A Stirring Tale from inside Earth

In the quest to solve one of Earth's biggest puzzles, a team of geophysicists has proposed a new theory for how heat escapes from the planet's scorching depths. The hypothesis, backed up by fresh discoveries, has the potential to douse a debate that has burned since the concept of plate tectonics revolutionized earth science in the 1960s.

For decades, researchers have tried to discover exactly how heat leaks upward through the great rocky bulk of the planet, called the mantle. Although the mantle is solid stone, the intense heat causes the rock to flow slowly.

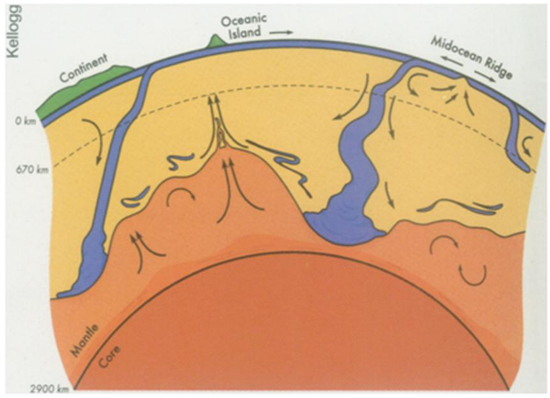
Most seismologists, who peer inside the planet by taking advantage of earthquake waves, see evidence that mantle rock mixes like boiling water in a pot. The hot rock, they say, rises from the bottom of the mantle to the top, cools off, and then sinks back down to complete a current of convection.

Researchers who study the chemistry of lavas, however, argue that the mantle resembles a double boiler, with separate upper and lower layers that each have their own systems of convection currents. In this case, the rock of the lower mantle, below 660 kilometers in depth, would not mix with that of the upper mantle.

In the new hypothesis, a team of researchers agrees with the double boiler system, except they picture the division much deeper and bumpier than previously thought. "The model reconciles the geochemical observations with the seismologic observations that have been difficult to reconcile for so long," says lead author Louise H. Kellogg of the University of California, Davis. Kellogg worked with Bradford H. Hager and Rob D. van der Hilst of the Massachusetts Institute of Technology. They publish their report in the March 19 SCIENCE.

According to Kellogg and her coworkers, the mantle has separated itself at a depth of about 1,600 km. Below that undulating partition lies a 1,300-km-thick layer of primitive mantle rock that represents what much of the planet was like in its infancy. Rock above the 1,600-km demarcation, however, has gotten stale, like old chewing gum. Over the 4.5-billion-year history of Earth, the upper half of the mantle has lost much of its allotment of gases and other important elements, which have congregated in Earth's crust and atmosphere.

Kellogg's team used a computer model to simulate double-layer convection, which carries heat to the surface. In their experiment, the two layers remain separate for billions of years—the geological equivalents of oil and water.



New theory for Earth's mantle: A reservoir of primitive rock (light orange) remains stuck near the bottom. Ocean crust sinks (blue) but doesn't mix with lower layer.

In the past, researchers have placed the hypothetical boundary at 660 km because that is a natural break point where rock gets squeezed into a more compact structure. Geochemists supported this concept because lavas suggest that the mantle contains a hidden reservoir of pristine rock. Seismic images, however, show pieces of ocean crust sinking well past the 660-km depth—leading the seismologists to reject the idea of a boundary at that level.

A deeper separation may prove more palatable. Although sinking ocean crust does breach the 660-km level, it meets some type of barrier below 1,600 km, according to a separate report in SCIENCE by van der Hilst and Hrafnkell Kárason of MIT. Moreover, analysis of earthquake waves indicates that the lowermost mantle contains different rock than the upper two-thirds, they say.

In a third SCIENCE paper, a Japanese and a British researcher report finding a thin sheet of rock, which they interpret to be old ocean crust, sitting about 1,400 to 1,600 km below the Pacific seafloor. Kellogg notes that this depth is just above the proposed boundary between the primitive lower mantle and the stale mantle rock above. "You might expect to see old crust piled up there," she says.

The new hypothesis has given geoscientists a different target on which to focus their attention. "It is an important model that we need to test," says Kenneth C. Creager, a seismologist at the University of Washington in Seattle.

That sentiment is echoed by Albrecht Hofmann of the Max Planck Institute for Chemistry in Mainz, Germany. "As a geochemist, I'm quite excited about exploring the further consequences of all this." —*R. Monastersky*

Newly launched spacecraft loses its cool

A hot WIRE is a dead WIRE.

Half an hour after its launch March 4, NASA's Wide-Field Infrared Explorer (WIRE) did something it shouldn't have done for 3 days. It popped open the lid covering its telescope.

The lid was designed to stay closed until the spacecraft's solar arrays pointed at the sun. That orientation would have kept the telescope looking safely in the opposite direction. Opening the lid prematurely allowed sunlight to strike the telescope's supply of frozen hydrogen, heating it up and causing it to vent into space.

The frozen hydrogen was needed to reduce the telescope's own infrared emissions, which would otherwise interfere with infrared observations of faint objects in the cosmos. With its entire supply of frozen hydrogen gone, WIRE's 4-month mission, intended to discover newborn galaxies and explore the history of star formation, ended before it ever began.

The rapid venting set the satellite spinning, but engineers have now regained control of the craft, says James Watzin of NASA's Goddard Space Flight Center in Greenbelt, Md.

WIRE is one of the agency's small explorer missions, an armada of low-cost craft instituted under NASA administrator Dan S. Goldin's mantra of "faster, better, cheaper." However, it's unclear if cost cutting played a role in WIRE's demise. Scientists have not found any obvious design flaws, says Watzin. A NASA panel is now investigating the matter.

The mission included several innovations. The satellite was the first to be built entirely from bonded graphite epoxy, a low-weight material, rather than metal. A special design allowed just 16 kilograms of frozen hydrogen to cool the telescope. In addition, WIRE's computer could, in a sense, think in advance. It could calculate how to maneuver the telescope to view the next target while still focused on its current one.

"People should keep in mind that every time you launch a mission that's pushing the envelope of new techniques and new technology, you have the potential for failure," Watzin says. —*R. Cowen*