The evacuation of a city is possible even under the fall of pumice, but must be made rapidly before the emplacement of pyroclastic flows, that generally occur in the later phases of an eruption, after the beginning of the Plinian phase. Moreover, people have to know what direction to take, not towards the sea or downwind.

The pyroclastic flows emplace more likely along the major drainage valleys of the volcano, and are generally able to destroy all edifices and obliterate any sort of life within a 10-15 km radius. So no refuge can be found within them unless at the very edge of the destruction zone, but the knowledge of the topography of the volcano may help in saving lives especially by avoiding valleys and depressions.

At Herculaneum, the dead bodies found in the city were only around ten, and it was hypothesized that most people had fled during the eruption, until, during the excavation of the suburban baths in 1980, more than 300 corpses were found amassed in the porches on the sea front of the town (Figure 10).

Most people had died waiting for an escape route toward the sea but, or maybe for this reason, only one boat was found on the beach. Perhaps the weather and adverse sea conditions had prevented their escape as also testified by Pliny the Younger, in relation to the death of his uncle Pliny the Elder, who was unable to leave Stabiae where he had landed the day before, because of contrary winds that did not permit the sailing of his ships.

Figure 10. Casts of skeletons of victims found in the porches of Herculaneum. Photo: L. Giacomelli.

Strong windstorms, and tsunami are known to accompany the explosive eruptions of volcanoes close to the sea. Similar phenomena occurred also during the 1631 eruption of Vesuvius even if on a smaller scale than those of 79 AD.

The eruption of 79 AD buried cities, which were still buzzing with life, and preserved intact a patrimony of historical and social knowledge that cannot be obtained from the study of ruins deteriorated by time. The bodies found in Herculaneum supplied a sample of population of all ages and social classes thus providing paleo-pathology with a better knowledge of the state of health and the diseases of an entire population during the Roman imperial period.

Although destructive, the activity of Vesuvius provided an invaluable lesson that permitted the development of volcanology, archeology and ancillary studies on the effects of an eruption on densely inhabited areas (Pesaresi et al., 2008; Pesaresi and Scandone, 2013) (Figure 11).

Presently, the Civil Protection has developed an evacuation plan in case of a renewal of activity. However, the great uncertainties related to the forecast of the exact time and character of an impending eruption, the large numbers of people to be evacuated (at least 700000), within a densely inhabited area, make the evacuation plans problematic. A formidable civil protection measure is the actual knowledge of the style of activity of the volcano and the actions to be taken, should an eruption occur without sufficient warning.

Figure 11. The facade of Vesuvius Observatory built by order of King Ferdinand II of Bourbon in 1841 to study the activity of the volcano. The first director was the physicist Macedonio Melloni. Photo: L. Giacomelli.

The history of the major eruptions of 79 AD and 1631 has shown that many people living around the volcano were able to escape even without any knowledge of volcanic phenomena and without knowing that Vesuvius was a volcano. The casualties were only those who remained close to their houses until the last minute. So, even in the case of the failure of all prevention measures, could it be possible to avoid large losses of people by the simple knowledge of elementary rules of behavior that should be taught at school. Primary school should provide the elementary information regarding volcanic phenomena and emergency drills. Specific ad hoc projects in junior schools may embrace science, history, and Latin language, supplemented with visits to the excavations and volcanic outcrops to better appreciate the nature of eruptive phenomena and their effect on the environment.

We hope that this patrimony may help to save lives in the future and eventually preserve a testimony of our time to the future, should a new disastrous eruption occur as far into the future as possible.

References

1. Cioni R., Santacroce R. and Sbrana A., "Pyroclastic deposits as a guide for reconstructing the multi-stage evolution of the Somma-Vesuvius caldera", *Bulletin of Volcanology*, 61, 4, 1999, pp. 207-222.
2. Delibrias G., Di Paola G.M., Rosi M. and Santacroce R., "La storia eruttiva del complesso Somma-Vesuvio ricostruita dalle successioni piroclastiche del Monte Somma", *Rendiconti della Società Italiana di Mineralogia e Petrografia*, 35, 1979, pp. 411-438.
3. Giacomelli L. and Scandone R., *Vesuvio, Pompei, Ercolano: eruzioni e escursioni*, Milan, BE-MA, 2001.
4. Giacomelli L., Perrotta A., Scandone R. and Scarpati C., "The Eruption of Vesuvius of 79 AD, and its Impact on Human Environment", *Episodes*, 26, 3, 2003, pp. 234-237.
5. Pesaresi C., Marta M., Palagiano C. and Scandone R., "The evaluation of 'social risk' due to volcanic eruptions of Vesuvius", *Natural Hazards*, 47, 2008, pp. 229-243.
6. Pesaresi C. and Scandone R., "Nuovi scenari di rischio nell'area vesuviana", in Paratore E. and Morri R. (Eds.), *Proceedings in honor of Cosimo Palagiano, Semestrale di Studi e Ricerche di Geografia*, 1, 2013, pp. 225-241.
7. Scandone R., Giacomelli L. and Gasparini P., "Mount Vesuvius: 2000 Years of Volcanological Observations", *Journal of Volcanology and Geothermal Research*, 58, 1993, pp. 5-25.
8. Sigurdsson H., Carey S., Cornell W. and Pescatore T., "The Eruption of Vesuvius in A.D. 79", *National Geographic Research*, 1, 1985, pp. 332-387.
9. Tanguy J.C., Ribiere C., Scarth A. and Tjetjep W.S., "Victims from Volcanic Eruption: a revised data base", *Bulletin of Volcanology*, 60, 2, 1998, pp. 137-144.

