

VOLCANIC TUFF

Live in danger. Build your cities on the slopes of Vesuvius.

—FRIEDRICH NIETZSCHE

FIRE OF THE GODS

The eruption of a volcano can be a terrifying event. In ancient times, and even today in many different cultures, volcanoes were seen as a sign of the wrath of the gods or a punishment for transgressing divine decrees. Their enormous power, noise, and potential for destruction made volcanoes more feared than any other geologic event except earthquakes. The Romans thought that the fires of the Mount Etna volcano in Sicily were due to the forges of the god of fire, Vulcan (Hephaistos to the Greeks). He used the heat of the underworld to hammer out armor, metalwork, and weapons for the gods (including the thunderbolts thrown by Jupiter/Zeus). When eruptions occurred, it was said that Vulcan was angry because his wife Venus (Aphrodite to the Greeks) had cheated on him. The Romans considered Mount Vesuvius on the Bay of Naples sacred to Hercules (Herakles to the Greeks), and some scholars think that the

name "Vesuvius" is derived from the Greek for "son of Zeus" (as Herakles was Zeus's son).

Yet one of the first truly scientific descriptions and insights into what a volcano is and how it erupts came from ancient times. In some senses, the eruption of Vesuvius in 79 c.e. can be considered the beginning of our modern understanding of Earth and the event that led to the birth of geology as a science.

At the time, the towns around Mount Vesuvius were prosperous and growing. The Bay of Naples supported a large fishing industry, and wine grapes were grown in many places, including the slopes of Vesuvius itself. Then, as now, the volcanic soils around Vesuvius were too rich to be ignored, and they were valued for growing crops and vines of wine grapes. The Roman emperors had a large villa out on the nearby island of Capri, and many other powerful Romans had homes in the region. Pompeii was a large city with a population of over 20,000, and there were many smaller communities in the region.

Vesuvius had not erupted since 217 b.c.e., so most Romans thought it was extinct. Yet there had been many earthquakes in the 17 years since the great earthquake of 62 c.e. that had destroyed much of Pompeii, Herculaneum, and Neapolis (Naples). As early as 30 b.c.e., the Greek historian Diodorus Siculus described the Campanian plain as "fiery" (*Phlegrean*) because Vesuvius showed signs of the fires that had burned long ago.

By August of 79 c.e., earthquakes had become more frequent, and many of the wells and springs in the area had dried up. August 23 was the Vulcanalia, the feast day of Vulcan, which the Romans celebrated every year. Ironically, the next day Vulcan replied to his worshippers with a huge explosion that darkened the skies with ash

and a rain of pumice that lasted 20 hours (figure 1.1). Some of the people of Herculaneum and Pompeii evacuated immediately, but there were many left behind, unwilling to leave or unable to do so because there were not enough boats in the harbor and the roads were clogged with traffic and almost 2.8 meters (9 feet) of fallen ash and pumice. Not only was it hard to escape, but it was even hard to breathe with the ash, which choked the lungs of people and animals. But this was only the warm-up. A day later, Vesuvius spewed out many *nuées ardentes* ("glowing clouds" in French) or pyroclastic flows. These superheated (up to 850°C, or 1,560°F) mixtures of volcanic gases and ash roared down the mountain slope at 160 kilometers per hour (100 miles per hour), incinerating everything in their path. They buried Herculaneum under tens of meters of volcanic deposits known as tuff.



Figure 1.1

The 1944 eruption of Mount Vesuvius. (Courtesy of Wikimedia Commons)

A HISTORIAN OF DISASTER

The eyewitnesses of the eruption mostly died or left no written records, so their thoughts have been lost in the mists of history. Fortunately, we do have one excellent eyewitness account, written by the historian Pliny the Younger. He was 17 at the time, fleeing with his family in a boat to the town of Misenum, across the bay 35 kilometers (22 miles) from the volcano. In a letter to his friend, the famous historian Cornelius Tacitus, the younger man described how his 56-year-old uncle Pliny the Elder, one of Rome's leading admirals, scholars, and naturalists, decided to take a boat closer to the mountain to rescue his friends. It has been one of my favorite accounts of any eruption ever since I first read it in the original in my high school Latin class:

