Uncovering Vesuvius

Vesuvius from Naples (Photo: CRJK).

Christopher Kilburn

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Pathé News, 1935.

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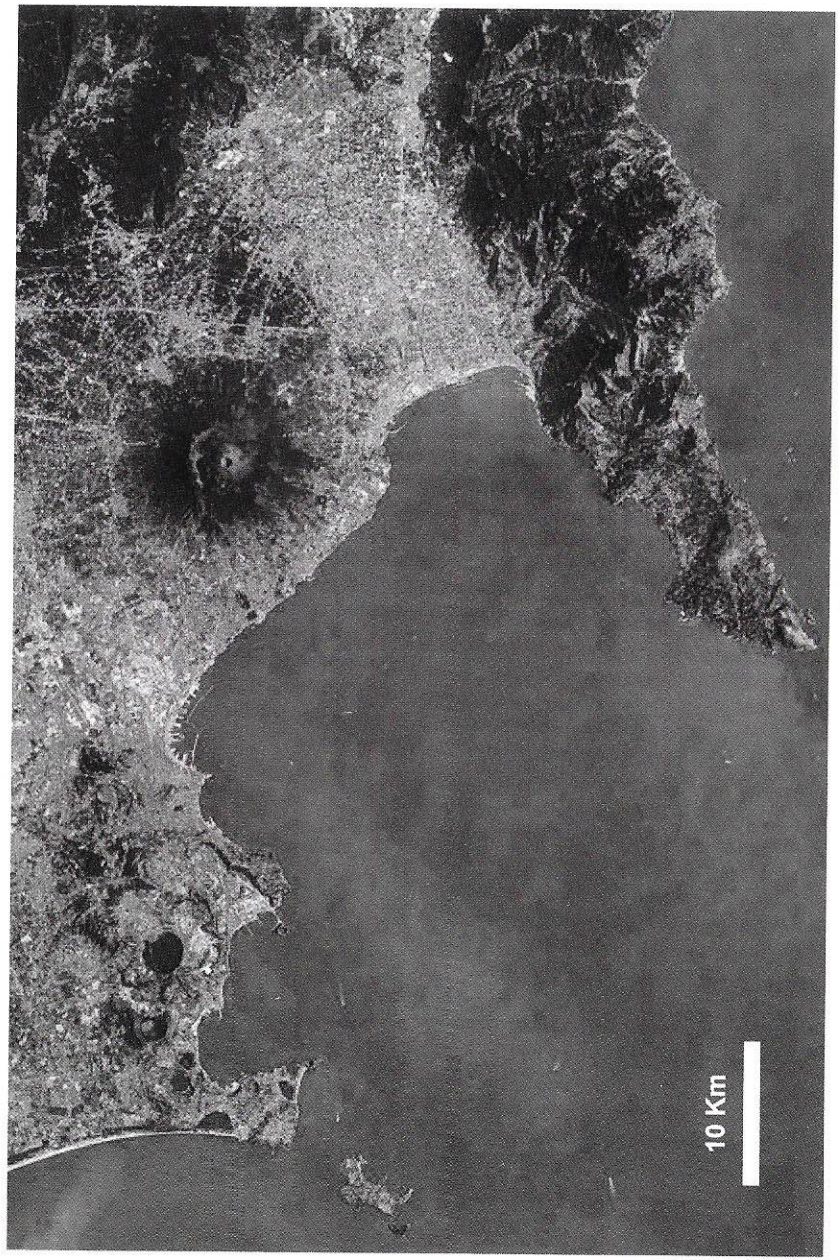
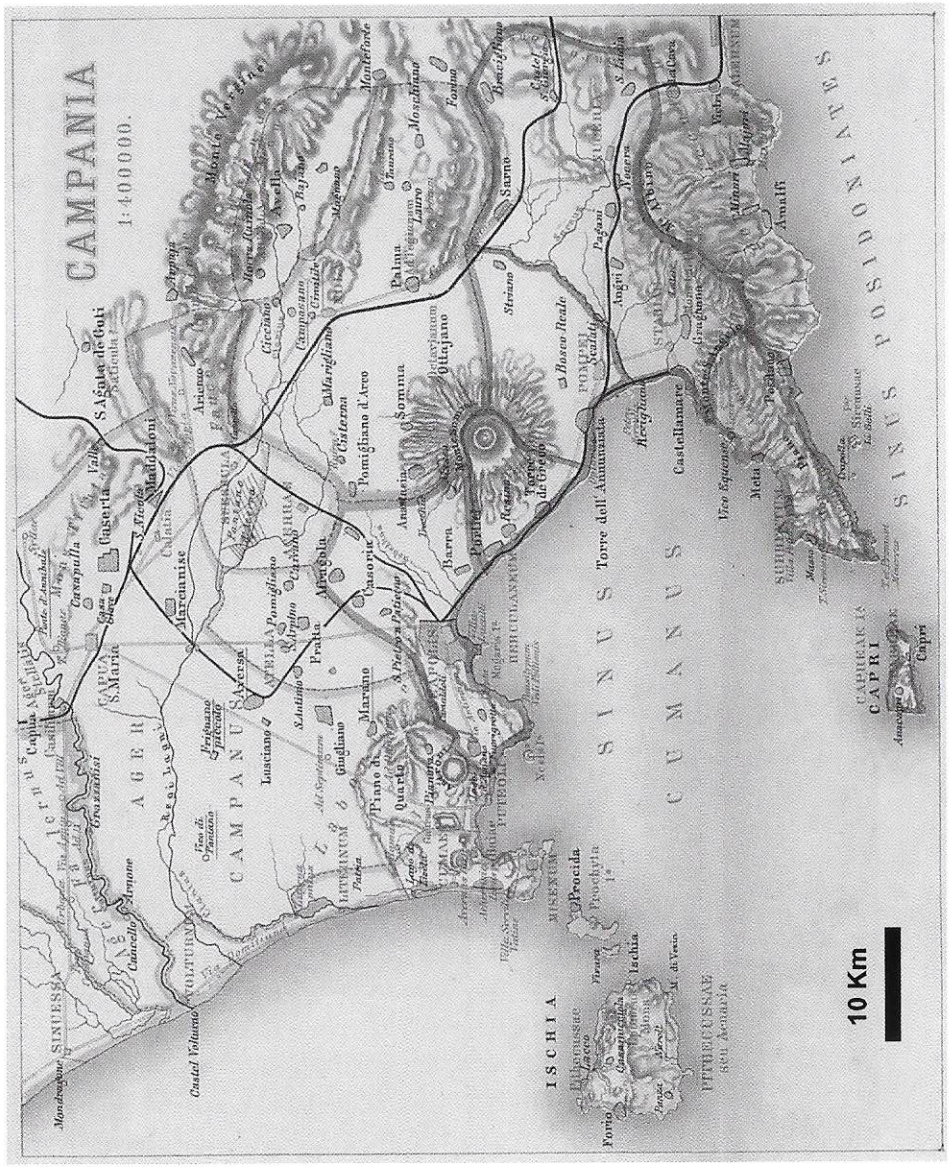




