'Highway from hell' fueled Costa Rican volcano

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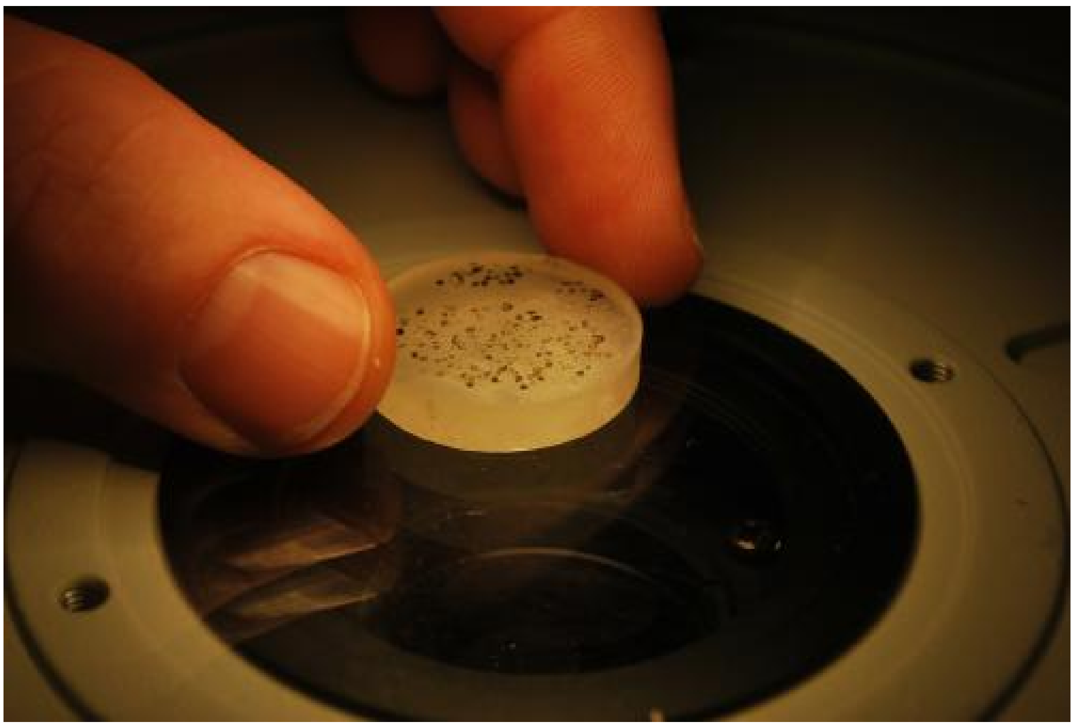

Spikes of nickel in the crystals indicated the magma was still relatively fresh. Credit: Kim Martineau

If some volcanoes operate on geologic timescales, Costa Rica's Irazú had something of a short fuse. In a new study in the journal *Nature*, scientists suggest that the 1960s eruption of Costa Rica's largest stratovolcano was triggered by magma rising from the mantle over a few short months, rather than thousands of years or more, as many scientists have thought.

The study is the latest to suggest that deep, hot magma can set off an eruption fairly quickly, potentially providing an extra tool for detecting an oncoming volcanic disaster.

"If we had had seismic instruments in the area at the time we could have seen these deep magmas coming," said the study's lead author, Philipp Ruprecht, a volcanologist at Columbia University's Lamont-Doherty Earth Observatory. "We could have had an early warning of months, instead of days or weeks."

Towering more than 10,000 feet and covering almost 200 square miles, Irazú erupts about every 20 years or less, with varying degrees of damage. When it awakened in 1963, it erupted for two years, killing at least 20 people and burying hundreds of homes in mud and ash. Its last eruption, in 1994, did little damage.

