

PLANETARY GEOLOGY

An Early Big Hit to Mars May Have Scarred the Planet for Life

Earth has its high-standing continents and low-lying ocean basins, thanks to plate tectonics. And Mars has its smooth northern lowlands and its cratered highlands. But there's no credible sign that plate tectonics ever operated on Mars, so how did a third of the planet come to be as much as 4 kilometers lower than the rest? For the past quarter-century, a leading theory has held that a giant impact battered the young planet and excavated the northern lowlands, but that idea seemed to have serious problems.

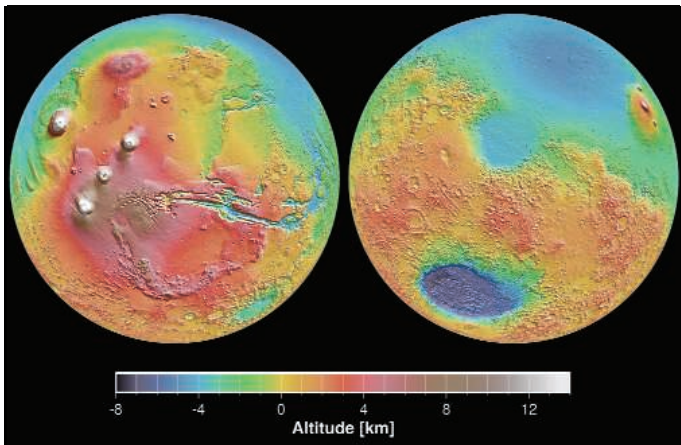
Now, two new studies purport to ease the difficulties with a giant impact. In one study, researchers reveal the true dimensions of the huge "Borealis basin," making it look much more like the crater of a giant impact. And a second group has run simulations that suggest how an impactor could have blasted out an 8000-kilometer-wide crater without melting it into an unrecognizable puddle of magma. "I think there's much to recommend [a giant impact] now with all this new work,"

U.S. Geological Survey, and Steven Squyres of Cornell University first proposed that a huge impactor had blasted out the Borealis basin. Fitting a circle to the "dichotomy boundary" between the basin and the highlands, they suggested that the circle could mark the outer edge of a huge crater. But the fit was too rough to win many converts.

So Andrews-Hanna and his colleagues looked for a better way to trace out the dichotomy boundary. The great Tharsis volcanic complex had obscured much of the boundary when it smothered one-quarter of the planet with lava hundreds of millions of years after the lowlands formed. To "remove" Tharsis, they drew on measurements of martian gravity and surface height from the past decade of Mars orbiters. Subtle variations in the pull of gravity—evidenced in variations of a spacecraft's orbit—reflect the added mass of Tharsis lavas as well as the extent of the deep, less-dense crustal rock buoying up the highlands. The height of the surface constrains the volume of added lavas.

By combining the data in a model, the researchers erased Tharsis's contribution to the present surface and traced the topographic edge of the Borealis basin right under Tharsis. Rather than a circle, the best shape for the basin turns out to be a 10,650-kilometer-long ellipse, they reported at the LPSC meeting. That's a familiar look for big impact basins. The 2300-kilometer Hellas impact basin in the southern highlands, for example, is also elliptical and also underlain by a uniformly thin crust. And there's no particular reason, Andrews-Hanna said, why the giant-impact theory's only serious rival—a peculiar sort of churning deep within the planet—would produce an elliptical basin or the observed sharp boundary between thin and thick crust.

The other long-standing objection to impact excavation was the mere survival of a craterlike feature of any sort. Any object ▶



Striptease. Removing the Tharsis volcanoes of Mars (reds and yellows, left panel) from part of the northern lowlands (light blue, right panel, top) uncovered an elliptical basin that looks like an impact crater.

says Sean Solomon, a planetary geophysicist at the Carnegie Institution of Washington's Department of Terrestrial Magnetism in Washington, D.C.

