Martian Methane: Rocky Birth, Then Gone With the Wind?

CAMBRIDGE, U.K.—In the medieval city where Isaac Newton worked on the gravitational laws, about 850 scientists gathered from 4 to 9 September for the 37th meeting of the American Astronomical Society's Division for Planetary Sciences.

Last year, a spectrometer on board the European Space Agency's Mars Express spacecraft detected methane above areas of the martian surface where there also appears to be subsurface ice (*Science*, 1 October 2004, p. 29). Many researchers hailed the find as possible evidence that bacteria are living in the ice and producing the gas. After all, almost all the methane in Earth's atmosphere is produced by living organisms. Indeed, says planetary scientist Sushil Atreya of the University of Michigan, Ann Arbor, many alternative explanations for the existence of the methane don't work. Volcanic activity would also produce sulfur dioxide, which is not observed. A freak cometary impact in the past few thousand years could have delivered methane to the martian surface, but then the gas wouldn't be concentrated in specific regions.

Methane muddle. Who's found the right concentration, Mars Express or Gemini South (*inset*)?

But, Atreya announced at the meeting, it's too soon to invoke martian microbes as the source. Instead, a little-known geochemical process known as low-temperature serpentinization could be the culprit. In this process, which has been observed on Earth's ocean floor, liquid water chemically alters basalt to produce the gas. Atreya thinks it might produce huge amounts of martian methane, which would then be quickly destroyed by oxidation, ultraviolet sunlight, and possibly also by electrical activity of atmospheric dust.

Atreya says basalt reacts with liquid water to produce minerals known as serpentines, releasing hydrogen in the process. The hydrogen then reacts with carbon dioxide to produce methane. The process operates at temperatures of about 40° to 90° Celsius and is distinct from the high-temperature hydrothermal activity also seen on Earth's ocean floors. At a few kilometers beneath the martian surface, low-temperature serpentinization in reservoirs of liquid water could produce up to 200,000 tons of methane per year, Atreya says—more than enough to explain the concentrations of some 10 parts per billion seen in the atmosphere.

So where does all the methane go? Given that methane concentrations vary widely over the martian surface, it must be destroyed too quickly for the gas to spread out evenly. The explanation may lie in the electrostatic charging of dust particles, says Atreya. In small dust devils and larger dust storms, electric fields as strong as 25 kilovolts per meter could be produced. Such voltages would break up water molecules, and the hydroxyl molecules created would then oxidize methane. If this removal mechanism is indeed operating on Mars, it could mean that the production rate of methane is actually much higher than has been assumed until now.

Indeed, Michael Mumma of NASA's Goddard Space Flight Center in Greenbelt, Maryland, observed Mars with telescopes on Earth and found much higher methane concentrations (up to 250 parts per billion) in some equatorial regions. However, Atreya says "something is weird" about these observations. Such high concentrations would almost blind Mars Express's sensitive spectrometer, a problem that does not occur. Mumma is currently reanalyzing the data using new and better calibrations, but so far there's no indication that the high values will go away, he says.

Snapshots From the Meeting

A rapidly rotating rugby ball. A recently discovered miniplanet in the outer solar system is almost twice as long as it is wide, says David Rabinowitz of Yale University. The object, known as 2003 EL_{61}, has the shape of a squashed rugby ball, measuring 1960 × 1520 × 1000 kilometers. The elongated shape results from the object's rapid rotation; its period of 3.9 hours is the fastest ever measured for a large solar system body. Using the 10-meter Keck Telescope at Mauna Kea, Hawaii, Rabinowitz and his colleagues have also detected a small satellite orbiting the miniplanet at a surprisingly large distance of almost 50,000 kilometers. It's unclear how the system could have formed or whether the rapid rotation and the strange satellite are somehow related. Says Rabinowitz: "2003 EL_{61} may not quite be as big as Pluto, but it's much more interesting dynamically."

Irregular satellites explained? No one really knows how to explain the large number of "irregular" satellites that swing around the giant planets in slow, eccentric, tilted orbits. Most likely they're asteroids, long ago slowed by gas drag and captured by the rotating disks of gas and dust from which each of the planets formed. But computer simulations show that such captured objects quickly spiral into the nascent planet unless something boosts their orbits well outside the cluttered inner parts of the planet-spawning disk.