Glossary

Ash Pulverised magma.

Caldera A depression formed by collapse of the volcano's summit.

Eruption column Clouds of volcanic gas, ash and pumice that rise as a column to heights of kilometres to tens of kilometres.

Lava flow Molten rock (magma) that has reached the surface to flow downslope.

Magma Molten rock below ground (the distinction with lava is a historical quirk before magma and lava were recognised as the same material).

Plinian eruption An explosive eruption characterised by eruption columns rising to tens of kilometres. It is named after Pliny the Younger's description of the AD 79 eruption of Somma-Vesuvius.

Pumice Fragments of frothy magma that may be light enough to float.

Pyroclastic A collective term for fragments of magma (ash, pumice and scoria) produced by explosive activity.

Pyroclastic flow A cloud of volcanic gas and fragmented magma that travels over the ground rather rise as an eruption column.

Scoria Fragments of magma heavier than pumice.

Strombolian eruption A succession of small explosive outbursts that deposit scoria and bombs around the vent. They are named after typical behaviour at Stromboli volcano, in the Aeolian Islands, and rarely produce eruption columns.

Subplinian eruption An eruption similar in style to a plinian eruption but 10 or more times smaller.

Tephra A synonym for pyroclastic.

Somma-Vesuvius

Vesuvius has evolved in a region forged by volcanism for at least 300,000 years. The present mountain, 1,270 m high, is properly known as Somma-Vesuvius: Somma refers to the bulk of the volcanic edifice, while Vesuvius strictly describes the summit cone, constructed (despite episodes of collapse) during the past 1,800 years (Fig. 1).

