New study challenges traditional theory of Yellowstone formation

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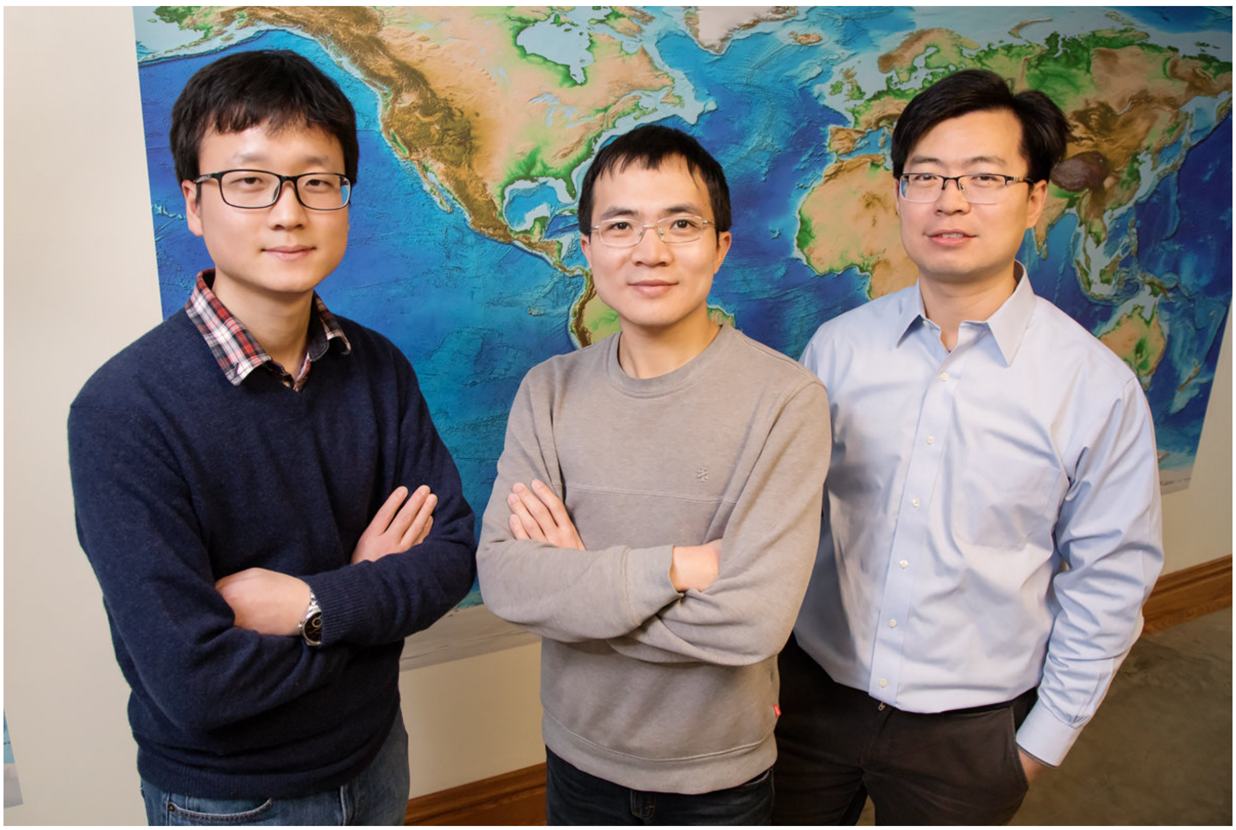

From left, geology graduate students Jiashun Hu and Quan Zhou and professor Lijun Liu challenge traditional theories about western US volcanism with new evidence from supercomputer modeling. Credit: L. Brian Stauffer

Recent stories in the national media are magnifying fears of a catastrophic eruption of the Yellowstone volcanic area, but scientists remain uncertain about the likelihood of such an event. To better understand the region's subsurface geology, University of Illinois geologists have rewound and played back a portion of its geologic history, finding that Yellowstone volcanism is more far more complex and dynamic than previously thought.

"The heat needed to drive volcanism usually occurs in areas where tectonic plates meet and one slab of crust slides, or subducts, under another. However, Yellowstone and other volcanic areas of the inland western U.S. are far away from the active plate boundaries along the west coast," said geology professor Lijun Liu who led the new research. "In these inland cases, a deep-seated heat source known as a mantle plume is suspected of driving crustal melting and surface volcanism."

In the new study, reported in the journal *Nature Geosciences*, Liu and graduate students Quan Zhou and Jiashun Hu used a technique called seismic tomography to peer deep into the subsurface of the western U.S. and piece together the geologic history behind the volcanism. Using supercomputers, the team ran different tectonic scenarios to observe a range of possible geologic histories for the western U.S. over the past 20 million years. The effort yielded little support for the traditional mantle plume hypothesis.

"Our goal is to develop a model that matches up with what we see both below ground and on the surface today," Zhou said. "We call it a hybrid geodynamic model because most of the earlier models either start with an initial condition and move forward, or start with the current conditions and move backward. Our model does both, which gives us more control over the relevant mantle processes."

One of the many variables the team entered into their model was heat. Hot subsurface material - like that in a mantle plume - should rise vertically toward the surface, but that was not what the researchers saw in their models.

"It appears that the mantle plume under the western U.S. is sinking deeper into the earth through time, which seems counterintuitive," Liu said. "This suggests that something closer to the surface - an oceanic slab originating from the western tectonic boundary - is interfering with the rise of the plume."

The mantle plume hypothesis has been controversial for many years and the new findings add to the evidence for a revised tectonic scenario, the researchers said.

"A robust result from these models is that the heat source behind the extensive inland volcanism actually originated from the shallow oceanic mantle to the west of the Pacific Northwest coast," Liu said. "This directly challenges the traditional view that most of the heat came from the plume below Yellowstone."

"Eventually, we hope to consider the chemical data from the volcanic rocks in our model," Zhou said. "That will help us further constrain the source of the magma because rocks from deep mantle plumes and near-surface tectonic plates could have different chemistries."

As for likelihood of a violent demise of Yellowstone occurring anytime soon, the researchers say it is still too early to know.

"Of course, our model can't predict specific future super-eruptions. However, looking back through 20 million years of history, we do not see anything that makes the present-day Yellowstone region particularly special - at least not enough to make us suspect that it may do something different from the past when many catastrophic eruptions have occurred," Liu said. "More importantly, this work will give us a better understanding of some of the mysterious processes deep within the earth, which will help us better understand the consequences of plate tectonics, including the mechanism of earthquakes and volcanoes."

More information: Western US volcanism due to intruding oceanic mantle driven by ancient Farallon slabs, *Nature Geosciences* (2017). nature.com/articles/doi:10.1038/s41561-017-0035-y

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