Uncovering Vesuvius, Pompeii and ancient Naples: Italy

Pre-tour reading list

Written below are a selection of *New Scientist* articles which will give you some insightful context into the themes of the tour and the places you will visit, before you begin your journey with us.

They are by no means mandatory to read but will give you a flavour of the context and research conducted on the topic over recent years.

Best wishes,
New Scientist Discovery Tours

Pompeii's streets show how the city adapted to Roman rule

Pompeii only came under Roman control around 160 years before its destruction – and its traffic-worn streets show how the locals adjusted their business operations

By Colin Barras

17 February 2025

Cart wheels left deep ruts in the stone streets of Pompeii
imagoDens/Shutterstock

A close look at Pompeii's stone-paved streets has shown how traffic through the ancient city changed dramatically after it was incorporated into the Roman world.

Although often seen as a quintessentially Roman place, Pompeii was anything but. For several centuries it was actually governed by a different people known as the Samnites – and even after it fell to the Romans in 89 BC, Pompeii retained traces of its Samnite identity right up until its destruction by the eruption of Mount Vesuvius in AD 79.

"If I was visiting Pompeii in AD 78, it would have had a very different character than a city closer to Rome," says David Picker-Kille at Florida State University.

Despite this, however, life in Pompeii did change after it became a Roman colony, says Picker-Kille. He has concluded that traffic patterns shifted – potentially evidence of local entrepreneurs reorganising their business operations to cater to Rome's vast trade networks.

His conclusion came in part from the fact that the Samnites and Romans had slightly different measurement systems. Crucially, these differences are significant enough that we can tell whether pairs of wheel ruts worn into Pompeii's streets were left by Samnite-style or Roman-style carts.

Using this fact, Picker-Kille discovered that ruts in the streets around Pompeii's northern city gate – which faces Vesuvius – were typically left by Samnite-style carts. Ruts in the streets around Pompeii's southern gate – which faces the Sarno river – were typically left by Roman-style carts.

This doesn't tell us when those different carts were in use – but there are clues from a recent analysis of Pompeii's streets led by Eric Poehler at the University of Massachusetts Amherst. With colleagues, Poehler built up a detailed picture of how Pompeiians repaired their streets in response to the wheel rut damage caused by carts.

After studying this evidence, Picker-Kille realised it showed that the streets around the northern city gate were most heavily used and repaired in the decades just after Pompeii became a Roman colony. The streets around the southern gate, in contrast, were most heavily used later in Pompeii's history, shortly before the eruption of Vesuvius.

Collectively, this suggests Pompeii's traffic changed from being mostly Samnite-style carts entering the north gate to being mostly Roman-style carts entering the south gate. "We're seeing this shift affecting different kinds of vehicles used in different areas of the city," says Picker-Kille.

He suspects this reflects Rome's influence. Under Samnite rule, Pompeiians had traditionally farmed on the fertile lands around Vesuvius to the north of Pompeii. After the Romans took over, Pompeiians might have preferred farming on lands to the south so as to be nearer to the Sarno river, on which archaeologists suspect there was a port that tapped into Rome's maritime trade network.

"I think it's an innovative and important study," says Ivo Van der Graaff at the University of New Hampshire. He is impressed with the way Picker-Kille used evidence from within Pompeii to understand the relationship between the city and its surrounding countryside. "Much of the Pompeiian countryside is still buried and out of reach," he says.

Has a volcanic eruption ever wiped out a species of hominins?

Volcanoes have been proposed as the reason for the extinction of the Neanderthals and the hobbits of Indonesia, but the end of those species may not have come from a single, dramatic event

By Michael Marshall

13 January 2025

Erta Ale Volcano in Ethiopia
Shutterstock/Tatyana Druzhinina

So, volcanoes are scary. I have vivid memories of visiting Pompeii and Herculaneum with my parents and seeing the twisted preserved corpses of people that were buried under the pyroclastic flow from Vesuvius. The people in question lived in what was, at the time, one of the most technologically advanced societies on the planet – yet they died in their thousands. Volcanoes are one of those phenomena that serve to remind us of how small we are, and remind us to treat nature with due caution and awe.

No doubt prehistoric peoples also died in volcanic eruptions. There are more than 100 active volcanoes in Africa, where humans evolved. They include Erta Ale in Ethiopia, one of the few volcanoes in the world that has a lava lake like you might see in the movies, and which lies in the Afar Region where many key hominin fossils have been found. As hominins migrated beyond Africa, they found their way to many volcanically active regions, such as Italy, Indonesia and South America. Some of those people, surely, got toasted.

However, what I want to get into is whether volcanoes have ever done more than kill a few unlucky souls who happened to be nearby when they erupted. Has a volcanic eruption ever caused the extinction of a hominin species? There have been plenty of claims of such apocalyptic eruptions. As we'll see, volcanoes have been linked

to the extinctions of the Neanderthals and the hobbits – and one eruption was claimed to have taken our own species to the brink of extinction. But as we'll see, there's reason to be sceptical about all these ideas.