Consisting largely of lava flows, growth of the Somma volcano was complete before 25,000 years ago. With a summit elevation between 1,400 m and 2,000 m, the volcano may well have resembled a scaled-down version of the present Mt Etna. About 25,000 BP, Somma's activity changed from modest effusions of lava to catastrophic plinian eruptions. Five further plinian events have occurred since then, at intervals of about 2,000 to 8,000 years (Table 1). Of these, the most famous is undoubtedly the most recent, which in AD 79 destroyed Pompeii and Herculaneum.

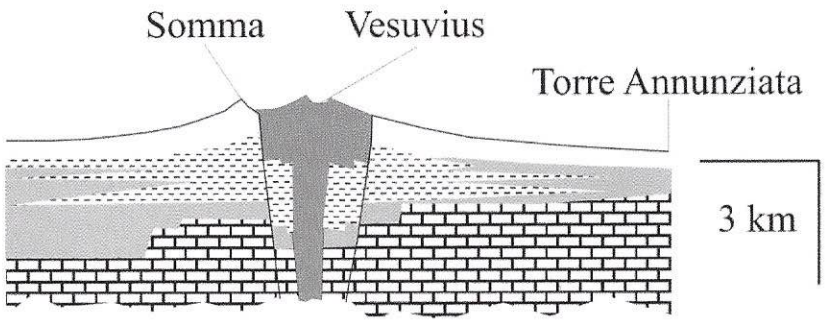


Figure 1. Simplified cross-section through Somma-Vesuvius. The section is approximately N-S, with the coast (S) to the right. Volcanic material has punctured and rests upon the carbonate upper levels of the crust. Magma chambers feeding plinian eruptions had their tops at about 5 km beneath the surface, just below the section. *Dark grey*, Vesuvius cone and feeding conduit. *White*, volcanic flank deposits 25,000 years or younger. *Dashed*, pre-25,000 year lava basement. *Grey*, sediments. *Brick*, carbonate crust.

Each plinian eruption expelled 1-3 km^3 of pumice within days. The rapid rate of magma expulsion fed eruption columns that rose to 16-20 km, at which levels seasonal winds carried material inland along directions oriented from northwest to southeast. Dustings of fine ash probably settled hundreds of kilometres away. However, the main blankets of ash and pumice (with thicknesses of centimetres or more) extended tens of kilometres from the volcano. Across the volcanic edifice itself, thick pumice layers were overrun by pyroclastic flows, formed by local collapses from the unstable outer portions of eruption columns.

Table 1. Plinian eruptions from Somma-Vesuvius (volumes approximate)

Name (older names in brackets)	*Date (Years BP)*	*Deposited Volume (Km^3)*	*Dense Rock Equivalent, DRE (Km^3)*
Codola	25,000	2.3	1.0
Sarno (Basal)	17,000	4.6	1.8
Novelle (Greenish)	15,000	1.3	0.4
Ottaviano (Mercato)	8,400	5.0	2.0
Avellino	3,500	2.3	1.0
Pompeii	1,947 (AD 79)	8.0	3.2

Rapid expulsion of magma also left the walls of the emptying magma chamber unstable, leading to repeated collapse at the summit. If Somma had originally reached to 2,000 m above sea level (asl), as much as 40 km^3 of the original edifice may have been lost in the last 25,000 years.

The present walls of the Somma caldera are highly irregular, reaching 1,000-1,150 m asl to the north and northeast, but to only 500-700 m towards the coast. Since AD 79, the caldera floor has been filled by younger volcanic deposits. At its centre, cones hundreds of metres high have been built and destroyed at least three times. The current cone stands about 400m high and is 2 km across at its base.