My dear Tacitus,

You ask me to write you something about the death of my uncle so that the account you transmit to posterity is as reliable as possible. I am grateful to you, for I see that his death will be remembered forever if you treat it [in your *Histories*]. He perished in a devastation of the loveliest of lands, in a memorable disaster shared by peoples and cities, but this will be a kind of eternal life for him. Although he wrote a great number of enduring works himself, the imperishable nature of your writings will add a great deal to his survival. Happy are they, in my opinion, to whom it is given either to

do something worth writing about, or to write something worth reading; most happy, of course, those who do both. With his own books and yours, my uncle will be counted among the latter. It is therefore with great pleasure that I take up, or rather take upon myself the task you have set me.

He was at Misenum in his capacity as commander of the fleet on the 24th of August [79 C.E.], when between two and three in the afternoon my mother drew his attention to a cloud of unusual size and appearance. He had had a sunbath, then a cold bath, and was reclining after dinner with his books. He called for his shoes and climbed up to where he could get the best view of the phenomenon. The cloud was rising from a mountain—at such a distance we couldn't tell which, but afterward learned that it was Vesuvius. I can best describe its shape by likening it to a pine tree [today we would compare it to a "mushroom cloud"]. It rose into the sky on a very long "trunk" from which spread some "branches." I imagine it had been raised by a sudden blast, which then weakened, leaving the cloud unsupported so that its own weight caused it to spread sideways. Some of the cloud was white, in other parts there were dark patches of dirt and ash. The sight of it made the scientist in my uncle determined to see it from closer at hand. [This style of explosive mushroom cloud of ash and pumice is now called a "Plinian eruption" in his honor.]

He ordered a boat made ready. He offered me the opportunity of going along, but I preferred to study—he himself happened to have set me a writing exercise. As he was leaving the house he was brought a letter from Tascius's wife Rectina, who was terrified by the looming danger. Her villa lay at the foot of Vesuvius, and there was no way out except by boat. She begged him to get her away. He changed his plans. The expedition that started out as a quest for knowledge now called for courage. He launched the quadriremes and embarked himself, a source of aid for more people than just Rectina, for that delightful shore was a populous one. He hurried to

a place from which others were fleeing, and held his course directly into danger. Was he afraid? It seems not, as he kept up a continuous observation of the various movements and shapes of that evil cloud, dictating what he saw.

Ash was falling onto the ships now, darker and denser the closer they went. Now it was bits of pumice, and rocks that were blackened and burned and shattered by the fire. Now the sea is shoal; debris from the mountain blocks the shore. He paused for a moment wondering whether to turn back as the helmsman urged him. "Fortune helps the brave," he said. "Head for Pomponianus."

At Stabiae, on the other side of the bay formed by the gradually curving shore, Pomponianus had loaded up his ships even before the danger arrived, though it was visible and indeed extremely close, once it intensified. He planned to put out as soon as the contrary wind let up. That very wind carried my uncle right in, and he embraced the frightened man and gave him comfort and courage. In order to lessen the other's fear by showing his own unconcern he asked to be taken to the baths. He bathed and dined, carefree or at least appearing so (which is equally impressive). Meanwhile, broad sheets of flame were lighting up many parts of Vesuvius; their light and brightness were the more vivid for the darkness of the night. To alleviate people's fears my uncle claimed that the flames came from the deserted homes of farmers who had left in a panic with the hearth fires still alight. Then he rested, and gave every indication of actually sleeping; people who passed by his door heard his snores, which were rather resonant since he was a heavy man. The ground outside his room rose so high with the mixture of ash and stones that if he had spent any more time there escape would have been impossible. He got up and came out, restoring himself to Pomponianus and the others who had been unable to sleep. They discussed what to do, whether to remain under cover or to try the open air. The buildings were being rocked by a series of strong tremors, and appeared to have come loose

from their foundations and to be sliding this way and that. Outside, however, there was danger from the rocks that were coming down, light and fire-consumed as these bits of pumice were. Weighing the relative dangers they chose the outdoors; in my uncle's case it was a rational decision, others just chose the alternative that frightened them the least.