Last month, planetary geophysicist Jeffrey Andrews-Hanna of the Massachusetts Institute of Technology in Cambridge and colleagues presented their test of the giant-impact hypothesis at the Lunar and Planetary Science Conference (LPSC) in Houston, Texas. In 1984, planetary scientists Donald Wilhelms, now retired from the

Biotech Lawyers, Rejoice

It's back to square one for would-be reformers at the U.S. Patent and Trademark Office (USPTO). Last week, a Virginia federal court rejected rules the office proposed last year that would have limited the number of so-called continuations that can extend the normal 17-year life of a patent claim with amendments and appeals. Up to one-third of U.S. patent filings in recent years have been continuations (*Science*, 28 July 2006, p. 425), and USPTO said the proposed limits would have cut their workload. Other critics say continuations give some patent holders an unfair advantage. But the Biotechnology Industry Organization said the changes would have inhibited the "financing necessary to bring innovative ... life-saving products to market." Industry sued last year to block the change; a federal judge sided with them, saying the rules exceeded "USPTO's rulemaking authority."

—ELIOT MARSHALL

The Big Apple Does Science

New York City will display its scientific chops next month when a coterie of scientists, media stars, foundations, and university presidents present the World Science Festival. The 5-day event will include a play about oxygen, a dance performance inspired by string theory, a neuroscience lecture paired with a musical meditation on consciousness, and a World Science Summit modeled on the annual Davos confab. Running from 28 May through 1 June, the extravaganza is the brainchild of Columbia University physicist Brian Greene and his partner, Tracy Day, a television producer, who hope "to sustain a general public informed by the content of science."

—ANDREW LAWLER

Buffaloed

An effort to prevent the spread of brucellosis from bison in Yellowstone National Park to nearby cattle is poorly managed, says the U.S. Government Accountability Office (GAO). Although there are no documented cases of transmission, federal and Montana state agencies are 5 years behind schedule in vaccinating bison and securing a conservation easement around the park. The plan currently sanctions the slaughter of thousands of bison that leave Yellowstone, as long as the herd doesn't drop below 3000. Worried by the extensive culling, members of the House Committee on Natural Resources requested the GAO investigation. The resulting report calls for concrete objectives and greater accountability in the plan, which began in 2000.

—ELSA YOUNGSTADT

hundreds of kilometers across that hit Mars at tens of thousands of kilometers per hour, the thinking went, would heat the planet so dramatically that any crater would disappear in a sea of globe-girdling melted rock. Now that computer models are up to the task of simulating giant impacts in detail, that thinking is changing.

As most recently reported at last December's American Geophysical Union meeting, planetary scientist Margarita Marinova of the

California Institute of Technology in Pasadena and colleagues have simulated a range of giant impacts on Mars, all producing 8000-kilometer craters. They found that the melt from vertical impacts does in fact obliterate the crater but that faster, low-angle impacts do not. Simulated glancing blows at angles below 30° produce less melt overall and splash much of it into space. The giant-impact mechanism "was always thought dynamically impossible," said Andrews-Hanna at LPSC.

"Now you can't dismiss the possibility."

The two studies are convincing researchers that "the giant impact lives (after all)!" as planetary geophysicist Roger Phillips of Southwest Research Institute in Boulder, Colorado, playfully writes in an e-mail. Few are entirely won over yet, but a giant impact worked out as the origin of Earth's moon. Perhaps it will also serve to explain the deepest mystery of martian geology.

—RICHARD A. KERR

APPLIED PHYSICS

At Mixed Odds, Racetrack Memory Charges From Gate

For more than a decade, physicists and engineers have been trying to replace the electronic memories that computers, cell phones, and other devices rely on. Now, on page 209, Stuart Parkin, a physicist at IBM's Almaden Research Center in San Jose, California, and colleagues demonstrate a memory that pushes magnetic bits around tiny nanoscale "racetracks." Racetrack memory might someday replace the electronic memory that can store thousands of songs and pictures in an iPod, Parkin says. But skeptics doubt it can live up to its advance billing.