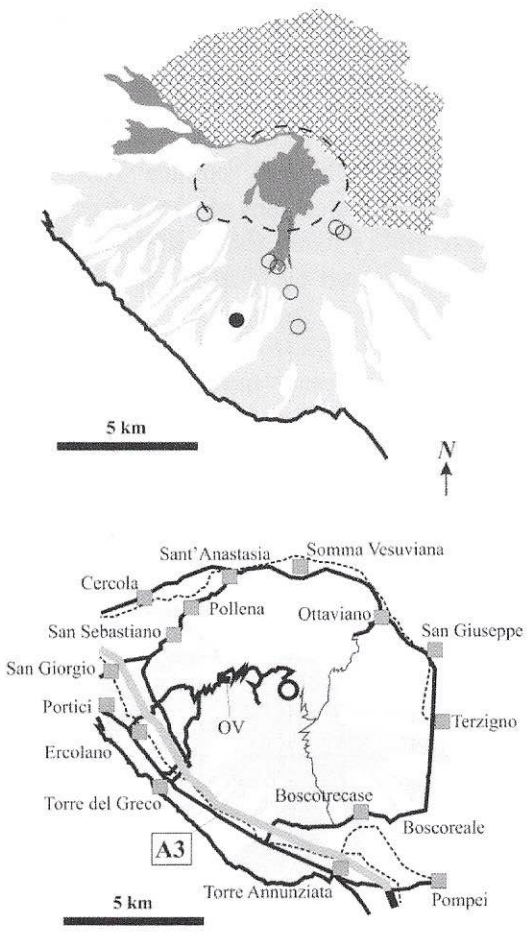


Figure 2. Simplified geological (*top*) map of Somma-Vesuvius. The north-eastern half of the volcano is covered by pyroclastic materials (*cross-hatched*), mostly from plinian eruptions. Most of the south-western half has been covered by historical lava flows, divided into the 1944 lavas (*dark grey*) and other post-1631 lavas (*grey*). Circles show historical flank vents; the filled circle marks the pre-AD 79 Camaldoli cone. The dashed line traces the rim of the Somma ccollapse.

The location map (*bottom*) shows the main towns around the volcano, the principal connecting roads (*solid lines*), the *circumvesuviana* railway routes (*dotted lines*), the A3 motorway (*grey*), and the Osservatorio Vesuviano museum (*OV*).

Historical activity

Vesuvius' most recent activity began in 1631 after a repose of several generations - possibly as long as 500 years. Between then and 1944 it remained in virtually continuous eruption. Lava flows filled and overflowed the summit crater, punctuated by explosive summit outbursts and by occasional effusions from lateral vents in the Somma edifice. Thus, although the volcano is typically associated with the AD 79 Pompeii eruption, it has been an essentially effusive centre since the Seventeenth Century. Indeed, the term lava was coined from the Italian *lavare* (to wash) to describe the flows from Vesuvius.

Trapped to the north and northeast by the walls of the Somma caldera, lava overflows from the Vesuvius cone have been free to spill beyond the caldera only to the west, south and east (Fig. 2). Flank events also have been restricted to the southern and south-western sectors of the volcano. As a result, coastal towns have been most vulnerable to Vesuvius' effusions for the last three centuries.

Most outpourings have involved volumes of lava in the range 10-30 million m^3 and have continued for a matter of days. Exceptional effusions have emitted as much as 100 million m^3 over a period of years. Numerous rapid, short-lived flows have swept the flanks of the volcano burying settlements 5-6 km from the summit: a notable example is San Sebastiano which, in the northwest foothills of Somma, was overwhelmed three times between 1855 and 1944.

The 1631-1944 activity is important not only because it is the most recent and best documented, but also because it is the only *known* interval of *persistent* eruptive activity since plinian eruptions first occurred 25,000 years ago. Some 2-5 km^3 of magma were erupted in the course of 313 years, similar in volume to the amount needed to produce a single plinian event. Activity during this period has been interrupted by 17 intervals of apparent repose, never longer than seven years. The notion of repose may be misleading. Frequently, eye-witnesses claim that a volcano is in repose provided that magma cannot be seen at the surface. Such a criterion cannot distinguish between true repose (when the upper kilometres of a

volcanic system are closed) and when the level of fresh magma has simply dropped a few hundred metres below the summit. Hence, it is possible that magma was almost always present within the Somma-Vesuvius edifice between 1631 and 1944.

Classic eruptions: AD 79 and 1944

Two eruptions illustrate the extraordinary range of behaviour at Somma-Vesuvius: the AD 79 plinian eruption for which the volcano is probably most famous; and the 1944 effusive eruption which, as well as being the most recent event from the volcano, shows the destructive potential of even its smallest outbursts.

The Pompeii eruption, AD 79

The coastline beyond Naples, from Campi Flegrei to the Sorrento Peninsula, was a prized zone for development two thousand years ago. Financed by the Roman State, farms and villas appeared around the truncated Somma edifice, taking advantage of its fertile slopes, comfortable climate, and easy access to the sea. New economic centres were soon dominated by Pompeii, inland to the southeast, and Herculaneum, on the coastal road from Somma to Naples.

