CORE CONCEPTS

Mantle plumes

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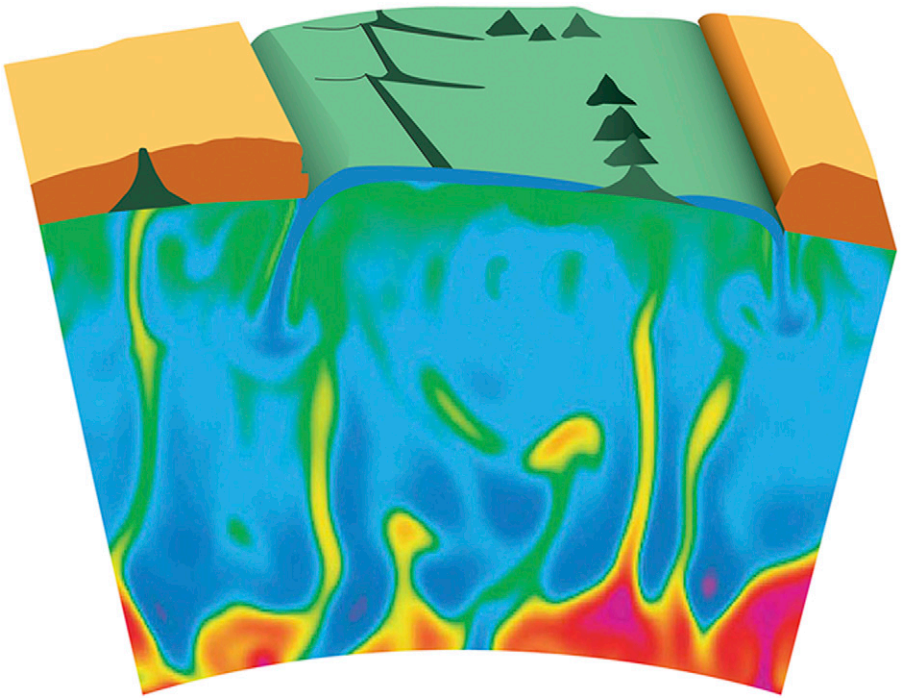
Volcanoes are usually found near the borders of tectonic plates that are violently either pushing or pulling at each other. Mysteriously, however, volcanoes sometimes erupt in the middle of these plates instead. The culprits behind these outbursts might be giant pillars of hot molten rock known as mantle plumes, jets of magma rising up from near the Earth's core to penetrate overlying material like a blowtorch. Still, decades after mantle plumes were first proposed, controversy remains as to whether or not they exist.

The concept of mantle plumes began in 1963 with the enigma of the Hawaiian volcanoes, which dwell more than 2,000 miles (3,200 km) from the nearest plate boundary. Scientists think that as the Pacific plate slid over a "hot spot," a line of volcanoes blossomed.

In 1971, geophysicist W. Jason Morgan proposed that hot spots resulted from plumes of magma originating in the lower mantle near the Earth's core at depths of more than 1,550 miles (2,500 km). Researchers think these mantle plumes are shaped like mushrooms: narrow streams of molten rock topped with bulbous heads that buoyantly bob upward, like blobs in a lava lamp.



Mantle plumes can be emitted from the core-mantle boundary region to reach the Earth's crust. Because of the lateral displacement of the tectonic plates at the surface, the mantle plumes can create a series of aligned hot-spot volcanoes. A mid-ocean ridge and a subducted plate are also shown. Image courtesy of the European Synchrotron Radiation Facility/Denis Andrault/Henri Samuel.

The potential importance of mantle plumes may go well beyond explaining volcanism within plates. For example, the mantle plume that may lie under Réunion Island in the Indian Ocean has apparently burned a track of volcanic activity that reaches about 3,400 miles (5,500 km) northward to the Deccan Plateau region of what is now India. Catastrophic volcanism there 65 million years ago gushed lava across 580,000 square miles (1.5 million km^2), more than twice the area of Texas, potentially hastening the end of the age of dinosaurs.

However, it remains hotly debated whether mantle plumes exist. For example, Massachusetts Institute of Technology seismologist Qin Cao and her colleagues used seismic waves to image activity beneath Hawaii; instead of finding a narrow mantle plume, they discovered that a giant thermal anomaly about 500–1,250 miles (800–2,000 km) wide located far west of the islands is apparently what feeds its volcanoes. The seismologists suggest Hawaiian volcanoes are fueled by a vast pool of hot matter on top of the lower mantle, not at its bottom near Earth's core by a deep mantle plume. Some researchers suggest hot spots may form in ways besides mantle plumes, such as spreading or cracking within tectonic plates, or "superplumes" that reach up from near the core to the near the base of the upper mantle, where they then give rise to smaller plumes that rise to the surface.

To help see if mantle plumes are real, a French-German experiment known as RHUM-RUM (Réunion Hotspot and Upper Mantle-Réunions Unterer Mantel) is seeking to image the area beneath Réunion down to the bottom of the mantle. In 2012, the investigators deployed nearly 60 seismometers on the floor of the Indian Ocean over a vast area of about 1.5 million square miles (4 million km^2). Another 30 instruments will be installed on land to assist, making this project the largest campaign ever to map a mantle plume. The investigators aim to collect the ocean seismometers and their data in 2013.