It's a controversial effort that's even been funded with controversial money. Racetrack memory started creating a media buzz about a year ago, but many researchers doubt it will ever emerge as a commercially viable technology. "A lot of us don't think that this is going to reach the finish line," says Robert Buhrman, an applied physicist at Cornell University. Others have faith in Parkin, whose previous work led to huge leaps in computer hard-drive technology. "He's the right person to take on such a challenge," says Gernot Güntherodt, a physicist at RWTH Aachen University in Germany.

Memory comes in several types. A hard drive stores information in tiny magnetic bits that can be magnetized in one direction or another with a magnetic field to store the 1s and 0s of binary code. It's capacious but slow. The electronic "random access memory" (RAM) that connects directly to a computer's processor encodes information in electric charges stored on tiny capacitors or in voltages in networks of transistors. RAM is fast, but it forgets everything when powered down. The flash memory in digital cameras and other small devices works a bit like RAM but

involves capacitors that can be semipermanently polarized to hold information without power. Flash bits eventually wear out, however. And all electronic technologies may soon

says Jian-Gang "Jimmy" Zhu, an electrical engineer at Carnegie Mellon University in Pittsburgh, Pennsylvania. "It does prove the basic concept," Zhu says.

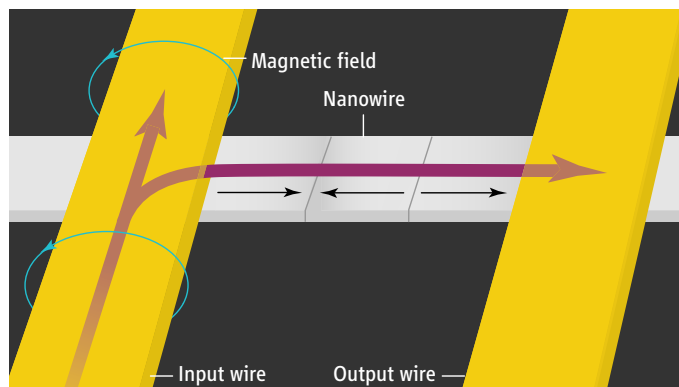
"It's demonstrating, in my mind, a paradigm shift in building magnetic memories," Parkin says. He envisions laying down scads of racetracks to make a new type of RAM. That memory could be faster, cheaper, and more robust than flash, he says. And if the little racetracks could be manufactured on end as towers, the memory could be dense enough to replace hard drives, Parkin says.

Others say that such visions may be hard to achieve. Moving the domain walls takes a lot of juice—200 million amps per square centimeter—Buhrman notes. "That's a huge current density," he says. Zhu says that to make the memory competitive, researchers will have to stand the nanowires on end. Nobody knows how to do that, he says.

Some people also question the way the research was funded. The money came in part from a federal earmark directed toward the Center for Nanoscale Science and Engineering at the University of California, Riverside. The center gave IBM \$5.1 million for the work from 2004 to 2006, according to figures provided by Robert Haddon, a chemist at Riverside and director of the center. Parkin says the money amounted to only 20% or 30% of the total investment and that he didn't seek the funding: "They came to me."

In spite of the questions surrounding it, Zhu says he likes the racetrack memory concept. "It's very different, very bold," he says. Time will tell whether it leads to a revolutionary new technology or fades from memory.

—ADRIAN CHO



Driven. Bits consist of magnetized "domains" pushed along by flowing electrons (purple). Researchers read them by measuring the wire's resistance, which is affected by the "walls" between oppositely magnetized domains.

reach their limits as engineers strive to cram ever more bits onto a chip.

Racetrack memory stores bits of information on metal nanowires, in minuscule "domains" that can be magnetized to point either way along the wire. But unlike the stationary bits in a hard drive, the bits in racetrack memory move. To write a bit, electrons flowing through an input wire create a magnetic field (see figure). If the bit has a different value from the preceding one—one is a 0 and the other is a 1—then a domain wall will exist between them. Some of the electrons also flow down the nanowire, and in theory they should push the domain walls, and hence the bits, down the wire.

That's just what Parkin and colleagues showed. The team made a three-bit "shift register" that could reliably pass a sequence of bits from input to output. That's the basic function that the memory element has to perform, and there's no question that it works,