Although recognised as a volcano, Somma had been quiet for a millennium and was considered extinct. Mild earthquakes were common, but since they rarely caused any damage they were not seen to be threatening. This view changed on 5 February 62, when a major earthquake struck the Somma coastline, decimating temples and villas from Pompeii to Naples.

The AD 62 earthquake was the worst in a series that was to shake the region for the next seventeen years. Although the larger earthquakes were probably tectonic in origin, some of the tremors must have been caused by magma pushing to the surface. It is likely, too, that the volcano began to deform, but perhaps at such a slow rate as to pass unnoticed against the effects of the earthquakes. Certainly, no-one was prepared when Somma burst back into life on 24 August 79.

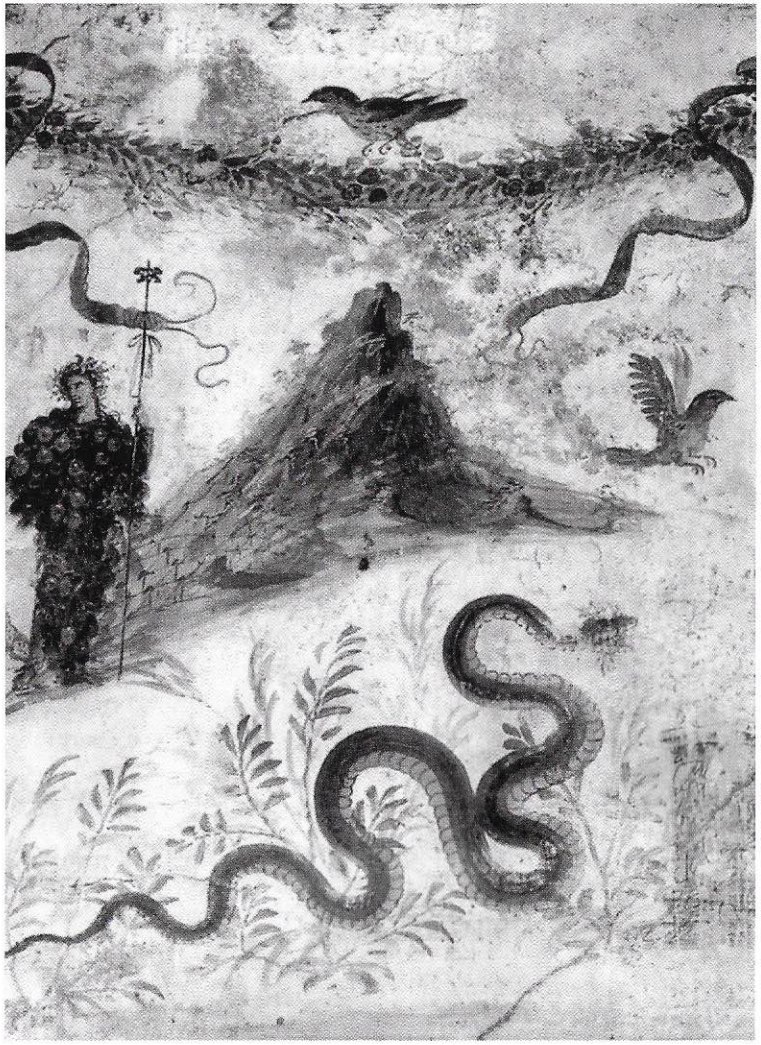
The main eruption started just after midday. A column of ash climbed more than 17 km above the summit. Blown southeast by the summer winds, fragments of pumice rained down on Pompeii. Within hours, the roofs of buildings were giving way beneath piles of ash two-metres thick. Unable to see through the ashfall, Pompeians groping their way along the streets were caught in the deadly grip of pyroclastic flows. Sweeping through Pompeii at 100 km an hour, the lethal mixtures of incandescent ash and gas flattened buildings, burned lungs and erased the town within minutes. Forty-eight hours later, Pompeii and its people had disappeared from sight, buried by the first ash from Vesuvius for nearly 1,500 years.

Along the coastline, the sea was pulling back into the Tyrrhennian, only to crash back onto the new beaches as a train of tsunamis. At Herculaneum, just seven kilometres from the summit, the terrified population was huddling inside arches along the harbour, trapped between the volcano and the unpredictable sea. With most of the ash raining southeast over Pompeii (Fig. 3), it seemed for a while that Herculaneum might escape the worst of the eruption. It was not to be. Without warning, the town was struck by a succession of pyroclastic flows surging downslope, some with clouds that glided 30 km across the Bay of Naples and into Campi Flegrei – reaching the adolescent Pliny the Younger who had been watching the eruption from near Capo Miseno (and from whose description such volcanic activity has become known as a plinian eruption). Within hours, Herculaneum had vanished beneath 20 metres of pyroclastic flows and surges.

