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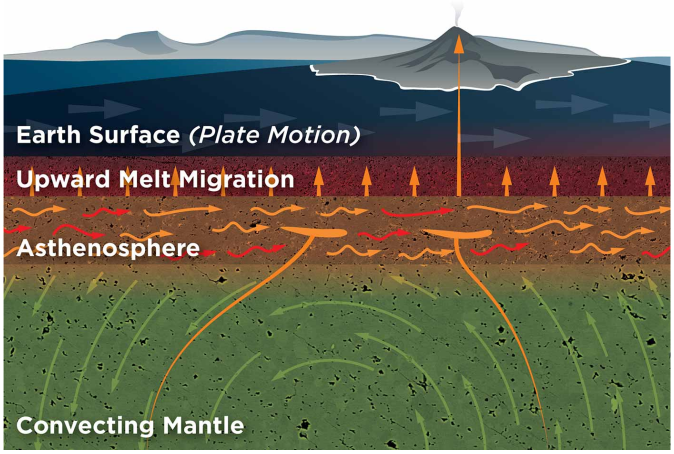
Novel Experiments Give Glimpses of Earth's Interior Dynamics

Tracking electrical signals allows researchers to piece together inner-Earth structures and magma flow



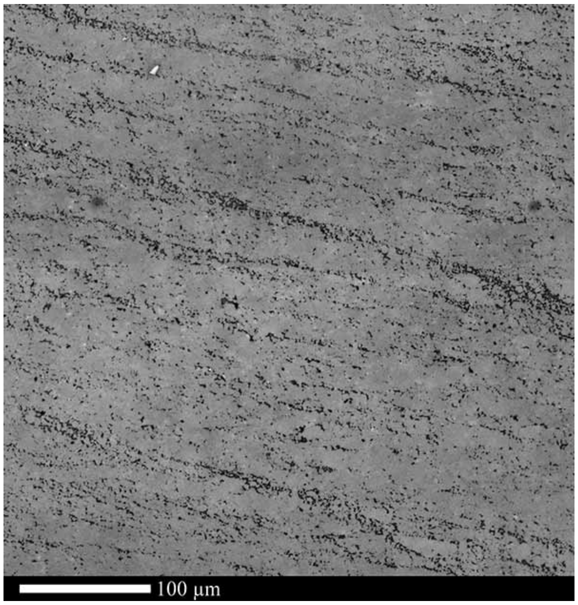
A graphical depiction of the upward motion of melt through the earth's interior layers. Scripps Institution of Oceanography, UC San Diego

Results from new geophysical experiments led by a researcher at Scripps Institution of Oceanography at UC San Diego are helping scientists understand the complex forces unfolding tens of miles below the planet's surface.

To understand such inner-Earth dynamics, Scripps experimental petrologist Anne Pommier and her colleagues track and measure electrical currents as they travel through rocks and magma. The strength of electrical currents depends strongly on the presence of fluids or melt (magma), and provides important clues about what's happening as Earth's tectonic plates shift at the planet's surface, as well as deeper processes in the mantle within layers known as the lithosphere and asthenosphere.

As described in the June 11 issue of the journal *Nature,* Pommier and her colleagues conducted innovative two-step experiments that mimic the structure of the interior of the planet. They used deformed partially molten rocks developed by coauthors at the University of Minnesota in high-pressure torsion experiments conducted at temperatures up to 1,300 degrees Celsius (2,372 degrees Fahrenheit) at Arizona State University.

By measuring the electrical properties of these materials at high pressure and temperature conditions in different directions in the samples, the researchers were able to produce an accurate simulation of conditions and dynamics in the upper mantle.



A microphotograph of a deformed sample (under torsion), with gray olivine grains and black melt. Melt-rich bands form along a preferential direction due to shear while melt segregates into bands under deformation, resulting in olivine layers alternating with melt-rich bands. Electrical conductivity is high in the direction of main deformation (parallel to the layers) and low if measured in perpendicular.

“The main result of this study is that we now understand a bit better of what’s going on between the lithospheric plates and the underlying mantle in the context of when the plates move very fast, producing a lot of localized deformation,” said Pommier, a researcher at the Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics at Scripps.

In addition to deciphering processes in the upper mantle, the results can lead to a better understanding of other planetary processes, including how volcanoes function and where magma reaches the earth’s surface.

“In the lab we can interpret (electrical) conductivity measurements in terms of how much magma is there, its temperature, storage conditions, and composition,” said Pommier. “This is very important to predict how magma is stored in the earth and how it migrates from the mantle to the surface of the planet to feed volcanoes and mid-ocean ridges. It also helps us understand what the earth is made of in certain locations around the world, as well as the evolution of geological processes that shape the planet’s surface.”

The results were used to develop new models of electrical conductivity, which were then compared with field data (some collected by Scripps researchers) at locations such as below the East Pacific Rise and the Cocos Plate.

“It’s important to understand how the asthenosphere works if we want to understand how the entire planet works,” said Pommier. “The asthenosphere directly underlies the tectonic plates; thus, if we better understand how it works we can place important constraints on the dynamics at the scale of the planet.”

Coauthors of the study included Kurt Leinenweber, Edward Garnero, and James Tyburczy of Arizona State University; David Kohlstedt and Chao Qi of the University of Minnesota; and Stephen Mackwell of the Universities Space Research Association.

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