

Volcano

## Would a supervolcano eruption wipe us out?

**Throughout our planet's history, massive volcanic eruptions have devastated life. Could one bring an end to human civilisation?**



**By David Cox**  
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In the Bay of Naples, Europe's most notorious giant is showing signs of reawakening from its long slumber.

Campi Flegrei, a name that aptly translates as "burning fields", is a supervolcano. It consists of a vast and complex network of underground chambers that formed hundreds of thousands of years ago, stretching from the outskirts of Naples to underneath the Mediterranean Sea. About half a million people live in Campi Flegrei's seven-mile-long caldera, which was formed by vast eruptions 200,000, 39,000, 35,000 and 12,000 years ago.

The past 500 years have been fairly peaceful ones for **Campi Flegrei**. There have been no eruptions at all since 1538, and that was a comparatively small event that resulted in the formation of the "New Mountain", Monte Nuovo. But recent events suggest that this period of quiescence may be coming to an end.

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An acceleration of processes causing deformation and heating within the caldera saw the Italian government **raise the volcano's threat level** in December 2016. Fears are growing that magma deep inside Campi Flegrei could be reaching the "critical degassing pressure", where a sudden large-scale release of volcanic gases could abruptly inject heat into surrounding hydrothermal fluids and rocks. When this happens on a significant scale, it can cause catastrophic rock failure within the volcano, triggering an eruption. In line with this, **a study published in May 2017** found evidence that the supervolcano has been building towards an eruption for decades.

But the difficult question is not if, but when, and just how big an event this would be.



The Bay of Naples was formed thanks to several enormous volcanic explosions (Credit: iStock)

"Campi Flegrei is in a critical state," says **Antonio Costa** of the National Institute of Geophysics and Volcanology in Bologna, who is part of a team monitoring the supervolcano. "In probabilistic terms, we expect something called a 'violent Strombolian eruption'. This is relatively small-scale to a supereruption. However, it's not easy to say if there will definitely be an eruption in the coming years. Campi Flegrei has not erupted during the timescale that it's been under observation, so we don't know entirely what to expect."

A violent Strombolian eruption would blast molten rock and volcanic gases a few thousand feet into the atmosphere. It would surely be a major event, potentially requiring the evacuation of hundreds of thousands of people. But in the context of Campi Flegrei's past, it would be minor.

The volcano's most notorious supereruption was the Campanian Ignimbrite eruption, which occurred some 39,000 years ago. It punched an estimated 300 cubic kilometres of molten rock 70km up into the stratosphere, along with an estimated 450,000 tons of sulphur dioxide. The ash cloud was carried as far as central Russia, some 2,000km away.

The eruption occurred at a time when much of Europe was already going through a lengthy glacial period, and the consequences are thought to have devastated much of the continent for centuries.

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*The huge quantity of sulphur dioxide released would have created a volcanic winter*

Entire swathes of land, including Italy, the Mediterranean coast and the entirety of eastern Europe, were left covered in up to 20cm of ash. This would have destroyed vegetation and created a vast desert. Much of Russia was immersed in 5cm of ash, enough to disrupt plant life for decades or more.

"We know from chemical analysis that the ash contained fluorine, which has a strong impact on vegetation, and it would have produced a disease called fluorosis in animals," Costa says. "This would have had a knock-on impact on humans."

In addition, the huge quantity of sulphur dioxide released would have created a volcanic winter. Sulphur dioxide backscatters the Sun's radiation in the upper atmosphere, preventing it from reaching the ground. The 1991 Mount Pinatubo eruption, one of the biggest of the 20th Century, did exactly this, temporarily lowering the global temperature **by around 0.6C**. But the Campanian Ignimbrite eruption may have had a far greater impact, with some scientists estimating that it

decreased temperatures in Europe by **as much as 4C**, drastically altering the climate for many years.

The timing of this huge eruption is suspicious, because many archaeologists believe that 39,000 years ago is roughly when our cousins the Neanderthals **died out in Europe**. It has long been speculated that the eruption triggered extreme environmental conditions across Europe, contributing to the extinction of the Neanderthals, at least in some regions.

However, while the impact on the Neanderthals was surely significant, many scientists now believe it is unlikely that this single event was cataclysmic enough to wipe them out. Archaeological evidence suggests that Neanderthals persisted in parts of western Europe for some 10,000 years after the Campanian Ignimbrite eruption. This may be because of the way the ash dispersed.

"After the eruption, Neanderthal archaeological sites are found only in France and Spain," Costa says. "This is probably because these two areas were not affected by the eruption at all, because the wind was blowing towards the east."