Irazú sits on the Pacific Ring of Fire, where oceanic crust is slowly sinking beneath the continents, producing some of earth's most spectacular fireworks. Conventional wisdom holds that the mantle magma feeding those eruptions rises and lingers for long periods of time in a mixing chamber several miles below the volcano. But ash from Irazú's prolonged explosion is the latest to suggest that some magma may travel directly from the upper mantle, covering more than 20 miles in a few months.

"There has to be a conduit from the mantle to the magma chamber," said study co-author Terry Plank, a geochemist at Lamont-Doherty. "We like to call it the highway from hell."

Their evidence comes from crystals of the mineral olivine separated from the ashes of Irazú's 1963-1965 eruption, collected on a 2010 expedition to the volcano. As magma rising from the mantle cools, it forms crystals that preserve the conditions in which they formed.

Unexpectedly, Irazú's crystals revealed spikes of nickel, a trace element found in the mantle. The spikes told the researchers that some of Irazú's erupted magma was so fresh the nickel had not had a chance to diffuse.

View of the main crater of Irazú Volcano. Sedimentary layers on the inner slopes of the and cut by erosion are from the 1963-65 eruption studied in Ruprecht and Plank (2013). Credit: Philipp Ruprecht

"The study provides one more piece of evidence that it's possible to get magma from the mantle to the surface in very short order," said John Pallister, who heads the U.S. Geological Survey (USGS) Volcano Disaster Assistance Program in Vancouver, Wash. "It tells us there's a potentially shorter time span we need to worry about."

Deep, fast-rising magma has been linked to other big events. In 1991, Mount Pinatubo in the Philippines spewed so much gas and ash into the atmosphere that it cooled Earth's climate. In the weeks before the eruption, seismographs recorded hundreds of deep earthquakes that USGS geologist Randall White later attributed to magma rising from the mantle-crust boundary. In 2010, a chain of eruptions at Iceland's Eyjafjallajökull volcano that caused widespread flight cancellations also indicated that some magma was coming from down deep. Small earthquakes set off by the eruptions suggested that the magma in Eyjafjallajökull's last two explosions originated 12 miles and 15 miles below the surface, according to a 2012 study by University of Cambridge researcher Jon Tarasewicz in Geophysical Research Letters.

Volcanoes give off many warning signs before a blow-up. Their cones bulge with magma. They vent carbon dioxide and sulfur into the air, and throw off enough heat that satellites can detect their changing temperature. Below ground, tremors and other rumblings can be detected by seismographs. When Indonesia's Mount Merapi roared to life in late October 2010, officials led a mass evacuation later credited with saving as many as 20,000 lives.

Still, the forecasting of volcanic eruptions is not an exact science. Even if more seismographs could be placed along the flanks of volcanoes to detect deep earthquakes, it is unclear if scientists would be able to translate the rumblings into a projected eruption date. Most problematically, many apparent warning signs do not lead to an eruption, putting officials in a bind over whether to evacuate nearby residents.

"[Several months] leaves a lot of room for error," said Erik Klemetti, a volcanologist at Denison University who writes the "Eruptions" blog for Wired magazine. "In volcanic hazards you have very few shots to get people to leave."

Scientists may be able to narrow the window by continuing to look for patterns between eruptions and the earthquakes that precede them. The Nature study also provides a real-world constraint for modeling how fast magma travels to the surface.

"If this interpretation is correct, you start having a speed limit that your models of magma transport have to catch," said Tom Sisson, a USGS volcanologist based at Menlo Park, Calif.

Olivine minerals with nickel spikes similar to Irazú's have been found in the ashes of arc volcanoes in Mexico, Siberia and the Cascades of the U.S. Pacific Northwest, said Lamont geochemist Susanne Straub, whose ideas inspired the study. "It's clearly not a local phenomenon," she said. The researchers are currently analyzing crystals from past volcanic eruptions in Alaska's Aleutian Islands, Chile and Tonga, but are unsure how many will bear Irazú's fast-rising magma signature. "Some may be capable of producing highways from hell and some may not," said Ruprecht.

More information: Paper: dx.doi.org/10.1038/nature12342

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