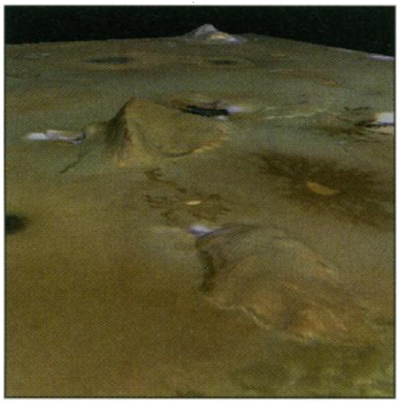
PLANETARY SCIENCE

Landslide Exposes Roots of Io's Peaks

Fans of the Galileo spacecraft's exploits near Jupiter are well acquainted with the pockmarked face of Io, the Jovian moon where volcanoes spew sulfurous lava and isolated mountain peaks jut skyward. Now, a new analysis of images taken nearly 20 years ago by Voyager 1 reveals another kind of scar on Io's tortured face: a giant landslide. On page 1514, the researchers who identified the slide say it's more than another blemish; it may be a sign that movement along faults deep in Io's crust built many of its peaks. If so, says coauthor Paul Schenk of the Lunar and Planetary Institute (LPI) in Houston, Texas, Io would be unique among the solar system's rocky moons in having this style of tectonics, which is common on Earth.


P. SCHENK/LUNAR AND PLANETARY INSTITUTE

The big slide. Voyager 1 reconstruction (vertical scale exaggerated five times) shows that an entire side of Euboea Montes (center) slide into the plains of Io.

Io's volcanoes have posed no great mystery. It is the innermost of Jupiter's four large moons, and its nearby parent exerts strong tidal forces that flex and melt the moon's interior to feed its volcanoes. But scientists have puzzled over Io's other prominent features: about 50 isolated mountains that tower above the surrounding plains like "rockbergs," as geophysicist William McKinnon of Washington University in St. Louis describes them. Most of these scattered crags don't seem volcanic, leaving geologists wondering where they come from.

To help find out, Schenk and Mark Bulmer of the National Air and Space Museum in Washington, D.C., reanalyzed stereo images from the 1979 flyby of Voyager 1 with an automated program, devised with the help of Brian Fossler at LPI, to calculate Io's topography. On a mountain called Euboea ("you-BEE-uh") Montes, an oval massif that surpasses Mount Everest with a height of 10.5 kilometers, Schenk and Bulmer identified a remarkable feature: a 200-kilometer-wide fan of debris. This slide contains an estimated 25,000 cubic kilometers of rock, a volume rivaled only by possible mass movements on the flanks of the Olympus Mons volcano on Mars. It is 10,000 times bigger than the landslide that set off the 1980 eruption of Mount St. Helens.

The slide gave Schenk and Bulmer clues to the churnings beneath Io's surface that create its mountains. The peak's slope and the height of the debris, Schenk says, suggest that a 2-kilometer-thick layer of loosely consolidated rock shifted into the plains, implying that formerly flat layers of rock must have tilted when the mountain rose. He and Bulmer reasoned that such tilting could only have resulted from crustal movements along deep faults.

In this scenario, Io's volcanoes drive these movements by ejecting lava plumes from the interior so fast that they spread a layer of new material a kilometer thick on the surface every 100,000 years. "Such rapid rates of burial are bound to put a considerable strain on the crust," Schenk says. As a shell of new crust subsides into the moon, its circumference shrinks, squeezing the rock until "something has to give way." Schenk thinks these compressional forces thrust entire blocks of crust upward along deep faults, a process much like the one that lofted parts of the Rockies. "These [mountains] should pop up at random above the surface of Io as the lithosphere fractures," Schenk says, noting that neither Voyager nor Galileo has found any pattern in the peaks' distribution.

Although planetary scientists say that Voyager's coarse resolution of about 1 kilometer leaves room for interpretation, many find Schenk and Bulmer's model plausible. The detailed topographic data "cinch the story of the landslide for me," says planetary geologist Jeffrey Moore of NASA's Ames Research Center in Mountain View, California. Moore adds, "[They] deserve a lot of credit for developing a technique to get this topographic information." But planetary geologist Alfred McEwen of the University of Arizona, Tucson, wonders whether other processes might be at work instead, such as buoyant floating of low-density blobs of crust or intrusions of magma from deeper within the planet.

McEwen notes, however, that if Schenk and Bulmer are right, then Galileo scientists are in for a treat next year when the spacecraft makes close flybys of Io, imaging its surface at up to 100 times the resolution of the Voyager photos. "If these truly are tilted and rotated crustal blocks, that means Io has exposed layers of its crust to us," McEwen says. "To a field geologist, that's wonderful."

–Robert Irion

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PHYSICS

A Dial-Up Quantum Reality

The lenient laws of quantum mechanics permit a lone electron to be in two places at once—as long it avoids leaving a trace in its surroundings. Now physicists have built an environment with a knob so they can dial up the quirky quantum world or tune it out. The tabletop device, built by physicist Mordehai Heiblum and colleagues at the Weizmann Institute for Science in Rehovot, Israel, and described in last week's *Nature*, pulls electrons through two adjacent corridors atop a tiny microchip. If not watched—that is, if it can skirt through the hallways without interacting with them—a single electron will go through both at the same time and "recombine" when the pathways merge. But add something that can detect which path the electron takes and suddenly it cleans up its act, taking one corridor or the other like a rat in a maze.

The Weizmann researchers rigged a kind of adjustable electric dam in one of the channels. By adjusting an electric field near the channel, they could, in effect, block part of the channel so that only a couple of electrons could squeeze by. Roughly speaking, the higher the dam, the more accurately they could tell whether an electron had passed by. Raise it, and more electrons should be forced to take a single path. "You can tell 'Oho!'—one went by," says Heiblum. Lower it, he says, and all the electrons should duplicitously slide through both channels at once.

By watching the flow of electrons where the two corridors merged, the researchers could count how many electrons had taken the single route and how many had taken the double route. When they set the dam to detect 5% of the electrons, about that same percentage took a solitary corridor. As they lowered the dam, the strange hand of quantum mechanics took over again until all electrons were taking both paths.

"It's a beautiful experiment," says Ned Wingreen, a physicist at the NEC Research Institute in Princeton, New Jersey. In the everyday world, he says, the environment that kills quantum behavior is unfathomably complex, but "here, it's something you can understand perfectly" with the laws of quantum mechanics. That suggests that any environment is just a big quantum system, which brings up the strange question of whether the universe itself is forever splitting off, taking multiple paths at once. That's the logical conclusion, he says, "but it makes me ill to think about it."

–David Kestenbaum