Volcano go boom

Of course, over the course of Earth's history there have been examples of volcanic eruptions causing extinctions. The end-Permian extinction 252 million years ago was the worst mass extinction of the last half-billion years: it seems to have been caused by massive volcanic eruptions in what is now Siberia, which disrupted the chemistry of the oceans and atmosphere. The later end-Triassic extinction has also been linked to volcanic eruptions.

In both cases, the extinctions don't occur because of the immediate impacts of the eruptions, like lava flows. These effects are too localised to cause widespread harm. The problems arise because the eruptions alter the climate and environment, sometimes across the entire planet. Only the biggest eruptions can do this.

One type of huge eruption is a large igneous province. This is when there are lots of ongoing eruptions over a wide area, sometimes lasting over a million years. The eruptions that caused the end-Permian extinction were a large igneous province. However, the most recent one happened in North America up to 16.7 million years ago – long before hominins evolved. So large igneous provinces aren't in the frame for causing any hominin extinctions.

The other type of mega-eruption is a supervolcano: a single discrete eruption that goes off with spectacular force, far larger than a normal eruption. A supervolcano eruption can cover a vast area with ash and cool the climate for years. There has not been a single supervolcano eruption in recorded history. The most recent was the Oruanui eruption of the Taupō volcano on the North Island of Aotearoa, or New Zealand, more than 25,000 years ago – millennia before humans reached the islands.

However, there have been several supervolcano eruptions during the 7 million years that hominins are known to have existed. Fortunately for our ancestors, most of them were in the Americas and happened before anyone got there. The Yellowstone supervolcano went off 8.7, 6.0, 4.5, 2.1 and 0.6 million years ago, and supervolcanoes in Argentina, Bolivia and Chile also erupted within the last 7 million years. However, there is no evidence that any of these had any effect on hominins.

And so we come to the Toba supervolcano, and the Toba bottleneck hypothesis.

The Toba caldera on northern Sumatra
NASA/GSFC/MITI/ERSDAC/JAROS; U.S./Japan ASTER Science Team

Close to the brink

Today, Toba is a lake on the island of Sumatra in Indonesia. But 74,000 years ago it was a supervolcano that went off with spectacular force, releasing perhaps 2500 cubic kilometres of magma – which is almost double the volume of Mount Everest. Some researchers argue that the ensuing "volcanic winter" caused a population crash in our species, Homo sapiens, to the point that only about 10,000 of us survived.

This idea has an unusual history. The first person to propose it seems to have been science journalist Ann Gibbons, in a news story in Science in 1993. Gibbons was writing about genetic research that showed there was relatively little genetic variation in modern humans: this pointed to a population crash around 70,000 years ago, followed by rapid population growth around 50,000 years ago. In her story, she linked this to the Toba supervolcano, suggesting that it "triggered a climate change that made life tough for early humans about 70,000 years ago".

To be clear, Gibbons did nothing wrong: she joined the dots in a reasonable way and made clear that this was just a suggestion, not a hard fact. Subsequently, researchers took up the idea. However, in the subsequent three decades the evidence has turned against the Toba bottleneck hypothesis.

For one thing, it's not clear that the eruption's climate impacts were powerful and long-lasting enough to cause major harm. Worse, there is no sign of animal extinctions – and if adaptable modern humans were badly affected, why weren't other creatures? Furthermore, archaeological digs in India show modern humans living similar lifestyles before and after the ash fell, and a site in Ethiopia seems to record a couple of dry years, to which humans adapted. Finally, the genetic bottleneck seems to be less to do with population shrinkage and more to do with a "founder effect" – basically, one small population in Africa expanded into the rest of the world, carrying

their genetic traits with them. But this doesn't mean the total human population at that time was especially small.

Mount Doom

Leaping forward in time a few millennia, we come to the hobbit extinction. Homo floresiensis were small-bodied hominins, barely a metre tall, that lived on the island of Flores, also in Indonesia (but further east). They seem to have lived there between 190,000 and 50,000 years ago.

In 2018 I reported on research that showed several large animals disappeared from the Flores fossil record at the same time as the hobbits, 50,000 years ago. The losses included dwarf elephants, which seem to have been crucial for the ecosystem: hobbits and other animals ate them. The researchers found traces of a volcanic eruption that caused a pyroclastic flow 50,000 years ago, which may have killed off the elephants and damaged the ecosystem.

However, even the researchers themselves did not pin the hobbit extinction solely on the volcanic eruption: the dwarf elephants and hobbits had survived many big eruptions before. Instead, they pointed to the arrival of modern humans, with their more advanced hunting techniques, as a possible factor in the extinction of the elephants – and thus the hobbits.

Earlier this month, New Scientist contributor Christa Lesté-Lasserre reported on a reconstruction of changing rainfall patterns on Flores. This revealed a long-term drying trend just before the extinctions, which may have created intolerable pressures on the elephants and hobbits.

This is a tangled tale and we can't yet untangle it. I would not be surprised if the volcanic eruption was a factor in the hobbit extinction – but I think it would have been the straw that broke the camel's back, not the ten-tonne weight that weakened it.

