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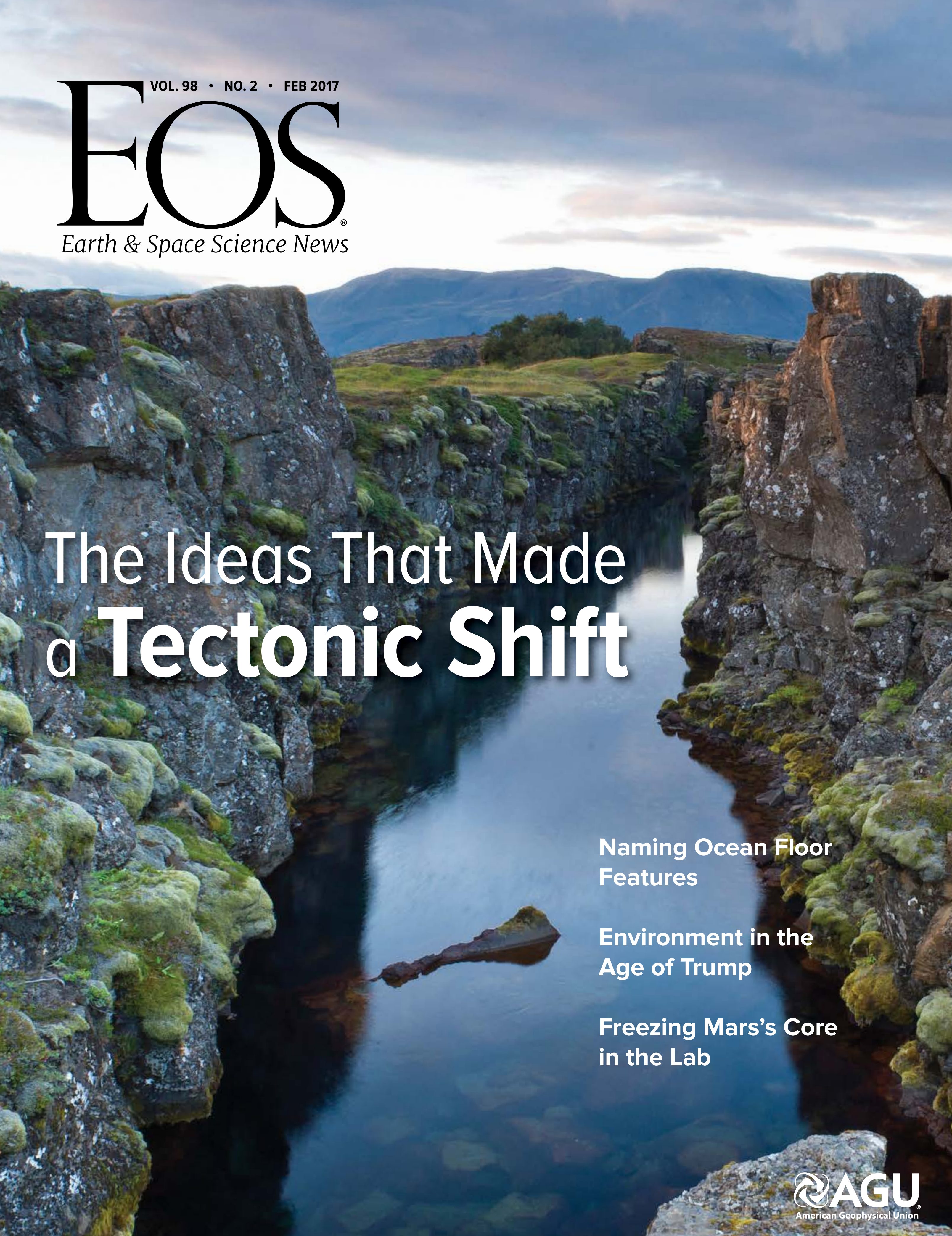

# The Ideas That Made a Tectonic Shift

## Naming Ocean Floor Features

## Environment in the Age of Trump

## Freezing Mars's Core in the Lab

AGU
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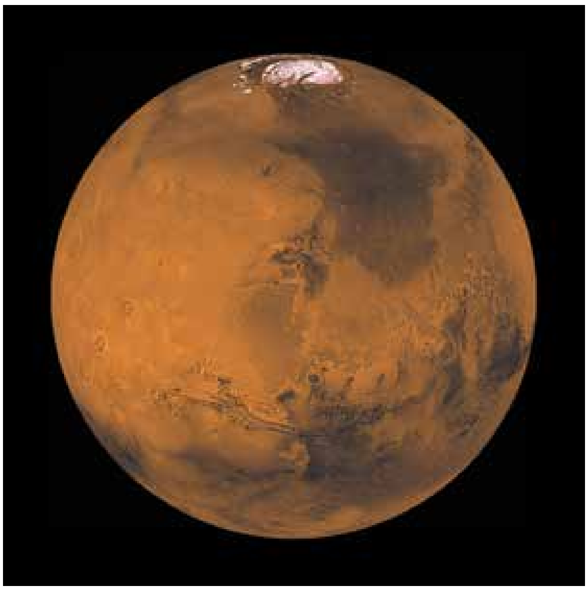
# Freezing Mars's Core—in the Lab