By 26 August, the eruption was spent. Fertile countryside had been transformed into a wasteland of smouldering ash. At least 2,000 people had perished and a jewel of the Roman Empire lost for almost 2,000 years. As a contemporary account describes: "Here was the seat of Venus (Pompeii); there the town of Hercules. Everything has been buried in flames, beneath squalid ashes. Not even the gods would have wreaked such havoc."

This fresco of Somma comes from Pompeii. The peak is *not* the summit cone, but the high point on a wall surrounding collapse. It shows that a caldera had formed *before* the AD79 eruption.

Can you spot the central collapse (or caldera)?



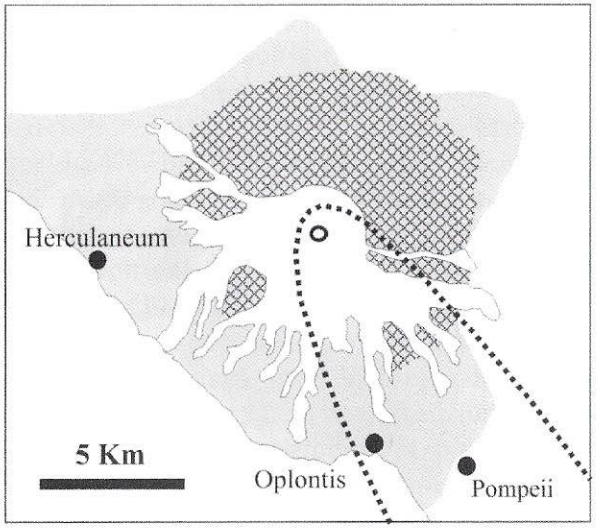


Figure 3. Distribution of AD 79 products. Seasonal winds directed the ash cloud southeast over Pompeii. The *dotted* outline encloses the area with ash deposits thicker than 1 m. The grey area encloses districts in which pyroclastic flows and surges achieved cumulative thicknesses greater than 3 m. The present Somma edifice (*cross-hatched*) and historical lava flows (*white*) are shown for scale.

The 1944 eruption

By March 1944, the Italian front in the Second World War had moved north to Montecassino, some 100 km from Vesuvius on the way to Rome. Poverty and hunger were commonplace as Naples and surrounding districts began the long struggle toward peacetime stability. For more than 30 years, Vesuvius had been gently filling its crater with a succession of lava flows, sending an occasional flow down the outer flanks of the cone. Within a month of the last minor overflow in January 1944, the level of magma unexpectedly began to subside within the crater, triggering small inward collapses of its walls. If anything, the lowering of magma seemed to portend continuing tranquillity – certainly not the largest eruption for almost four decades.

Vigorous strombolian activity began at 16.30 on Saturday, 18 March. Lavas filling the crater overflowed the Vesuvius cone, to the north and south. Initially advancing more than 300 m an hour, the southern flows had slowed to a halt by 21 March, their fronts nearly 3 km from the cone. The northern flows, however, blocked by the walls of the Somma caldera, headed west along the Atrio del Cavallo (the valley separating the Somma caldera from the historical Vesuvian lavas). About 2 km downslope, the flows found a notch beyond the end of the raised caldera walls and began pouring down the Somma flanks towards Massa, San Sebastiano and Cercola (Fig. 4). Over 12,000 people were being evacuated as the lava fronts reached the first buildings early on 21 March. By the time they had halted the following day, the outskirts of San Sebastiano and most of Massa had disappeared from sight.

Within 72 hours, the volcano had expelled some 20-25 million m^3 of lava. Hopes that the eruption was waning already on the evening of 21 March were dashed when vigorous lava fountains began playing from the Vesuvius cone. Scoria and ash, buoyed upwards by convection above the lava fountains, were carried to the East and Southeast, falling as much as 200 km away. Nearer the volcano, the blanket of ash and scoria decreased in thickness from a metre or so near the cone to about 10 cm as far as 20 km away.

