Analyzing magma temps may help in forecasting eruptions

By Mark Floyd
Guest Contributor

CORVALLIS — Although volcanic eruptions are often quite hazardous, scientists have been unable to pinpoint the processes leading up to major eruptions – and one important limitation has been a lack of knowledge about the temperature history of the magma.

A new study analyzed crystals of the mineral zircon – zirconium silicate – in magma from an eruption in the Taupo Volcanic Zone in New Zealand about 700 years ago to determine the magma's history. The analysis shows the magma went through a comparatively "cool" period for thousands of years before heating up. Once magma temperatures reached 750 degrees Celsius, it was a short amount of time – decades or less – before an eruption occurred.

This pattern of long-term crystal storage in near-solid magma, punctuated by rapid heating, is applicable to many other volcanoes around the world, the researchers say, and may begin to help scientists recognize when a volcano is heading toward an eruptive phase.

Results of the research, which was supported by the National Science Foundation, are being reported this week in *Science*.

"Mobility in magma is a function of temperature, and most of the time when it's sitting there in the Earth's crust under the volcano it's cool," said Adam Kent, an Oregon State University geologist and co-author on the study. "Of course, cool is a relative description since it's still some 650 degrees (Celsius). I wouldn't put my finger on it.

"But to erupt onto the Earth's surface magma needs to heat up so it can be runny enough to be squeezed along cracks in the Earth and pushed up to the surface. At lower temperatures, the magma is too crystal-rich and viscous to move. It's like trying to spread cold peanut butter onto a piece of bread. It takes higher temperatures to get things moving – and then our data show it's only a period of years or decades before it erupts."

Kent said the Taupo magma system has similarities to many volcanoes around the world, including the Cascade Range in the Pacific Northwest of the United States. A past study by Kent and his colleagues using a different approach found that Mount Hood in Oregon also spent most of its history in a cold, rigid state before moving rapidly into an eruptive phase.

This new study adds more certainty to the method and provides a new tool to apply this work to other volcanoes, the researchers say.

The key to honing in on these long-term geologic processes is understanding the volcanoes' thermal or temperature history, according to the researchers. Past studies began making inroads into understanding the history of magma temperatures, but they relied on trying to reconcile data from a sample containing many thousands of individual crystals.

Using zircon crystals, which can be dated through analyzing the decay of uranium and thorium, adds more resolution, or precision, to the process. The crystals are like a "black box" flight recorder for studying volcanic eruptions, according to Kari Cooper of the University of California, Davis, corresponding author on the study.

"Instead of trying to piece together what happened from the wreckage," Cooper said, "the crystals can tell us what was going on while they were below the surface, including the runup to an eruption."

Zircon crystals occur in magma from many volcanoes, and the new technique will have wide applications to volcanoes along the ring of fire – the belt of volcanoes that surround the Pacific Ocean – and elsewhere.

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South Sister is not asleep...

"It removes some uncertainty and gives us a great new tool to go back and look at other volcanoes," Kent said.

The finding also suggests that if many volcanoes store their magma in this relatively cold state, recognizing volcanoes where warm and mobile magma is present may help researchers find volcanoes in the early throes of producing future eruptions. The technology to monitor volcanoes using seismic waves and other remote techniques is improving all the time, the researchers said.

The *Science* study was led by Allison Rubin and Cooper of the University of California at Davis. Other researchers included Christy Till and Maitrayee Bose of Arizona State University; Fidel Costa, Nanyang Technological University of Singapore; Darren Gravley and Jim Cole of the University of Canterbury in New Zealand; and Chad Deering, Michigan Technological University.

Kent is on the faculty of the College of Earth, Ocean, and Atmospheric Sciences at Oregon State.