# New Images Reveal Different Magma Pools Form the Ocean's Crust

August 29 2005

For the first time, scientists have produced images of the oceanic crust and found that the upper and lower layers of the crust are likely formed from different magma pools.

The images begin to answer some lingering questions about where new ocean crust comes from and whether it is all formed the same way.

Geophysicists Robert Detrick and Juan-Pablo Canales of Woods Hole Oceanographic Institution (WHOI) and colleagues used reflected seismic, or sound, waves to successfully image the structure of the lower crust across the flanks of the Juan de Fuca Ridge, a spreading plate boundary off the Pacific Northwest coast.

Their study, co-authored by researchers at Columbia University's Lamont-Doherty Earth Observatory and Scripps Institution of Oceanography, appears in the August 25, 2005 issue of Nature.

By recording the reflection of seismic waves off the lower crust at the crust-mantle boundary, a technique common in oil exploration, the researchers found evidence strongly suggesting that the base of the crust forms much differently than its overlying layers.

"Seismic reflection is a powerful tool to image the sub-surface detailed structure of the Earth down to several kilometers or miles below the surface," study co-author Canales said.

"Scientists studying the formation of the ocean crust have been debating over the past decade whether all of the crust is formed from magma that accumulates in a single pool or lens a mile or two deep, or if it forms from multiple magma sills at different levels."

Detrick, Canales and colleagues analyzed about 1,500 kilometers (935 miles) of data collected on the Juan de Fuca Ridge off the coast of Washington, Oregon and northern California.

The images are the first of their kind showing solidified magma lenses and sills, narrow lateral intrusions of magma, embedded in the boundary between the mantle and the overlying crust, a region known as the Moho transition zone.

The existence of these magma lenses near a mid-ocean ridge suggests that the lower oceanic crust is formed from several smaller sources of magma rather than a single large pool located in the middle of the crust.

Unlike continental crust, which is very old and thick, oceanic crust averages 6-7 kilometers (3-4 miles) thick and is constantly being recycled at tectonic plate boundaries on the seafloor. Crust is destroyed at subduction zones, where plates come together, and created at mid-ocean ridges, where plates are pulling apart, like the Juan de Fuca Ridge.

At these ridges, also known as seafloor spreading centers, molten rock, or magma, rises from deep within the earth and solidifies to become new crust. But the exact source of that magma—particularly the magma that forms the lower layers of the crust—was not well understood until now.

Previously, geophysicists knew that the topmost layer of the crust cooled from molten rock supplied by a single pool, or lens, of magma located in the crust's middle layers.

What was not known was whether the lower crust, which lies just above the mantle, solidified from the same melt lens or from many smaller magma bodies in the deeper crust-mantle transition zone. The new study found evidence of multiple pockets of molten rock now frozen, lending strong support to the latter theory.

Geophysical studies along mid-ocean ridges to date using seismic reflection have been able to image only one single crustal melt lens, supporting the first model of crustal formation.

However, other remote-sensing geophysical methods that are used to infer the mechanical properties of the crust indicate that magma must also accumulate at deeper levels, in particular at the base of the crust or the Moho transition zone.

The multiple-lens model comes from field observations at ophiolites where the remnants of the multiple melt sills can be mapped. Ophiolites are slabs of oceanic crust long ago thrust up onto dry land and are easily accessible to geologists seeking clues to what new crust might look like.

"It is exciting that different observational approaches, marine seismology and ophiolite studies, that look at the same problem at different spatial and resolution scales are converging towards a unified geological and geophysical model of how the ocean crust is formed," Canales said.