Astronomy

Ron Cowen reports from Houston at the annual Lunar and Planetary Science Conference

Staring at the moon's mantle

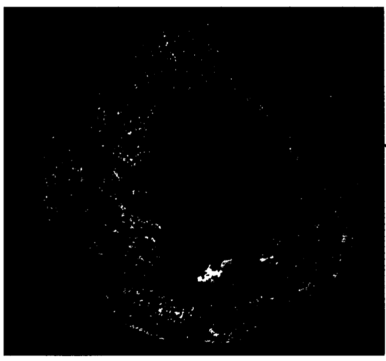
If you want to know how a planet formed or to understand the chemical composition of a moon, you can't stop at the crust. You've got to get under their skin.

The crust coating Earth's moon accounts for only a few percent of its mass and extends no more than 100 kilometers beneath the surface. In contrast, the mantle—the layer of rocky, silicate-rich material that lies directly under the crust—extends thousands of kilometers deep and accounts for about half the moon's mass.

The challenge is to find exposed chunks of the mantle. At present, excavating mantle material by drilling a 100-km hole through the moon's crust isn't possible. But for years planetary scientists have held onto the hope that nature has already done the drilling for them. A new study suggests their hunch was right.

Researchers focused their search on the moon's South Pole-Aitken basin, a mammoth depression 12 km deep and 2,500 km across—a quarter of the moon's circumference.

The asteroid or comet that slammed into the moon's South Pole to create this gigantic crater most likely penetrated into the mantle. The crater walls then may have collapsed to form today's shallower depression.



Lunar and Planetary Institute

South Pole-Aitken basin as seen by Clementine.

After analyzing images collected at different wavelengths by the Clementine spacecraft, a low-cost mission that orbited the moon for 71 days in 1994 (SN: 11/18/95, p. 324), researchers say they have almost certainly detected the chemical signature of mantle material in the Aitken basin. Paul G. Lucey of the Hawaii Institute of Geophysics and Planetology in Honolulu and his colleagues find that the crater floor, sampled in several places, has a slightly higher abundance of titanium and a significantly higher abundance of iron than the lunar crust does. The team concludes that the bottom of the South Pole-Aitken basin is most likely a mixture containing about equal proportions of upper mantle and lower crust.

Although the Apollo missions of the late 1960s and early 1970s brought back to Earth numerous moon rocks, "a sample [from the mantle] has not been found before," says Lucey.

He cautions that the evidence does not yet rule out a less likely alternative—that the projectile which struck the moon's South Pole didn't penetrate the mantle and that the chemical signature detected by Clementine reflects some previously unseen composition of crust. That interpretation would mean that "cratering models need drastic revision, [that] our understanding of lunar impactors is really lousy," says Lucey.

Carle M. Pieters of Brown University in Providence, R.I., says that Clementine's high resolution provides the best data so far on the basin. But she adds that the craft can only infer, not directly detect, abundances of elements such as titanium and iron. By directly measuring abundances of several elements, a sensitive spectrometer aboard the Lunar Prospector, a small craft scheduled for launch next year, should settle the question of whether the floor of the south polar crater truly contains mantle material, Lucey says.

If the craft confirms the existence of mantle material in the basin, planetary scientists would love to get their hands on a sample. "We'd learn more about the moon from a single sample [of mantle] at the South Pole than all the samples [of crust] ever obtained from the Apollo missions," says Lucey.

Physics

Richard Lipkin reports from St. Louis at a meeting of the American Physical Society

Detector measures single molecules

Taking advantage of the atomic force microscope's extreme precision, researchers have adapted its highly sensitive detection mechanism for use in a hand-held sensor of biomolecules.

The new force-amplified biological sensor can detect molecules—including proteins and DNA—in concentrations as low as 1 particle per 100 microliters of fluid, or one molecule in a billion billion.

Chemists David R. Baselt, Gil U Lee, and Richard J. Colton of the Naval Research Laboratory in Washington, D.C., say that the new sensor can perform an assay in 10 to 15 minutes. Conventional bioassay techniques often take hours or days.

"We can now spot small numbers of viruses or bacteria," says Colton. "This device may prove useful . . . when there's not enough time to culture or amplify the sample." The group is designing the sensor to be small and rugged enough for use in clinics and emergency vehicles.

The device uses tiny magnetic beads coated with receptor molecules designed to latch onto target molecules in a sample, Colton explains. Beads that pick up the target molecules then stick to tiny cantilevers coated with receptors that bind elsewhere on the target molecules. The device measures the force exerted on the cantilevers when a magnetic field acts on the beads.

Compared to current bioassay methods, the new sensor has the potential to increase detection sensitivity by a factor of more than 1 million, the researchers estimate. The scientists also say they can adapt the device to measure trace elements and heavy metals in soil samples.

Magnetic tools enhance surgical techniques

The magic of magnetism lies in its ability to act at a distance. Now, a team of physicists and neurosurgeons has built a system that uses magnetic fields to assist in brain surgery.

The magnetic stereotaxis system, developed by Stereotaxis and the Washington University School of Medicine's Barnes-Jewish Hospital, both in St. Louis, uses magnetic force to guide a pellet through brain tissue to inoperable tumors or other hard-to-reach locations. Surgeons believe they will be able to use the pellets to deliver treatments.

"The magnetic pellet acts like a tugboat," says Matthew A. Howard III, a neurosurgeon at the University of Iowa Hospitals and Clinics in Iowa City. "It can pull a catheter into position, deliver radioactive sources, implant electrodes, or move a drug pump into place. It does the least amount of damage to brain tissue."

The magnetic system, which has proven successful in pigs, should eliminate the need for cutting open a large section of the skull. Instead, a physician would make a tiny incision, lay a magnetic pellet on the brain's surface, and place the patient's head in a special helmet, says George T. Gillies, a physicist at the University of Virginia in Charlottesville. In the helmet, an array of six computer-controlled superconducting magnets applies forces to move the pellet along a predetermined course designed to minimize damage.

In animal tests, the new system has proved accurate to within a fraction of a millimeter, says Rogers C. Ritter, also a physicist at the University of Virginia. The system's designers hope to begin clinical trials next year.

Bob Boston/Washington Univ. School of Medicine

This magnetic stereotaxis system can move a pellet into hard-to-reach brain areas for drug or radiation delivery.