They tied pillows on top of their heads as protection against the shower of rock. It was daylight now elsewhere in the world, but there the darkness was darker and thicker than any night. But they had torches and other lights. They decided to go down to the shore, to see from close up if anything was possible by sea. But it remained as rough and uncooperative as before. Resting in the shade of a sail he drank once or twice from the cold water he had asked for. Then came a smell of sulfur, announcing the flames, and the flames themselves, sending others into flight but reviving him. Supported by two small slaves he stood up, and immediately collapsed. As I understand it, his breathing was obstructed by the dust-laden air, and his innards, which were never strong and often blocked or upset, simply shut down. When daylight came again two days after he died, his body was found untouched, unharmed, in the clothing that he had had on. He looked more asleep than dead.

In a second letter to Tacitus a few days later, Pliny wrote:

By now it was dawn, but the light was still dim and faint. The buildings 'round us were already tottering, and the open space we were in was too small for us not to be in real and imminent danger if the house collapsed. This finally decided us to leave the town. We were followed by a panic-stricken mob of people wanting to act on someone else's decision in preference to their own (a point at which fear looks like prudence), who hurried us on our way by pressing hard behind in a dense crowd. Once beyond the buildings we stopped, and there we had some extraordinary experiences which

thoroughly alarmed us. The carriages we had ordered to be brought out began to run in different directions though the ground was quite level, and would not remain stationary even when wedged with stones. We also saw the sea sucked away and apparently forced back by the earthquake: at any rate it receded from the shore so that quantities of sea creatures were left stranded on dry sand. On the landward side a fearful black cloud was rent by forked and quivering bursts of flame, and parted to reveal great tongues of fire, like flashes of lightning magnified in size.

At this point my uncle's friend from Spain spoke up still more urgently: "If your brother, if your uncle is still alive, he will want you both to be saved; if he is dead, he would want you to survive him—why put off your escape?" We replied that we would not think of considering our own safety as long as we were uncertain of his. Without waiting any longer, our friend rushed off and hurried out of danger as fast as he could.

Soon afterward the cloud sank down to earth and covered the sea; it had already blotted out Capri and hidden the promontory of Misenum from sight. Then my mother implored, entreated, and commanded me to escape the best I could—a young man might escape, whereas she was old and slow and could die in peace as long as she had not been the cause of my death too. I refused to save myself without her, and grasping her hand forced her to quicken her pace. She gave in reluctantly, blaming herself for delaying me. Ashes were already falling, not as yet very thickly. I looked round: a dense black cloud was coming up behind us, spreading over the earth like a flood. "Let us leave the road while we can still see," I said, "or we shall be knocked down and trampled underfoot in the dark by the crowd behind." We had scarcely sat down to rest when darkness fell, not the dark of a moonless or cloudy night, but as if the lamp had been put out in a closed room. You could hear the shrieks of women, the wailing of infants, and the shouting of men; some were calling their parents, others their

children or their wives, trying to recognize them by their voices. People bewailed their own fate or that of their relatives, and there were some who prayed for death in their terror of dying. Many besought the aid of the gods, but still more imagined there were no gods left, and that the universe was plunged into eternal darkness for evermore. There were people, too, who added to the real perils by inventing fictitious dangers: some reported that part of Misenum had collapsed or another part was on fire, and though their tales were false they found others to believe them. A gleam of light returned, but we took this to be a warning of the approaching flames rather than daylight. However, the flames remained some distance off; then darkness came on once more and ashes began to fall again, this time in heavy showers. We rose from time to time and shook them off, otherwise we should have been buried and crushed beneath their weight. I could boast that not a groan or cry of fear escaped me in these perils, had I not derived some poor consolation in my mortal lot from the belief that the whole world was dying with me and I with it.