Neanderthals versus volcanoes

And so we come, finally, to the most famous hominin extinction of all: the Neanderthals. After living in Europe and Asia for hundreds of thousands of years, the Neanderthals disappeared – probably around 40,000 years ago, although there are claims that isolated populations survived a bit longer.

In December, I wrote about a pair of studies that used ancient genomes to reconstruct the interbreeding between Neanderthals and modern humans. It turns out this happened between 50,500 and 43,500 years ago, probably somewhere in the eastern Mediterranean. A few millennia later, the Neanderthals died out – and so, it seems, did the few modern human populations that had made it into Europe by that time.

During the press conference about the studies, Johannes Krause at the Max Planck Institute for Evolutionary Anthropology in Germany offered an explanation for the demise of the Neanderthals and modern humans in Europe. You guessed it: a volcano.

Or rather, a supervolcano. Under the Bay of Naples in Italy, there lies a huge magma chamber called Campi Flegrei. This erupted in a big way around 39,000 years ago, in what's now called the Campanian Ignimbrite eruption, and which covered much of eastern Europe with volcanic ash. Krause speculated that the Campanian Ignimbrite eruption wiped out both the last Neanderthals and the small Homo sapiens populations in Europe at the time – something a few other researchers have suggested over the years.

I'm intrigued but cautious. For starters, the timing doesn't seem quite right. If we take the dates at face value, the eruption was 1000 years after the last confirmed appearance of the Neanderthals, so it was too late to matter. That said, both the dates have uncertainties.

The geography is perhaps a bigger issue. The debris from the eruption seems to have mostly spread east, falling out over eastern Europe north of the Black Sea and out into what is now Russia. Meanwhile, the last Neanderthals were in western Europe – which was spared the worst impacts.

There's probably something quite revealing about human psychology in our tendency to look for single, dramatic causes for extinctions – which conservationists will tell you are almost always caused by multiple factors. Our Human Story's editor Chelsea Whyte wrote a story in 2022 about the "Cat Gap": a period of over 6 million years when cat-like animals disappeared from North America. It was tentatively linked to a big volcanic eruption, but it turned out other factors like climate change and lack of food were more important.

Dangerous as volcanoes are, I remain unconvinced that they have ever wiped out a hominin species. Hunter-gatherer populations are too mobile and dispersed to be killed en masse by eruptions.

In fact, there is evidence that hominins regularly lived near volcanoes and climbed them shortly after they erupted. On the Roccamonfina volcano in Italy, there are footprints preserved in solidified volcanic ash from 385,000 to 325,000 years ago. We can't be sure who made them, although Neanderthals are good candidates. There are no children, suggesting the adults knew the area was dangerous. However, they seem to have been walking at a relaxed speed – and some of them were heading uphill.

Ancient Herculaneum scroll piece revealed by AI – here's what it says

A Greek philosopher's musings on pleasure, contained in ancient papyrus scrolls buried by Mount Vesuvius's eruption 2000 years ago, have been rediscovered with the help of AI

By Jeremy Hsu

5 February 2024

The winners of the Vesuvius Challenge grand prize used technology to decipher a damaged papyrus scroll
Vesuvius Challenge

Artificial intelligence has helped decipher an ancient papyrus scroll, which was transformed into a lump of blackened carbon by volcanic ash from Mount Vesuvius in AD 79. The first passages of readable text reveal never-before-seen musings from a Greek philosopher.

The discovery nabbed the $700,000 grand prize in the Vesuvius Challenge, and used a combination of 3D mapping and AI techniques to detect ink and decipher letter shapes within segments of scrolls known as the Herculaneum papyri, which had been digitally scanned. The combined efforts of the winning team members – Youssef Nader, Luke Farritor and Julian Schilliger – could pave the way for more discoveries from additional papyrus scrolls that were once housed in a library in the ancient Roman town of Herculaneum.

"I think it's going to be a huge boon to our knowledge of ancient philosophy, just gigantic – a staggering amount of new text," says Michael McOsker at the University College London, who was not involved in the discovery.

The winning submission met the Vesuvius Challenge criteria of deciphering more than 85 per cent of characters in four passages consisting of 140 characters each – and as a bonus, it included another 11 columns of text for a total of more than 2000 characters.

Those rediscovered Greek letters reveal the thoughts of Philodemus, who is thought to have been the philosopher-in-residence at the library that housed the Herculaneum papyri. The deciphered text focuses on how the scarcity or abundance of food and other goods impacts the pleasure they deliver. That fits Philodemus's Epicurean school of philosophy, which prioritised pleasure as the main goal in life. His 2000-year-old writing even appears to possibly take a dig at the Stoic school of philosophy that has "nothing to say about pleasure".

And the Vesuvius Challenge isn't over. Its 2024 goals include figuring out how to scale up the 3D scanning and digital analysis techniques without becoming too expensive. The current techniques cost $100 per square centimetre, meaning that it could cost between $1 million and $5 million to virtually unroll an entire scroll – and there are 800 scrolls waiting to be deciphered.