Much of eastern Europe was covered in a layer of ash from the eruptions (Credit: iStock)

There is even an argument that the eruption could have benefited the Neanderthals, by delaying the arrival in Europe of modern humans, who would have competed with them for resources. "To reach western Europe, modern humans would have had to cross the Middle East and the vast desert



created by the eruption," says Costa. "It would have taken many hundreds of years for this land mass to recover."

For now, it is unclear how much damage Campi Flegrei's last major eruption did. But it is far from the only supervolcano on the planet. Earth's geological history is a catalogue of apocalyptic-looking volcanic events.

In south-west Colorado, there is a vast canyon approximately 100km wide and one kilometre deep. It serves as the legacy of **one of the most explosive single events in the planet's history**. La Garita Caldera was formed by an eruption nearly 28 million years ago, which expelled 5,000 cubic kilometres of molten rock.

Fortunately for us, the tectonic plates in the area have since rearranged themselves, so a repeat event is impossible. But approximately 75,000 years ago in Indonesia, an eruption of similar scale occurred, and the supervolcano responsible remains active.

Situated in the midst of a mountain range in northern Sumatra, the tranquillity and natural beauty of Lake Toba makes it a popular tourist location. But this lake is actually an enormous caldera, a footprint of the most extreme climatic event in human history.

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*The colossal scale of the eruption means that volcanic gases from Toba are thought to have been ejected through both hemispheres of the Earth's atmosphere, causing them to circulate all around the world*

"The Toba eruption was frankly as big as any in the past tens of millions of years," says **Clive Oppenheimer** of the University of Cambridge, who studies some of Earth's biggest volcanos. "It's a particularly prominent one, because it's within the timeframe of modern humans, and the timing is quite critical, because it occurs around the time that humans come out of Africa and spread across Asia."

But exactly what effect this had on the human race has been the subject of much controversy.



Eruptions like those at Campi Flegrei may have helped wipe out Neanderthals in Europe (Credit: iStock)

In the 1990s, **volcanologists discovered large ash deposits** from Toba in marine sediments scattered across the Indian Ocean. The ash contained a chemical signature that could be traced back 75,000 years. Later studies found similar ash in the South China Sea, Arabian Sea and even in Lake Malawi, some 7,000km away from Toba.

The colossal scale of the eruption means that volcanic gases from Toba are thought to have been ejected through both hemispheres of the Earth's atmosphere, causing them to circulate all around the world. But exactly which gases were emitted from Toba, and in what quantities, is crucial to knowing its impact on the climate and understanding what happened next. So far back in time, this is not straightforward.

"There's an ice core in Greenland where they have a chemical record of how global temperatures went up and down over the past 125,000 years," says archaeologist **Sacha Jones** of the University of Cambridge, who has spent many years researching Toba. "Distinct layers of ice are laid down each year, and people have measured how much sulphate is in these layers. There is a large peak of sulphate, which seems to correspond to the timeframe of Toba."

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*Most of the ash from Toba is believed to have fallen in the ocean, where it would have had only minimal effects on land-dwelling species like humans*

If the Toba eruption did indeed send vast quantities of sulphur dioxide around the world, scientists have predicted it may have sparked a volcanic winter, which blackened the skies and lasted some 6,000 years. In line with this, geneticists studying patterns in human mitochondrial DNA in the early 1990s, **identified what appears to be a population bottleneck**, which occurred somewhere between 50,000 and 100,000 years ago. Many were quick to make the link to Toba.

But not everyone is so convinced.

"Over the last 10 or so years, people have become more sceptical that Toba almost killed off *Homo sapiens*," Oppenheimer says. "Magmas can dissolve and hold things like carbon dioxide and water and sulphur in different amounts, depending on the volcano. And chemical analysis of ash from Toba has found that its magma can't actually hold very much sulphur."

There is also something suspicious in the archaeological record. Indonesia, Malaysia and India are thought to have been blanketed in at least 5cm of ash from Toba, which undoubtedly affected vegetation and caused mass floods. Yet archaeological studies of ash deposits appear to show that humans were remarkably resilient to the environmental changes.

"The main signs of human activity around this time are stone tools, such as hand axes and flint tips," says Jones, who has **excavated sites** in the Jurreru Valley in Andhra Pradesh, India. "When we excavated deposits above, through and below the Toba ash layer, we didn't really see much change at all in these Stone Age technologies before and after the eruption, which suggests that it didn't really cause any mass extinction."