After a pause until noon on 22 March, the volcano began belching thick clouds of black and pink ash, rising as a pulsating brain to more than 5 km. Highlighted by lightning, the darkness of the cloud signalled the ejection of solidified fragments, indicating the start of collapse inside the crater. Weighed down by cooler fragments, parts of the billowing cloud collapsed to feed small pyroclastic flows. At the same time, giant bombs were landing at least 1 km distant, while tremors shaking the cone were triggering small landslides of the recently-deposited pyroclastics. Just before 18:00, the volcano again paused abruptly. The calm was disconcerting, but lasted only three hours. At 21:00, two new eruption columns (indicating two vents) pulsed from the cone, finally bringing to an end the paroxysmal phase of the eruption before 23 March.

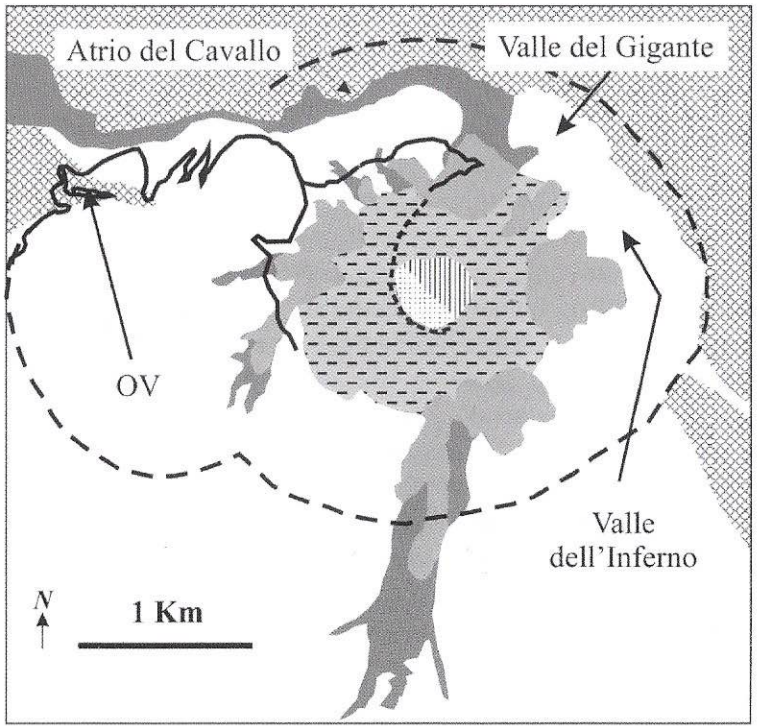


Figure 4. Principal features in the summit region of Somma-Vesuvius. The region is bordered to the north (*top*) and east by products from Somma (*cross-hatched*) and, elsewhere, by historical lava flows (*white*). The 1944 lava flows (*dark grey*) are overlain on the Vesuvius cone by tephra (*dashed*) and debris slides (*medium grey*). The large dashes outline the trace of the Somma caldera. *OV* shows the Osservatorio Vesuviano museum.

The waning stage of the eruption continued for the following five days. During this time the throat of the volcano appears to have been repeatedly blocked by crater collapse, allowing accumulation of gas pressure beneath and the sudden expulsion of the blockage and underlying magma. The resulting ash clouds commonly rose to beyond 2 km. Violent shaking continued to dislodge further loose material that collapsed down the cone has hot debris flows (Fig. 4).

The shaking had noticeably decreased by the end of 27 March and, from the 29th, activity was virtually confined to the lazy expulsion of ash following collapses within the crater.

Altogether, the eruption expelled about 35-40 million m^3 of magma, mainly within the first 4.5 days. Despite its modest size, the outburst cost more than the buildings engulfed by the lava flows in Massa and San Sebastiano. Forty-seven people were killed, most of them crushed as roofs (as far away as Nocera and Pagano, beyond Pompeii) collapsed beneath the weight of accumulated scoria and ash. Three died at Terzigno having been struck by large scoria – over 4 km from Vesuvius – while two were killed in a steam blast provoked by the lavas advancing through San Sebastiano. Insidiously, volcanic carbon dioxide escaping through the soil, especially from dry wells, continued to collect in pockets until the end of 1944. Many animals were killed after wandering into pockets of the gas collecting close to the ground, and parents were advised to carry babies and young children at chest height. Already, though, a horrible example had been given in Ercolano on 24 March when, taking cover from an air raid, two people had suffocated to death in their basement shelter.

The death of a town

The slow destruction of houses in Massa and San Sebastiano was graphically described by an unnamed correspondent for the Times of London[1]. The report (printed on but filed before 22 March) well captures the helplessness when dealing with volcanic eruptions.