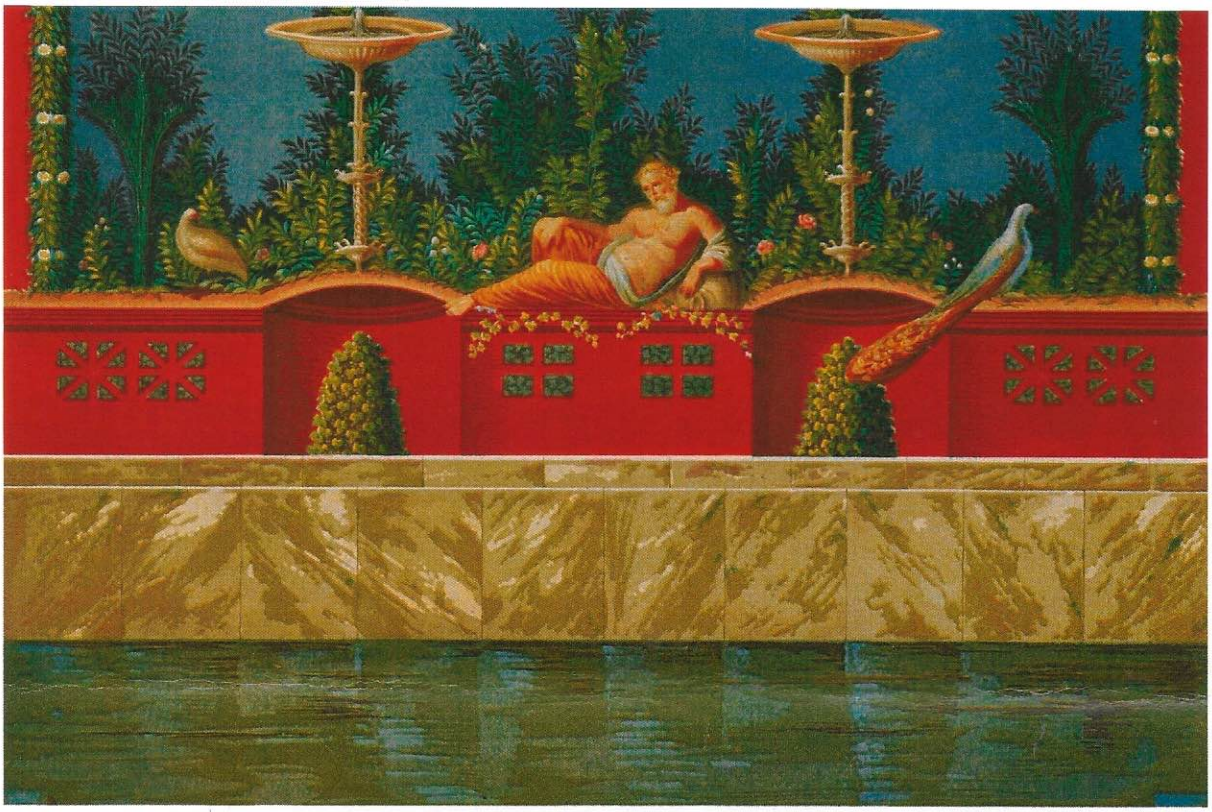
"Realistically, the vast majority of the known, already unrolled library is Epicurean philosophy and that's what we should expect, but there are also important Stoic texts, maybe some history and some Latin literature. Complete texts of authors like Ennius or Livius Andronicus, early Roman authors [whose works] did not survive, would be great," says McOsker. "Epicurus's Symposium, in which he wrote about the biology of wine consumption, would be a lot of fun."

Pompeii's public baths were unhygienic until the Romans took over

Before the Romans captured Pompeii, the famous town was run by the Samnite people – and a dip in their public baths might have been an unpleasant experience

By Colin Barras

12 January 2026



The Stabian Baths, one of the bathhouses first built by the Samnites in Pompeii
Icas94/De Agostini via Getty Images

A trip to Pompeii's public baths meant taking a dip in water contaminated with sweat and urine – until the Romans took over and sanitation improved.

It's easy to think of ancient Pompeii as a typical Roman city, particularly given that it lies only around 240 kilometres to the south-east of Rome itself. But for a large chunk of its history, Pompeii was occupied by the Samnite people, who had a distinct culture. It was only after 80 BC that it became a Roman colony, just 160 years before the city was buried under volcanic ash when the nearby Mount Vesuvius erupted.

Like the Romans, however, the Samnites seem to have been keen on bathing. They built at least two public baths – now known as the Stabian Baths and the Republican Baths – sometime after 130 BC.

