Volcanic crystals give a new view of magma

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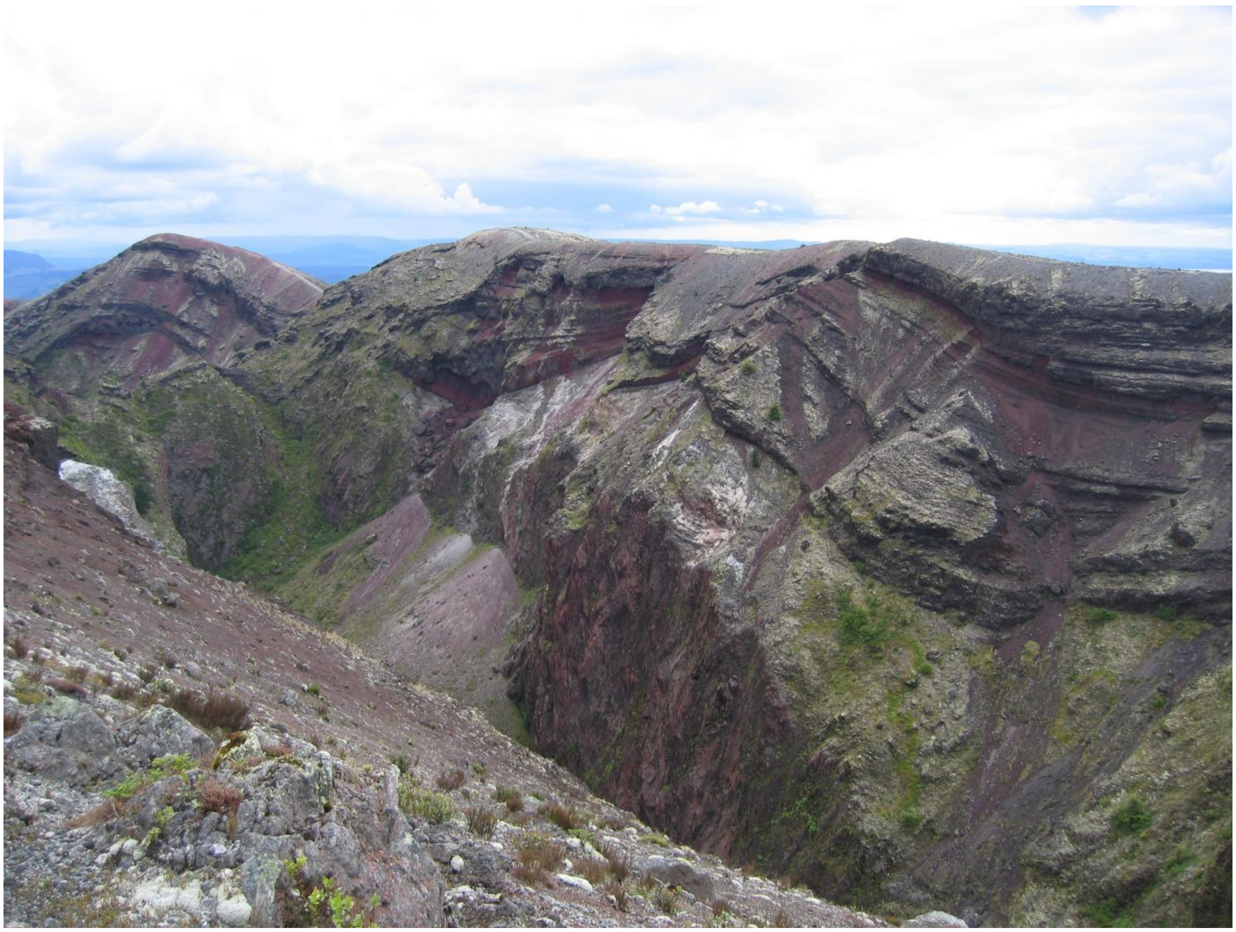


Mt. Tarawera, New Zealand. An eruption 700 years ago created these lava domes, and brought to the surface zircon crystals that reveal the history of changes in the magma chamber below. Understanding what happens in the magma chamber could lead to a better understanding of when and how volcanos erupt. The volcano was split by another eruption in 1886. Credit: Kari Cooper, UC Davis.

Volcanologists are gaining a new understanding of what's going on inside the magma reservoir that lies below an active volcano and they're finding a colder, more solid place than previously thought, according to new research published June 16 in the journal *Science*. It's a new view of how volcanoes work, and could eventually help volcanologists get a better idea of when a volcano poses the most risk.