NASA

*Mars with polar ice.*

Scientists know that it snows on Mars. Researchers years ago detected evidence of frozen carbon dioxide sprinkling from Martian skies. Now a group of researchers are conducting experiments to learn which conditions may make "snow" of a different sort fall someday inside the Red Planet—in this case, flakes of either iron or an iron-sulfur compound tumbling through molten regions of Mars's core.

Most Mars interior experts suspect that much of the planet's core remains molten. However, they are unsure to what degree; some argue that it is fully molten. "Right now, there's a lot of speculation about the state of Mars's core," said Forrest Gilfoy, a graduate student in Earth sciences at University of Michigan in Ann Arbor and lead researcher on the experiments.

Mars researchers agree, however, that the planet's core will eventually solidify as the planet cools, and some researchers have been investigating what kinds of freezing processes the molten core will undergo at that time.

A study published in 2007 by Swiss researchers proposed two scenarios for this core solidification in Mars: one in which flakes of "iron snow" form in the outer reaches of the core and descend toward the center and another in which a wave of crystallization begins in the liquid core near the center of the planet and propagates outward (see http://bit.ly/Science6-1-07). Earth researchers suspect that outward growing crystallization is taking place in our own planet's deep interior.

## Bringing Mars into the Lab

Gilfoy and his team decided to explore these scenarios by mimicking Mars solidification in the lab. They ground up and melted a mixture of iron, nickel, and sulfur, the main components of Mars's interior. They created different mixtures with varying sulfur concentrations that are all possible representations of Mars's interior. They altered the amount of sulfur in each alloy sample because sulfur is thought to have the most impact on melting temperature.

In an experiment called quenching, the scientists brought the pressure of the molten blend up to that of the outer core of Mars, 20 gigapascals, which is 200 times greater than the pressure of the deepest part of the ocean on Earth. After melting each sample, the researchers rapidly dropped its temperature. Multiple quenching experiments revealed the melting points of the range of alloy samples they had created.

The team then compared its melting curve to the calculated temperatures of the Martian core—with the hottest being near the center of the core and the coldest being near the core-mantle boundary—to determine the depth at which different alloys would solidify. Alloys that solidify at lesser depths become snow, whereas those that solidify at greater depths become part of the bottom-up crystal formation, Gilfoy explained. He presented the experimental results on 13 December at the 2016 AGU Fall Meeting in San Francisco, Calif.

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## Sulfur Scenarios

The experiments revealed that if the core contained 10%–12% sulfur, snowfall would dominate the core's freezing process, Gilfoy told *Eos.* During cooling, alloys would crystallize in the outer reaches of the core and then sink toward the planet's center, displacing lighter elements. This is what scientists think is happening within Mercury.

The team's second scenario is an Earth analogue. Our own planet's core is slowly solidifying in a process called bottom-up crystallization. "Imagine [that] iron forms at the center and slowly grows outward, like a growing apple," said Gilfoy. According to him, this occurred in melts with a large range of higher sulfur concentrations, above 13%. Because such a wide range of possible mixtures led to bottom-up crystallization, it's the most likely process to occur when Mars's core eventually does firm up, he said.

On the basis of their experiments, the researchers propose a third scenario that had not been previously discussed, Gilfoy added. If the sulfur concentration stands at exactly 13%, bottom-up growth and sulfur-rich iron alloy snowfall processes would take place simultaneously, he said.

## Mars's Interior Still Hot Liquid

Past studies determined only a few melting temperatures associated with different concentrations of sulfur, according to Gilfoy, which was not enough to predict solidifying behavior (see http://bit.ly/Breuer-et-al-2015).

From the new experimental results involving many more samples, he computed the temperatures at which alloys would melt at various pressures. Given that these temperatures were all below the most widely accepted interior temperatures of Mars, the results add further evidence that Mars's core is not solidifying yet, Gilfoy said.

"Sulfur changes the melting temperatures, so solidification will depend on how much sulfur there is," said Christian Liebske, a mineralogist at the Swiss Federal Institute of Technology in Zurich, who was not part of the study. "There is evidence that Mars's core is molten, but to what extent, we still don't know."

In 2018, NASA plans to install a measurement station on the surface of Mars to better understand Mars's interior.

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