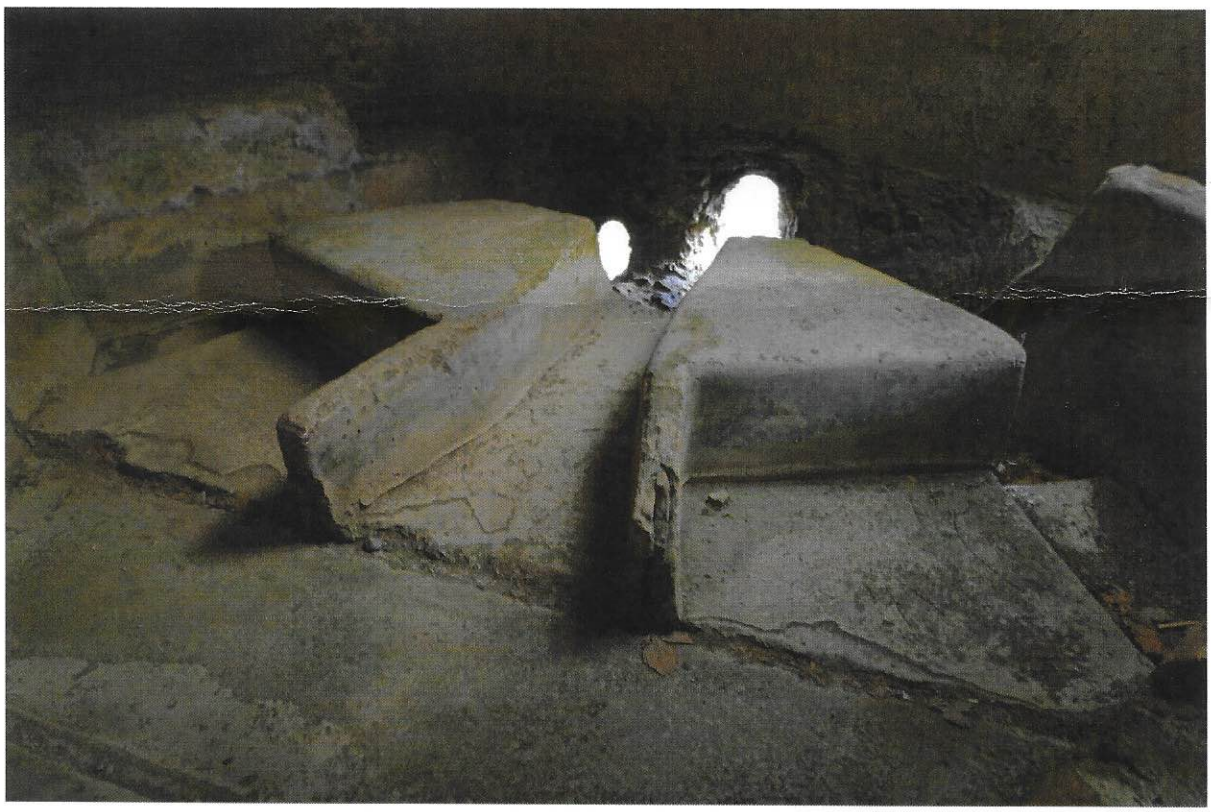
Gül Sürmelihindi at the University of Mainz in Germany and her colleagues have now analysed mineral deposits in the bathhouses to gain a clearer insight into the quality of the water that once filled their bathing pools.

It turns out that the water quality could have been better. "Water in the hot pool of the Republican Baths had low stable carbon isotope values, indicating the presence of abundant organic matter," says Sürmelihindi.

Significantly, when the researchers analysed mineral deposits in the 40-metre-deep wells that fed the pools, they found little sign of organic matter. "It means that the contamination must have taken place in the pools," Sürmelihindi says – almost certainly from sweat, oily sebum produced by the skin, and even urine left by the bathers.

There's probably a good reason for this, according to the researchers. Pulling water from the deep wells using a system of buckets was slow and laborious work, and they estimate that only between 900 and 5000 litres could have been drawn each hour. This was enough to replenish the water in the baths just once or twice per day.

But things changed under Roman rule. Within a few decades, the Romans had built an aqueduct to supply Pompeii with water from natural springs about 35 km to the north-east of the town. "We have the impression that building an aqueduct was a priority, but also a matter of prestige: if one city had one, the other would also want one," says Sürmelihindi.



Interior of the water castle, the water distribution structure of the aqueduct of Pompeii
Cees Passchier

The researchers estimate that the aqueduct supplied Pompeii with 167,000 litres of water each hour – enough to replenish the public baths far more frequently, as well as provide Pompeii's residents with a new and convenient supply of drinking water.

In line with the idea that public bathing became more hygienic, Sürmelihindi and her colleagues found that mineral deposits in the Roman-era drains from the Stabian Baths contained much less organic carbon, suggesting that any sweat and urine in the water was present at a much lower level because of more frequent replenishing of the bathing pools.

However, this doesn't necessarily mean that Pompeiians enjoyed a health boost from the new aqueduct. Before its construction, most people drank rainwater collected in tanks connected to the roofs of the city's buildings. Afterwards, many got their drinking water from the aqueduct via a network of lead pipes that ran through the city. Lead, a poison that can damage the brain, could then leach from the pipes and into the water.

The contamination should have lessened over time, because mineral deposits eventually coat the inside of the pipes so that the water is no longer in contact with the lead. But some researchers suspect that whenever sections of the city's plumbing were repaired with fresh piping, lead contamination would spike again.

"Pompeii's elite were probably better off, since they lived in houses with large atria with inward-sloping roofs that funnelled rainwater into a cistern," says Duncan Keenan-Jones at the University of Manchester, UK. "Poor people who may have lived in their shops were more reliant on the lead-contaminated water from streetside fountains."

