How rivers of hot ash and gas move when a supervolcano erupts

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Photographs scanned from Kodachrome slides show dark rocks embedded in layers of ash. The rocks were picked up and moved across the landscape by pyroclastic flows when the Silver Creek caldera, a supervolcano, erupted 18.8 million years ago. Credit: Greg A. Valentine

Supervolcanoes capable of unleashing hundreds of times the amount of magma that was expelled during the Mount St. Helens eruption of 1980 are found in populated areas around the world, including the western United States.

A new study is providing insight into what may happen when one of these colossal entities explodes.

The research focuses on the Silver Creek caldera, which sits at the intersection of California, Nevada and Arizona. When this supervolcano erupted 18.8 million years ago, it flooded parts of all three states with river-like currents of hot ash and gas called pyroclastic flows. These tides of volcanic material traveled for huge distances—more than 100 miles.

The new study suggests that pyroclastic flows from the ancient eruption took the form of slow, dense currents—and not fast-moving jets as some experts previously thought.

The research combines recent laboratory experiments with field data from the 1980s—some of it captured in colorful Kodachrome slides—to show that the rivers of ash and gas emanating from the Silver Creek caldera likely traveled at modest speeds of about 10 to 45 miles per hour.

"Intuitively, most of us would think that for the pyroclastic flow to go such an extreme distance, it would have to start off with a very high speed," says study co-author Olivier Roche. "But this isn't consistent with what we found."

University at Buffalo geology professor Greg A. Valentine holds up a Kodachrome slide showing a landscape associated with the eruption of the Silver Creek caldera supervolcano 18.8 million years ago. Valentine collected the data in the 1980s as a PhD student. Credit: Douglas Levere

The research was conducted by Roche at Blaise Pascal University in France, David C. Buesch at the United States Geological Survey and Greg A. Valentine at the University at Buffalo. It will be published on Monday, March 7 in *Nature Communications*, and all information in this press release is embargoed until 5 a.m. U.S. Eastern Standard Time on that date.

Research on pyroclastic flows is important because it can help inform disaster preparedness efforts, says Valentine, a UB professor of geology and director of the Center for GeoHazards Studies in the UB College of Arts and Sciences.

"We want to understand these pyroclastic flows so we can do a good job of forecasting the behavior of these flows when a volcano erupts," he says. "The character and speed of the flows will affect how much time you might have to get out of the way, although the only truly safe thing to do is to evacuate before a flow starts."

New and vintage data come together to tell the story of a supervolcano

The new study favors one of two competing theories about how pyroclastic flows are able to cover long distances. One school of thought says the flows should resemble turbulent, hot, fast-moving sandstorms, made up mostly of gas, with few particles. The other theory states that the flows should be dense and fluid-like, with pressurized gas between ash particles. The new research supports this latter model, which requires sustained emissions from volcanoes, for many pyroclastic flows.

University at Buffalo geology professor Greg A. Valentine holds up Kodachrome slides showing photographs of geologic formations associated with the eruption of the Silver Creek caldera supervolcano 18.8 million years ago. Valentine collected the data in the 1980s as a PhD student. Credit: Douglas Levere

The findings were based on two sets of data: results from recent experiments that Roche ran to simulate the behavior of pyroclastic flows, and information that Buesch and Valentine gathered at the Silver Creek Caldera eruption site in the 1980s when they were PhD students at the University of California, Santa Barbara, supplemented by some more recent fieldwork.

"I always tell students that they should take good notes while they're working in the field, because you never know when it could be useful," says Valentine, who has a fat binder full of Kodachrome slides showing images he snapped around the Silver Creek caldera.

The data that he and Buesch collected included photographs and notes documenting the size, type and location of rocks that were lifted off the ground and moved short distances by pyroclastic flows during the ancient eruption.

Many of the rocks the pair observed were relatively large—too large to have been shifted by sandstorm-like pyroclastic flows, which do not pick up heavy objects easily. Denser flows, which can move sizable rocks more readily, likely accounted for the rock patterns Buesch and Valentine observed.

To figure out how fast these dense flows may have been moving when the Silver Creek caldera erupted 18.8 million years ago, the team relied on a model developed by Roche through experiments.

In his tests, Roche studied what happened when a gas and particle mixture resembling a dense pyroclastic flow traveled across a substrate of beads. He found that faster flows were able to lift and move heavier beads, and that there was a relationship between the velocity of a flow and the weight of the bead it was capable of lifting.

Based on Roche's model, the scientists determined that the ancient pyroclastic flows from the supervolcano would have had to travel at speeds of about 5 to 20 meters per second (10 to 45 miles per hour) to pick up rocks as heavy as the ones that Buesch and Valentine saw. It's unlikely that the flows were going much faster than that because larger rocks on the landscape remained undisturbed, Valentine says.

The findings could have widespread applicability when it comes to supereruptions, says Valentine, who notes that patterns of rock deposits around some other supervolcanoes heavily resemble those around the Silver Creek caldera.

More information: O. Roche et al. Slow-moving and far-travelled dense pyroclastic flows during the Peach Spring super-eruption, *Nature Communications* (2016). DOI: 10.1038/ncomms10890

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