Drilling shortcut penetrates Earth's mantle

While physicians might dream of curing cancer, geoscientists have longed to drill through the Moho – the boundary between the planet's thin crust and its interior mantle. By taking a shortcut, researchers have come close to realizing that goal.

An international group of oceanographers returned late last month from an expedition near the Galapagos Islands, where they bypassed the crust and drilled directly into the upper mantle. The rocks they collected will help scientists attempting to understand the formation of the ocean floor – which forms two-thirds of the Earth's outer skin.

"The most important thing is that we have finally got these rocks. It's amazing to me that after all the years we've been drilling, this is the first time we've ever managed to catch these rocks," says Kathryn Gillis of the Woods Hole (Mass.) Oceanographic Institution. Gillis served as one of the chief scientists on the two-month-long drilling cruise, part of the Ocean Drilling Program (ODP).

The desire to pierce the Mohorovičić boundary, or Moho, goes back to the late 1950s, when leading oceanographers conceived "Mohole," a megascience project aimed at drilling straight through the 6-kilometer-thick ocean crust. But cost overruns and political problems sank the Mohole project soon after it began.

To drill through the entire ocean crust would take years. Gillis and her colleagues took a quick route into the mantle by drilling in an area called the Hess Deep, where rock from the deep crust and the mantle lies exposed on the seafloor, without kilometers of crustal covering. The interior rocks have reached the surface because plate tectonic forces are ripping the seafloor in the same way that bread crust might split as it bakes, exposing the dough inside.

Gillis and her colleagues did not succeed in drilling through the Moho, which would require passing from the crust into the mantle; that feat must wait for future cruises. Instead, they bored two major holes into rocks from the upper mantle that once lay close to the Moho.

The researchers found remarkable differences in the kinds of rocks present within the upper mantle. While typical mantle rocks appeared in one of the holes, the other yielded mantle rock in combination with a significant amount of gabbro, a rock that makes up the lower layer of the ocean crust. Gabbro forms from molten rock, called magma, that rises out of the mantle and hardens deep within the crust. Because they found this rock in the mantle, the researchers believe they penetrated a fossilized conduit though which mantle magma rose into the crust. The researchers also drilled a major hole into the gabbro rocks of the deep crust at a site nearby.

Geoscientists have long wondered how magma forms in the mantle and migrates upward. The rocks collected from Hess Deep suggest that magma in the mantle funnels into rising conduits that exist in some areas but not in others.

The new discoveries verify some lessons geologists have learned by studying ophiolites – slabs of the ocean floor that have been pushed up onto the continents. Because they are easily accessible, ophiolites have served as a model for understanding how the ocean floor forms. In recent years, some scientists have suggested that ophiolites represent special cases that are not good analogs for typical ocean crust. But the mantle rocks from Hess Deep vindicate those who study ophiolites, Gillis asserts. "They tell us we were on the right track," she says.

In 1986, an ODP Atlantic voyage collected a small amount of exposed mantle rock, but the Hess Deep rocks are the first mantle known from near the Moho.

The ODP drill crew is currently attempting to extend the deepest hole in the ocean floor, a 2-kilometer-long hole that they have drilled on and off for 13 years. Though far from the Moho, the bottom of the hole lies within reach of the gabbro layer that forms the bottom 4 kilometers of the ocean crust. *– R. Monastersky*

Near-Earth asteroids: Class consciousness

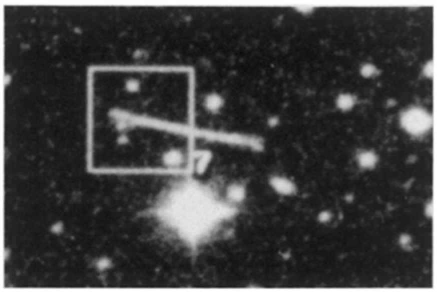
After examining the properties of several surprisingly small near-Earth asteroids discovered during the past year, astronomers last week reported that they have identified a new asteroid class. Unofficially named Arjuna, in honor of the hero of an epic Hindu poem, this class contains asteroids measuring no more than 100 meters across and orbiting the sun in a nearly circular path.

Detected by the 0.9-meter Spacewatch Telescope on Arizona's Kitt Peak, these asteroids appear unusual on several counts, says David L. Rabinowitz, a member of the Spacewatch team at the University of Arizona in Tucson. Ten near-Earth asteroids this small far exceeds the number astronomers had predicted Spacewatch could detect, he notes. But most striking, adds Rabinowitz, is that about five of these rocky bodies – those smaller than 50 meters – move about the sun in nearly circular orbits. Current theories about asteroids can't adequately explain why all five of these objects should have circular orbits.

While Rabinowitz considers only these five asteroids to belong to the Arjuna group, Spacewatch director Tom Gehrels believes that all 10 of the small bodies – including those with slightly more elliptical orbits – may belong to a special class. Gehrels notes that all 10 move no closer to the sun than the Earth does. However, Brian G. Marsden of the Smithsonian Astrophysical Observatory in Cambridge, Mass., says that a smaller, but significant percentage of larger near-Earth asteroids observed from the ground have similar orbits.

Rabinowitz described the work last week during a seminar at the Carnegie Institution of Washington (D.C.). Details will appear in an April issue of Astrophysical Journal.

Spacewatch researchers, who include James V. Scotti, say they aren't sure how the Arjuna class formed. These bodies might represent material gouged out of the lunar surface when other, larger asteroids slammed into it, Gehrels says. Or the Arjuna asteroids might be fragments of comets that passed close to Earth. But he adds that such fragments, like their parent comets, would likely have parabolic – rather than circular – orbits. Gehrels says he now favors another model: that the Arjuna asteroids are the secondary fragments, or grandchildren, of members of the main asteroid belt, which lies between Mars and Jupiter.


Rabinowitz, Gehrels, Scotti, *et al.*

Time-exposure photograph shows the small near-Earth asteroid 1992 JD (in box), which may belong to a new asteroid class.

Asteroid chunks leave the main belt under the influence of Jupiter's gravity, and some become kilometer-size, near-Earth objects. According to Gehrels, some of these chunks may collide with each other, and these small "fragments of fragments" might constitute the Arjuna class.

Marsden says that although the small size of these near-Earth asteroids is intriguing, scientists currently lack compelling evidence that all of the bodies were created by the same physical process. "It's a grave mistake to name a class that may not have any significance," he says.

Spectra of these fleeting objects may settle the controversy, Rabinowitz says. "Five years ago, [astronomers] had only observed about 100 near-Earth asteroids," he notes. "Now, in the past five years, scientists have found about 200." Researchers, he says, are in the midst of searching for telltale patterns among these bodies. *– R. Cowen*