Pompeii building site reveals how the Romans made concrete

Excavations of a workshop that was buried in Pompeii almost 2000 years ago have given archaeologists unique insights into Roman construction techniques and the longevity of the empire's concrete

By James Woodford

9 December 2025

Ceramic roof tiles and tuff blocks excavated at an ancient building site in Pompeii
Archaeological Park of Pompeii

A newly excavated, ancient construction site at Pompeii, frozen in time after the eruption of Mount Vesuvius, has allowed archaeologists to finally determine the methods used to make Roman concrete.

Pompeii, near the modern city of Naples, Italy, was buried and preserved under volcanic ash in AD 79. Excavations on the building site first began in the 1880s before being halted until early 2023, when a major new dig was undertaken.

Following the new excavations, archaeologists discovered a near perfectly preserved concrete workshop, complete with marks on the walls detailing work schedules and material quantities. Concreting tools and piles of quicklime were also found, along with recycled roof tiles.

Admir Masic at the Massachusetts Institute of Technology says the team was stunned at how "exceptionally well preserved" the site was and that it offered an opportunity to understand Roman concreting methods in a way that "no laboratory reconstruction could ever replicate".

"The materials were exactly as they were at the moment the eruption froze the city in time," says Masic. "Studying it truly felt as if I had travelled in time back to 79 CE and was standing beside the workers as they mixed and placed their concrete."

The team's findings suggest that a long-held belief about how Romans made their concrete will now need to be revised.

Historical texts reported that Romans used slaked lime – calcium hydroxide – to make concrete, and mixed the lime with water before adding it to other ingredients, such as volcanic ash.

However, chemical analysis of the dry, pre-mixed piles found in the Pompeii workshop shows that the ancient concreters were, in fact, using a hot mixing method involving quicklime, or calcium oxide. This involved mixing the lime with all other ingredients, including volcanic ash or a mineral called pozzolan before adding the water, and a chemical reaction heated up part of the concrete as it set.

"Our evidence shows that quicklime played the primary role in the structural concrete," says Masic. "Slaked lime, by contrast, was generally used for finishing mortars and plasters, where workability and smooth surfaces were essential.

One of the benefits of the hot mix method is that fragments of lime, called clasts, remain in the concrete after it sets, allowing for continuous self-repair of cracks and other minor structural faults.

"These lime clasts act as calcium reservoirs, dissolving and recrystallising in pores and cracks or reacting with volcanic ash to strengthen concrete microstructure," says Masic.

A modern concreter would have understood the Roman concreting process in Pompeii and could have easily entered the workshop and almost immediately set to work, he says. "The chemistry is ancient, but the craft is recognisable."

We're finally reading the secrets of Herculaneum's lost library

A whole library's worth of papyri owned by Julius Caesar's father-in-law were turned to charcoal by the eruption of Vesuvius. Nearly 2000 years later, we can at last read these lost treasures

By Hayley Bennett

14 October 2025

Joe Wilson

Deep within a particle accelerator, theoretical physicist Giorgio Angelotti is hard at work. He sets a black cylinder on a mount, bolts it down, then runs through some safety checks before retreating from the chamber, known as "the hatch". "You have to be sure there's no one in the hatch before you close the door," he says. "So no one dies."

That's because he is about to blast the sample with a super-powerful beam of X-rays. You might expect the target to be some advanced new material or delicate crystal. But, at its heart, this isn't really a physics experiment – and the object protected inside the cylinder is far from pristine. You could easily mistake it for a misshapen lump of old charcoal.

It is in fact a priceless relic, a 2000-year-old papyrus scroll, scorched beyond recognition in the cataclysmic eruption of Vesuvius in AD 79. It is just one of the Herculaneum papyri, a cache of hundreds of scrolls that are too fragile to be opened by hand, meaning their contents have long remained a mystery. But with the help of particle accelerators, artificial intelligence and a crack team of coders assembled online, Angelotti and his team are starting to make these charred lumps talk. They could soon be uncovering entire lost works of Greek philosophy, or texts written by the earliest Christians.

Discovered near Angelotti's home city of Naples, Italy, in the 1750s, the scrolls come from the library of a partly excavated, 1st-century-BC villa in Herculaneum. The town, a smaller neighbour of Pompeii, was once a seaside

holiday destination for rich Romans. The luxurious villa is thought to have been owned by Roman senator Lucius Calpurnius Piso Caesoninus – none other than Julius Caesar's father-in-law.

At least some of the 900 scrolls originally discovered were authored by the philosopher Philodemus of Gadara, one of those credited with bringing Epicurean philosophy from Greece to Italy. Classicist David Blank at the University of California, Los Angeles, explains that Philodemus had joined Piso's entourage, a cohort whose intellectual prowess publicly signalled the senator's importance. In turn, Piso became a patron of Philodemus's work, ensuring that a lot of his philosophical writings, including unique early drafts, ended up in Piso's personal collection.

