Rapid formation of bubbles in magma may trigger sudden volcanic eruptions

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Image: Hawaii Volcano Observatory (DAS)

It has long been observed that some volcanoes erupt with little prior warning. Now, scientists have come up with an explanation behind these sudden eruptions that could change the way observers monitor active or dormant volcanoes.

Previously, it was thought eruptions were triggered by a build-up of pressure caused by the slow accumulation of bubbly, gas-saturated magma beneath volcanoes over tens to hundreds of years. But new research has shown that some eruptions may be triggered within days to months by the rapid formation of gas bubbles in magma chambers very late in their lifetime.

Using the Campi Flegrei volcano near Naples, southern Italy, as a case

study, the team of scientists, from the universities of Oxford and Durham in the UK, and the Vesuvius Volcano Observatory in Italy, demonstrate this phenomenon for the first time and provide a mechanism to explain the increasing number of reported eruptions that occur with little or no warning.

The study is published in the journal *Nature Geoscience*.

Lead author Mike Stock, from the Department of Earth Sciences at the University of Oxford, said: 'We have shown for the first time that processes that occur very late in magma chamber development can trigger explosive eruptions, perhaps in only a few days to months. This has significant implications for the way we monitor active and dormant volcanoes, suggesting that the signals we previously thought indicative of pre-eruptive activity - such as seismic activity or ground deformation - may in fact show the extension of a dormant period between eruptions.

'Our findings suggest that, rather than seismic activity and ground deformation, a better sign of an impending eruption might be a change in the composition of gases emitted at the Earth's surface. When the magma forms bubbles, the composition of gas at the surface should change, potentially providing an early warning sign.'

The researchers analysed tiny crystals of a mineral called apatite thrown out during an ancient explosive eruption of Campi Flegrei. This volcano last erupted in 1538 but has recently shown signs of unrest.

By looking at the composition of crystals trapped at different times during the evolution of the magma body - and with the apatite crystals in effect acting as 'time capsules' - the team was able to show that the magma that eventually erupted had spent most of its lifetime in a bubble-free state, becoming gas-saturated only very shortly before eruption. Under these conditions of slow magma chamber growth, earthquakes

and ground deformation observed at the surface may not be signs of impending eruption, instead simply tracking the arrival of new batches of magma at depth.

Professor David Pyle from the Department of Earth Sciences at the University of Oxford, a co-author of the paper, said: 'Now that we have demonstrated that this approach can work on a particular volcano, and given apatite is a mineral found in many volcanic systems, it is likely to stimulate interest in other volcanoes to see whether there is a similar pattern.

'This research will also help us refine our ideas of what we want to measure in our volcanoes and how we interpret the long-term monitoring signals traditionally used by observers.'

The Campi Flegrei volcano system has had a colourful history. The Romans thought an area called Solfatara (where gas is emitted from the ground) was the home of Vulcan, the god of fire. Meanwhile, one of the craters in the system, Lake Avernus, was referred to as the entrance to Hades in ancient mythology.

Additionally, Campi Flegrei has long been a site of geological interest. In Charles Lyell's 1830 Principles of Geology, he identified the burrows of marine fossils at the top of the Macellum of Pozzuoli (an ancient Roman market building), concluding that the ground around Naples rises and falls over geological time.

More information: Late-stage volatile saturation as a potential trigger for explosive volcanic eruptions, Michael J. Stock, Madeleine C. S. Humphreys, Victoria C. Smith, Roberto Isaia and David M. Pyle, *Nature Geoscience*, DOI: 10.1038/NGEO2639