A supervolcano is likely to cause severe disruption to air travel (Credit: Getty Images)

The key factor may be that most of the ash from Toba is believed to have fallen in the ocean, where it would have had only minimal effects on land-dwelling species like humans. However, Jones believes that the impact was still extremely severe for some communities.

"Toba was an incredibly large eruption, so it will have had some massive effects in particular areas," she says. "The whole Pacific region in the immediate vicinity is very diverse, with lots of micro-climates. There's rainforest, desert, mountains, and people in certain areas may have suffered more than others."

But what of Toba's future? Geologists and geophysicists who study the volcano remain concerned about its magma chamber, which could be reawakened if the Sumatra fault line, which bisects the island and runs through Mount Toba, became active.

If it did, the only solution would be mass evacuation. But we do not even know how much warning we would receive.

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*If Yellowstone erupted again, some scientists think it would have more devastating consequences than Toba*



Located underneath Yellowstone National Park in the US, the Yellowstone supervolcano is one of the most actively monitored places on the globe. A variety of instruments, including seismometers to detect chains of earthquakes, GPS sensors to record how the ground swells and shifts, and even satellite images to detect pressure changes in the magma chamber, are all used to look for any noticeable trends in behaviour.

Yellowstone has had **three supereruptions in the past 2.1 million years**. The first remains one of the largest of all time, **producing 2,500 times** the volume of ash as the 1980 Mount St Helens eruption. If Yellowstone erupted again, some scientists think it would have more devastating consequences than Toba, because the majority of the ash would fall on land rather than in the sea.

"The last eruption of Yellowstone would potentially have put ash across both American continents," says **David Pyle** at the University of Oxford. "If you take a continental land mass and you suddenly cover it with 10cm of volcanic ash, all the organic matter and trees will lose their leaves and probably die. Animals will take in chemicals which are toxic to them. The ground will suddenly be much brighter than before, so a lot of the incoming solar radiation might simply be reflected back into the atmosphere, resulting in a lengthy drought."

With water supplies clogged, electricity transmission lines failing and a complete disruption in ground transport, there would be an immediate crisis.



If Yellowstone's supervolcano exploded, it could devastate the West Coast of the US (Credit: iStock)

"If Yellowstone, Campi Flegrei or Toba exploded, there would be huge economic impact across the globe, because of the way the world economy works now," Oppenheimer says. "We saw that after the relatively small Icelandic eruption [Eyjafjallajökull] in 2010. It affected supply chains for Volkswagen, because parts were coming from Japan. Global aviation could be affected for decades. If a lot of sulphur dioxide was released, this could precipitate monsoons and climate shifts, which could affect global food security."

This would all be very problematic, but scientists are sceptical that a single explosive event like this could actually wipe out humanity.

Instead, volcanologists say that another type of volcanic event may pose a much greater threat to our existence.

Over the past **500 million years**, all of the five largest mass extinctions in the fossil record have **coincided with huge lava eruptions**. These eruptions did not happen as single events, but as continuous outpourings going on for hundreds of thousands of years. They are known as flood lavas, and are caused by rising plumes of hot material from deep inside the Earth.

The most violent flood lava eruptions are thought to be associated with **continental drift**. Only 11 have taken place in the past 250 million years, each shaping vast mountain ranges, plateaus or volcanic formations. One such flood lava event took place 66 million years ago and created a huge expanse of volcanic rock called the Deccan Traps, in west-central India. These eruptions may have contributed to the mass extinction that took place at this time, by releasing cocktails of gases that slowly acidified the oceans and altered the climate.

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*While the world's volcanic hotspots are supremely well-monitored, we have no idea quite what to expect or how much warning we would receive*

The trouble is, nobody knows when the next flood lava event will occur. "We expect another flood lava event sometime in the next 50 million years, but I don't think anyone's got any idea where and when," Pyle says.

Whether we are predicting the next supervolcano eruption or the next flood lava event, the problem is the same. The former has not been observed in recorded human history, while the last major flood lava eruptions occurred 10 million years ago in southern Canada, many millions of years before our species walked the planet. As such, while the world's volcanic hotspots are supremely well-

monitored, we have no idea quite what to expect or how much warning we would receive before an event of such scale. Our tiny snapshot of monitoring time is dwarfed by volcanic cycles that can last millions of years.

We have no real idea where we are on these cycles. It is entirely possible that nothing will happen in our lifetimes, or even in the next hundred thousand years. There is only one certainty about these eruptions: they will, eventually, happen.

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