The Herculaneum papyri

Piso and Philodemus had been dead for decades when Mount Vesuvius blew, but the library remained. As hot mud and ash engulfed Herculaneum, heat dehydrated the scrolls, not burning them, but turning them to charcoal. "The fact they are carbonised is the only reason we have them," says papyrologist Federica Nicolardi at the University of Naples Federico II. Papyrus normally survives only in very dry climates. Other European examples rotted away centuries ago.

The Piso collection has since dwindled, however. The papyrus layers are tightly stuck together and early attempts to unwrap them resulted in a great many being mashed, sliced, peeled and otherwise processed in ways papyrologists would rather save for potatoes. Starting in the 1750s, the scrolls' first curator, a man named Camillo Paderni, bashed out their insides to leave just the exterior layers. "He would take the roll, cut through it... then take the butt end of his knife and pound the middle of the roll into dust," says Blank.

The Herculaneum papyri were turned to charcoal in the AD79 eruption of Mount Vesuvius. This one is known simply as "scroll 2"

The Digital Restoration Initiative, The University of Kentucky

A little later, Antonio Piaggio, a manuscript restorer from the Vatican Library, subjected some of the scrolls to a homemade machine. By mounting each scroll and sticking the end of the papyrus to a sheet of animal guts using glue made from fish, he was able to carefully unroll about 18 of them. These early abuses did yield several volumes' worth of readable texts. This is how we know that at least some of the scrolls were authored by Philodemus. But most of the charcoal lumps languished unread in the National Library in Naples.

And that was how things stood for centuries, until Brent Seales at the University of Kentucky entered the frame. Seales had lived through the early wave of digitisation, when the internet was becoming a repository for knowledge of all kinds. He wasn't much interested in the mass scanning of ordinary books, but he became gripped by the notion that parts of this global library might be left out due to damage to the physical works. "The idea that technology could create a representation of, or even extract new information from, the damaged stuff – that really appealed to me," he says.

In 2000, Seales used 3D scanning and computer software to digitally uncrumple and flatten pages from fire-damaged medieval documents amassed by Sir Robert Cotton, part of the founding collection of the British Library. Some books in the trove, however, were too fragile to be opened, so couldn't be restored using standard imaging techniques, which are based on visible light. Seales began to wonder whether the same methods we use to see inside bodies could be used to see inside books.

The first time he fired X-rays at a book from the Cotton collection, the ink showed up much like bones do in the black and white images, he says. Immediately, he wanted to get his hands on other collections containing unopened texts, and his thoughts turned to the most famous example he knew of: the Dead Sea Scrolls. But when Seales described his plan to conservators, he was met with a "hell no". Meanwhile, the Herculaneum scrolls entered his radar, courtesy of a tip-off from classicist Richard Janko at the University of Michigan, who had studied the contents of some of the physically opened scrolls.

These particular papyri, though, presented some special challenges. For one thing, unlike medieval writers, who used metallic inks, Philodemus and his contemporaries often wrote in soot-based ink. That meant the challenge was to discern an ink made mostly of carbon from a scroll that was also now mostly carbon. It wasn't exactly easy. Sure enough, Seales failed to find any ink in initial attempts with a small CT scanner in 2009.

Herculaneum was once a holiday destination for wealthy Roman citizens
CCinar/Shutterstock

Many Hebrew and Egyptian scribes used easier-to-image metallic inks. By 2015, Seales was able to read unseen text inside a charred 4th-century-AD Hebrew scroll. And not long after, a European team including Verena Lepper at Berlin's Egyptian Museum and Papyrus Collection used X-ray-based scans to read the words "oh Lord" inside an ancient papyrus package from the island of Elephantine on the Nile river. But scans from inside the Herculaneum scrolls still hadn't revealed a single word.

The digital unwrapping process wasn't straightforward, either. The papyrus layers are so jammed together that it is tricky to peel them apart, even virtually. If the software doesn't know the difference between one layer and the next, Nicolardi explains, "you produce something that's actually very similar to what happens with the mechanically opened scrolls". Pieces of text get spliced between layers, mangling the narrative.

By then, though, AI was on the rise and machines were starting to pick out features that human couldn't. It turned out that scans of the Herculaneum papyri were, in fact, picking up ink, but it was visible only to properly configured AI. Seales and his colleagues finally demonstrated this on unrolled Herculaneum fragments and fake scrolls inscribed with carbon ink in 2019. That was enough to help secure them use of the particle accelerator at Diamond Light Source near Oxford, UK. He used it as a supercharged CT scanner and obtained images of the insides of rolled-up, intact papyri. But still the scrolls taunted them. Seales's student Stephen Parsons taught AI software to spot ink on these high-resolution scans, but it struggled to see anything beyond mere traces.

That was when things changed decisively. Seales had connected with tech investor Nat Friedman, previously CEO of Github, hoping to pitch for more research funding. But Friedman had a different idea: put out a public challenge to see if anyone could write a program that could read the scrolls. Seales initially struggled with the proposal. This kind of cash-for-code challenge might be commonplace in the tech world, but for academic researchers it was unfamiliar territory – and it meant opening the scan data and Parsons's algorithms to a wider community. "It

wasn't an obvious right move for me," says Seales. "But we realised the only reason we were balking at the idea is that we might not get all the credit, and that was a really bad reason."