At last the darkness thinned and dispersed into smoke or cloud; then there was genuine daylight, and the sun actually shone out, but yellowish as it is during an eclipse. We were terrified to see everything changed, buried deep in ashes like snowdrifts. We returned to Misenum where we attended to our physical needs as best we could, and then spent an anxious night alternating between hope and fear. Fear predominated, for the earthquakes went on, and several hysterical individuals made their own and other people's calamities seem ludicrous in comparison with their frightful predictions. But even then, in spite of the dangers we had been through, and were still expecting, my mother and I had still no intention of leaving until we had news of my uncle.

THE AFTERMATH

The sixth and largest surge of ash trapped their ship in the harbor, so Pliny the Elder had no chance of escape. Eventually, boats returned to Pompeii, and found Pliny dead on the docks, apparently asphyxiated by ash or volcanic dust. He was one of thousands of victims; only a few of the original 20,000 people of Pompeii made it out alive. Pompeii was buried so deeply—by almost 20 meters (66 feet) of ash—that the city was abandoned and eventually forgotten (figure 1.2). It wasn't rediscovered until 1748, when well diggers dug down and found the first traces of it in almost 1,700 years. Since then, it has been almost completely excavated, giving us a remarkable window on life in the Roman Empire. Not only are the houses and natural objects well preserved, but the frescoes on the wall still have their original vibrant colors, the tiled mosaics are complete and undisturbed, and the artifacts not made of flammable material are surprisingly undamaged. Most striking was the discovery of empty cavities filled with air in the ash deposits. When these were filled with plaster and excavated, they turned out to be natural molds of the bodies of Romans (and their dogs) who died in the ash, asphyxiated by the gases, curled up in protective fetal positions (figure 1.3). Their bodies had been vaporized, but the cavities remained.



Figure 1.2

The ruins of Pompeii, with Mount Vesuvius in the background. (Courtesy of Wikimedia Commons)



Figure 1.3

Casts of bodies preserved in volcanic ash at Pompeii. (Courtesy of Wikimedia Commons)

Herculaneum was more difficult to excavate since it was covered in a 23-meter-thick (75-foot-thick) blanket of hard volcanic mudflow deposits. Even though it was found in 1709, and digging started in 1738, only part of it has been exposed. Unlike the big city of Pompeii, Herculaneum was a small coastal resort town of about 5,000 people, with many rich villas, as indicated by the houses, jewelry, and other artifacts unearthed there. As in Pompeii, archeologists found cavities left by bodies that had been vaporized, as well as 300 skeletons in death poses. Most were found near the waterfront, where they had been trying to escape but were killed

instantly by volcanic gases before their bodies were buried and vaporized.

After the eruption of 79 c.e. wiped Pompeii and Herculaneum from the map—and later from the memory of the Romans—Vesuvius remained active for decades. There was a big eruption in 203 c.e., and again in 472 c.e., with ash reaching as far as Constantinople. Then it went into a dormant phase until the twentieth century, when an eruption in 1906 produced many large flows that killed over 100 people. It erupted again during World War II in 1944, destroying many villages as well as 88 B-25 Mitchell bombers that were involved in Allied invasion of Italy. In the past 70 years, Vesuvius has been relatively quiet, but its history shows that it is still one of the most active and dangerous volcanoes on Earth. Nevertheless, there are now more than 1 million people living on its slopes and more than 3 million around its base, so the next eruption will be far more deadly and disastrous if it is anything like the event of 79 c.e.

The story of Vesuvius and Pompeii is not that different from other great volcanic eruptions. What sets it apart is the observations made by Pliny the Elder and his nephew of the eruption while it was in progress. Instead of treating the event as an act of divine vengeance, both men approached the eruption in a scientific fashion, eager to describe it as a natural phenomenon. This was consistent with the famous 37 volumes of natural history that Pliny the Elder wrote in his lifetime, one of the first such natural histories ever written. The descriptions by Pliny the Younger of the plume of ash that resembled a Mediterranean pine tree and the subsequent stages of the volcanic eruption are the first detailed, scientifically accurate, nonmythological accounts of a volcanic eruption in history. Thus, the accounts of the two Plinys (one of whom died doing

scientific observations) mark the beginning of naturalistic observations of earth processes that we now call geology.

FOR FURTHER READING

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