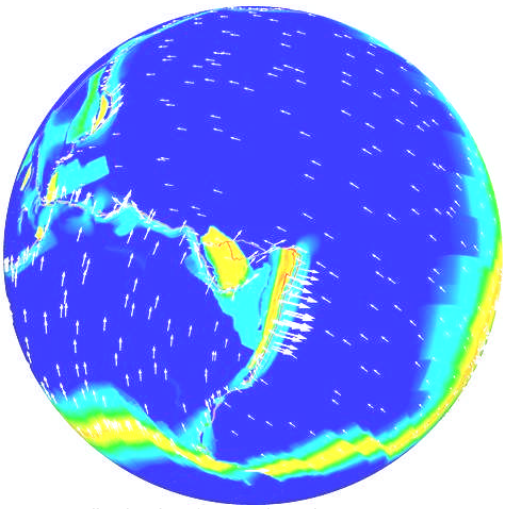
Computers take a closer look inside the Earth

Technology could improve understanding of forces behind movement of tectonic plates



Georg Stadler / Univ. of Texas / Austin
Simulated tectonic plate motion, indicated by arrows, is computed from a global flow model of Earth's interior. This view shows the Pacific and Australian plate, as well as South Pacific micro-plates. The model shows rapid trench rollback of the New Hebrides and Tonga micro-plate at the center of the plot.

By Lynne Peeples
OurAmazingPlanet
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More detailed pictures of the processes that continuously reshape the Earth from the inside out are being generated by new, more sophisticated computer models, yielding new insights into the hidden world beneath our feet.

The added resolution that these models provide — down to a single kilometer from a minimum of 20 kilometers (0.6 to 12 miles) in previous models — could improve our understanding of the forces behind the movement of the planet's tectonic plates, which cause the rumblings of earthquakes and explosion of volcanoes. It may also help explain why the Earth, uniquely in our solar system, has plate tectonics in the first place.

Some of the insights these models could provide are detailed in a study in the Aug. 27 issue of the journal Science.

Zooming in on the inner Earth
The movement of plates depends on many complex factors, including temperature, stress and the composition of the local rock.

To include all these things in a model requires very high resolution, explained Thorsten Becker of the University of Southern California, who was not part of the study but who wrote an accompanying editorial on the study in the same issue of Science.

"With this method, you don't need fine resolution everywhere," Becker said. "You can just zoom in on places you care more about, like plate boundaries where most of the deformation occurs." Without this level of detail, prior models forced researchers to do some "fudging," he

added. "But now we don't just have to pull with an arbitrary hand-of-God force. Rather, we can put everything in nicely."

Earthquake insights

Applying their powerful new model, study member Michael Gurnis of Caltech and his colleagues have already begun to uncover some surprising insights into the workings of the Earth.

"If you were to look down upon our planet as an alien, you would see it boiling away over long periods of time as a big heat engine," Gurnis said. "This study tells us how the physics of that heat engine really works."

It turns out that the deep interior of the Earth plays a major role in powering that engine, which then regulates how fast plates move.

"Most people would have thought that the forces in the shallow Earth were more important," Gurnis said. "But the resisting and driving forces in the lower mantle appear to determine whether a plate moves one or 10 centimeters (0.4 to 4 inches) per year. In effect, the shallow Earth is linked into parts of the Earth a thousand kilometers below our feet."

This kind of modeling might eventually provide clues for seismologists.

"We wouldn't be able to predict the next earthquake, but we might have a better idea of why this particular subduction zone has more earthquakes than another," Becker told OurAmazingPlanet.

Behind such variation is a mechanism called seismic coupling, or how much of the relative movement at a subduction zone is made up for by earthquakes as opposed to imperceptibly smooth deformations.

Gurnis and his team also discovered that while a tectonic plate releases a large amount of energy locally where it bends back into the Earth's interior, the dissipation was surprisingly insignificant globally. This changes the traditional view of the planet's energy balance.

"Ultimately, we're trying to understand why we have plate tectonics, and why plates move," Gurnis said. "That's a fundamental scientific question as important as the Big Bang."