The Vesuvius Challenge

And so, in March 2023, the Vesuvius Challenge was born. Any prize-winning solutions would become public, the code released for the team or others to build on, in the hope that this would speed things up a bit. And so it proved: by Christmas, the challenge's Discord channel had more than 1000 users.

Angelotti was one of them. Fresh from a doctorate in AI, he had barely heard of the Herculaneum scrolls, despite being born and bred in Naples. But the more he learned about them, the more they intrigued him. Between consultancy work and founding an AI start-up, he poured over digitised papyrus sheets online. As he knew nothing about papyrology, it was a steep learning curve, but it turned out to be time well spent, resulting in cash prizes including $20,000 for work to speed up image processing – and a job offer. Now the research project lead for the Vesuvius Challenge, Angelotti says reading the scrolls has become "a sort of quest to restore the cultural heritage of my homeland".

Meanwhile, students began to steal the limelight. In December 2023, ink-detection algorithms developed by Youssef Nader and Luke Farritor helped reveal around 2000 Greek characters. Nader taught AI to see ink by carefully training it on broken-off scroll fragments where the papyrus surface was already exposed. At the same time, Farritor was picking out the first word, porphyras (purple), from inside an unopened scroll by using a separate AI model trained on sections where a faint, but just visible, "crackle" pattern seemed to be associated with the inked parts.

By pooling their code and working with Julian Schilliger, a student at ETH Zürich in Switzerland who had been successfully stitching digital papyrus sheets together from pixels, they were able to get better results, not to mention a nod in a peer-reviewed papyrology paper. The translated text uncovered ancient musings on food, music and pleasure, in which the author seemed to ponder the timeless question of what makes life worth living.

Their efforts won them the Vesuvius Challenge's $700,000 grand prize in 2023 – and, for Nader, a Mount Vesuvius cake (complete with scroll) baked by his family in Egypt. He, too, has since joined the challenge team, continuing to work on ink detection. This is far from a fully solved problem, because the ink varies from one scroll to another. In the long term, the team aims to build a fast, general ink-detection software that works for everything. "So that we can, at some point, just upload a scan of a scroll and download the text," says Nader.

Students Youssef Nader, Luke Farritor and Julian Schilliger produced this prize-winning image of the text inside one of the scrolls

The unrolling problem hasn't been completely solved yet, either. Initially, the inked surfaces of the papyrus layers were painstakingly mapped to flattened sections of digital papyrus by humans. But, with help from community members like Schilliger, the team is now increasingly able to get AI to do the task, which should yield faster results.

Could solutions to these problems help researchers read other ancient papyri too? "I don't think there's one solution and there doesn't need to be," says Lepper, whose work on the Elephantine papyri used more traditional, non-AI software. Each collection has its quirks, she explains. Elephantine papyri, for example, aren't charred, but many are folded instead of rolled, which can make unwrapping them more complex.

Revealing hidden text in ancient manuscripts is no trivial task. But for the Vesuvius Challenge, at least, progress continues to accelerate "as a direct result of the contest", says Seales, his initial reservations now seemingly forgotten. Both Seales and Angelotti are optimistic that there will come a time when it is as easy as pressing a button and letting the software do the rest. Right now, though, there are still plenty of scrolls left to scan, meaning more time spent kicking around in the control rooms of particle accelerators.

When New Scientist spoke to Angelotti in mid-July, he had just finished scanning more than 30 Herculaneum scrolls at Diamond Light Source and the European Synchrotron Radiation Facility, the particle accelerator in Grenoble, France, with "the hatch". He had also been carrying out crucial experimental work, the early results of which suggest that scanning at a higher resolution may help AI see features common to ink across all the scrolls. If so, the whole collection could become imminently readable. The only problem, Angelotti groans, is that it would mean the scans take about six times longer than usual – so more hours to kill in a control room.

Meanwhile, the Vesuvius Challenge team has been preparing to release more data to its community of coders, and successes have continued to mount up. In May 2025, computer science graduates Marcel Roth and Micha Nowak at the University of Würzburg in Germany adapted medical-imaging software to read the first-ever title from within the scrolls, winning themselves $60,000. Roth says the pair got hooked on the contest, at one point skipping university for nearly three months.

And the title? Philodemus, On Vices. "We were all very happy to see it was really Philodemus," says Angelotti, because it confirmed the AI wasn't hallucinating. It is unlikely to be the last we hear from Philodemus, either, because most of the scrolls read so far seem to come from the philosophy section of Piso's vast library.

Back in the Bay of Naples, there could be many more scrolls still to excavate. After all, part of the villa remains unexplored, obstructed by 20 metres of volcano spew and messy local politics. The New Testament puts Paul the Apostle on the scene around AD 50, before his execution about a decade and a half later. Could his movements have been recorded before Vesuvius's eruption? Perhaps, "if the Herculaneum library had a current events section," quips Seales. Until recently, of course, there wouldn't have been much point in looking for such long-lost treasures, since we couldn't unlock their contents. But now that we can, there's a good argument for getting out the shovels.