"The progress of destruction is almost maddeningly slow. There is nothing about it like the sudden wrath of devastation by bombing. The lava hit the first houses in San Sebastiano at about 2.30 a.m., but by dawn it still had not crossed the main street, only 200 yards away, but was nosing its way through the vines and crushing down the small outhouses more slowly than a steam-roller.

[1] Norman Lewis gives another eyewitness account in his book *Naples '44*.

As it gradually filled up the backyards of houses on the village street the flow seemed to pause. Very slowly the glowing mass piled itself up against the walls with all its weight. For a while it seemed as if it would engulf the houses as they stood but then, as the weight grew, a crack would appear in the wall. As it slowly widened first one wall would fall out and then the whole house would collapse in a cloud of rubble over which the mass would gradually creep, swallowing up the debris with it.

Every now and then what looked like a geyser would suddenly spout as the molten rock engulfed a well and created a pocket of steam under pressure. Masses of steam of slightly darker quality rose as cellars full of casks of wine exploded. Over all one heard a steady cracking as the monster consumed *hors d'oeuvre* of vine stalks, olive trees and piles of faggots stored in backyards, while slowly digesting other morsels. ...

People show an apparent indifference to the disaster which is remarkable. I had expected scenes of panic, of wailing women and distracted fathers of families. There was nothing of this. Groups gathered to watch the slow immolation of the village as if it were a casual bonfire. The village doctor turned aside from saving some of his possessions to show me a good vantage point for the view.

There have even been touches of humour. We were watching the lava preparing to swallow a house which bore, somewhat unnecessarily in the circumstances, the Fascist slogan "*Viva pericolosamente*" (Live dangerously). Presently the house collapsed. As the dust-cloud subsided a mongrel collie suddenly emerged from the masses of plaster. It shook itself and dashed to safety. It had lived up to Mussolini's injunction."

The future

Vesuvius has been quiet since 1944. It will erupt again - but when? For the past 25,000 years, it has been reawakened by plinian eruptions every few thousand years (Table 1) and, in between, by explosive eruptions tens times smaller (so-called subplinian eruptions) at intervals of centuries. The subplinian eruptions have,

in turn, been followed by periods of mainly lava effusion. The last plinian eruption occurred nearly 2,000 years ago (79) and the last subplinian eruption about 400 years ago (1631). Hence, the volcano today lies within the return times of both types of eruption. The 64,000 dollar question is which will it choose?

When Spartacus led a rebellion of gladiators in 73-71 BC, he established a camp inside Somma's summit caldera. Under seige, they escaped through crevices down twisted ropes of vine-branches – already the forests on the volcano's slopes were being replaced by vineyards.

Blame Culture

Glenn Marshall, Private Eye.

Rediscovering Pompeii

Buildings from Pompeii were discovered in the 16th Century during construction of an underground canal through the "Civita Hill" to redirect the course of the Sarno river for land reclamation. Two centuries were to pass before concerted excavations began, to reveal that the Civita Hill was the burial mound of Pompeii.

The journalist Vittorio Paliotti has offered a more colourful reconstruction in his 1981 book, Il Vesuvio: Una Storia di Fuoco:

"I've found a phallus! A bronze phallus, a great big one! Come and see; it's in my vegetable garden. I was planting some seeds when I found pieces of an old wall, then a three-legged stand and, right next to it, a phallus. All of you, come and have a look!"

These were the words, uttered by a country farmer in 1745, that launched the excavation of Pompeii. The farmer obviously didn't exclaim the word "phallus", which I have used to spare readers' blushes. The fact remains, though, that if the farmer had found just a three-legged stand, the discovery would not have passed by word of mouth until it had reached Naples and the Court of Carlo III, who commanded the start of further excavations.

Excavations had already been underway for some years along the coast at Herculaneum. However, the ground at Herculaneum was more difficult to dig through and so efforts soon became concentrated at Pompeii. At this time, William Hamilton - nascent volcanologist, vase collector, UK ambassador to the Court of Naples and patient husband of Emma - noted the difference in the material being dug out. He recognised that the comparatively loose accumulations of pumice at Pompeii had probably rained down from an eruption column and, hence, that the harder deposits at Herculaneum had been produced under different conditions. He speculated that the material at Herculaneum had flowed over the ground and so likened the process to a mud flow. We know today that the flows were pyroclastic flows – but the concept of "pyroclastic flows" only became established 150 years after Hamilton's studies.