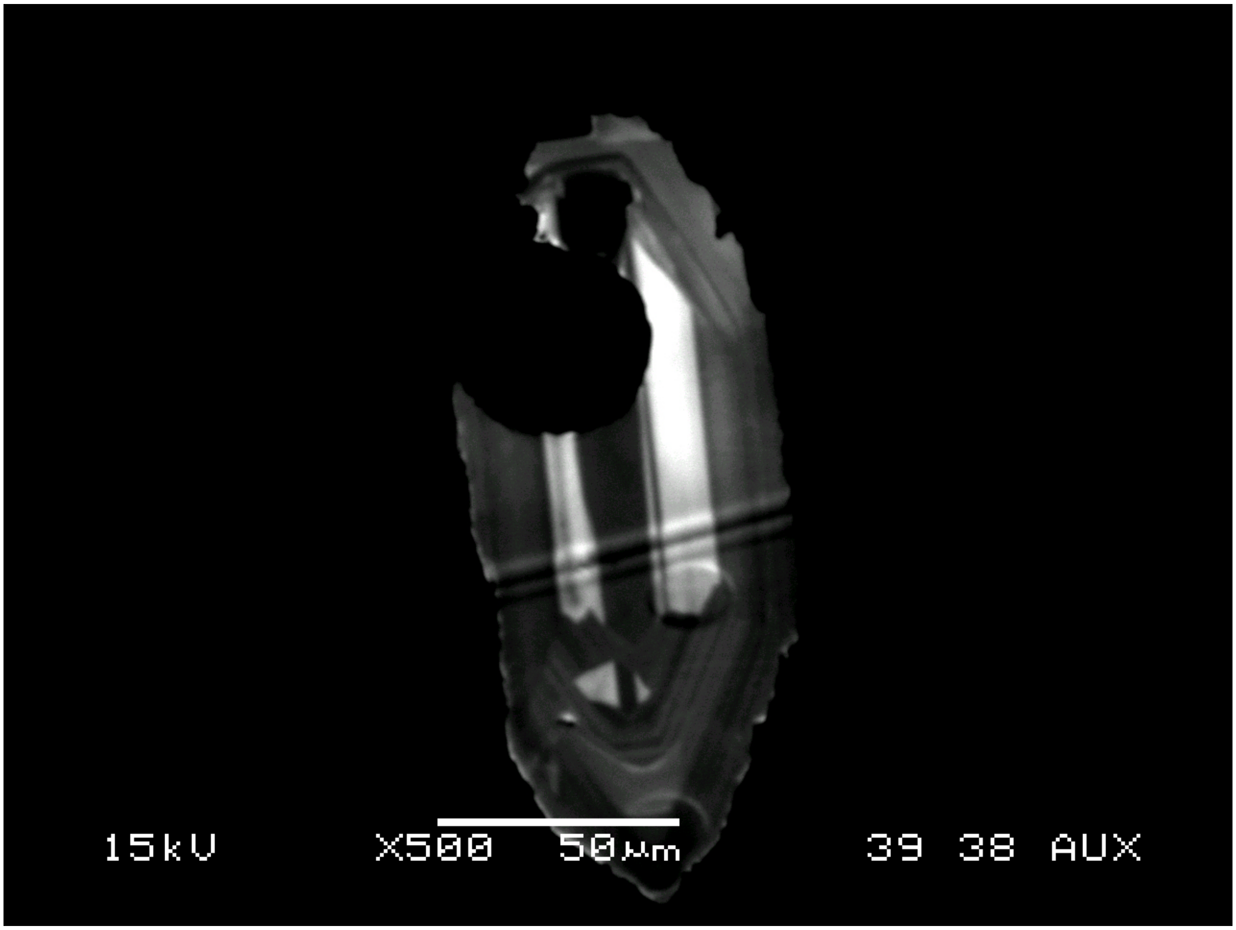
"Our concept of what a magma reservoir looks like has to change," said Kari Cooper, professor of earth and physical sciences at the University of California, Davis and corresponding author on the paper.

It's hard to study magma directly. Even at volcanic sites, it lies miles beneath the Earth's surface and while geologists have occasionally drilled into magma by accident or design, heat and pressure destroy any instrument you could try to put into it.

Instead, Cooper and her colleagues collected zircon crystals from debris deposited around Mount Tarawera in New Zealand by an eruption about 700 years ago. That eruption, roughly five times the size of Mount St. Helens in 1980, brought lava to the surface that had resided in the reservoir, exposed to its temperature and chemistry. Once on the surface, that record of the past was frozen in place.

The crystals are like a "black box" flight recorder for studying volcanic eruptions, Cooper said. "Instead of trying to piece together the wreckage, the crystals can tell us what was going on while they were below the surface, including the run up to an eruption."

By studying trace components elements within seven zircon crystals, they could determine when the crystals first formed and how long during their life within the magma reservoir they were exposed to high heat (over 700 degrees Celsius). The crystals give information about the state of the part of the magma reservoir in which they resided.



A zircon crystal from an eruption at Mt. Tarawera, New Zealand, about 700 years ago. The hole at upper right is where a piece was removed with a laser. The chemical profile across the crystal reveals the conditions under which it formed and survived in the magma chamber. Credit: Allison Rubin

The researchers found that all but one of the seven crystals were at least tens of thousands of years old, but had spent only a small percentage (less than about four percent) exposed to molten magma.

A Snow Cone Not a Molten Lake

The picture that emerges, Cooper said, is less a seething mass of molten rock than something like a snow cone: mostly solid and crystalline, with a little liquid seeping through it.

To create an eruption, a certain amount of that solid, crystalline magma has to melt and mobilize, possibly by interacting with hotter liquid stored elsewhere in the reservoir. The pre-eruption magma likely draws material from different parts of the reservoir, and it happens very quickly in geological time - over decades to centuries. That implies that it may be possible to identify volcanoes at highest risk of eruption by looking for those where the magma is most mobile.

Interestingly, all the crystals studied had remained unmelted in Mount Tarawera's magma reservoir through a gigantic eruption that occurred about 25,000 years ago, before being blown out in the smaller eruption 700 years ago. That shows that magma mobilization must be a complex process.

"To understand volcanic eruptions, we need to be able to decipher signals the volcano gives us before it erupts," says Jennifer Wade, a program director in the National Science Foundation's Division of Earth Sciences, which funded the research. "This study backs up the clock to the time before an eruption, and uses signals in crystals to understand when magma goes from being stored to being mobilized for an eruption."

More information: A.E. Rubin el al., "Rapid cooling and cold storage in a silicic magma reservoir recorded in individual crystals," *Science* (2017). science.sciencemag.org/cgi/doi … 1126/science.aam8720

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