Now, Brett Gladman and Matija Ćuk of the University of British Columbia in Vancouver think they've found such a mechanism. According to their numerical simulations, an orbital resonance between Jupiter and Saturn that occurred in the distant past would have "pumped up" the orbits of Saturn's irregular satellites to a safe distance from the planet. A similar past resonance between Saturn and Uranus may have preserved the latter planet's irregular satellites, says Ćuk. However, he admits that Jupiter's troop of irregulars is not so easily explained.

–G.S.

CREDIT: D. DUCROS/ESA; INSET: GEMINI OBSERVATORY/AURA

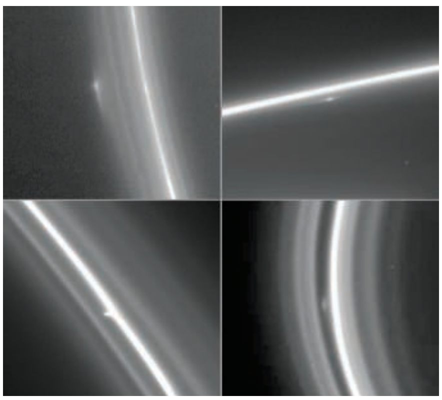
Published by AAAS

As for the origin of the gas, Mumma says he's not sure that Atreya's low-temperature serpentinization scenario applies to Mars. "I'd keep the biological option open," he says. A definitive check on the origin of methane will likely have to wait for NASA's Mars Science Laboratory, scheduled for launch in 2009. Says Mumma: "This is going to be a long tale."

Several New Twists for Saturn's Rings

They may appear serene and eternal, but Saturn's rings are changing, and changing fast. Over the past 25 years—the mere blink of an eye in planetary evolution—one particular ringlet in the innermost, tenuous part of the ring system moved 200 kilometers inward and became one-tenth as bright. "That's radical," says Carolyn Porco of the Space Science Institute in Boulder, Colorado, head of the imaging team for NASA's Cassini spacecraft. Porco's team discovered the rapid change by comparing Cassini ring photos with images the Voyager spacecraft sent to Earth in 1980. "This is one of the reasons why we wanted to come back," she says. The dramatic change suggests that this part of the ring system could be young and rapidly developing, although no one yet knows how to interpret the observations.

Other ring results presented at the meeting are equally baffling. For instance, Cassini's temperature measurements of the rings indicate that ring particles are 15° cooler on their night side than on their day side. According to Linda Spilker of NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, this means that all particles—from a few centimeters to a few tens of meters across—rotate too slowly to bake evenly on all sides. "We always thought that mutual collisions would lead to a wide variety of rotation rates," says Spilker. Maybe the particles are fluffy and porous, she adds, which would dampen the effects of collisions.

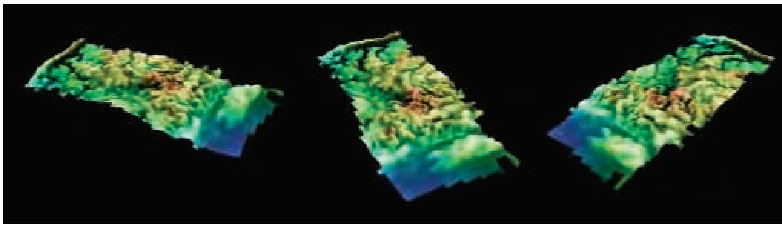


Spiral mystery. Do these objects wind up Saturn's F ring?

Weirdest of all is Saturn's thin, braided, kinky F ring, which lies just outside the main ring system. Cassini's images show that various strands of the F ring are actually one and the same narrow dust ring, tightly wound into a spiral. This unique structure—unrelated to the spiral density waves that have been seen in other parts of the ring system (*Science*, 9 July 2004, p. 165)—may be caused by a small moonlet discovered by Cassini in an eccentric orbit that appears to cross the F ring. That orbit is a mystery in itself: The F ring is believed to contain many large boulders and moonlets, which would make it hard for a small satellite to survive multiple crossings. Even so, the tiny object (denoted S/2004 S6) has been observed for almost a year.

Cassini has also spotted more bright knots close to the F ring, some of which are very elongated. "We have a hard time deciding which of these objects are real moons and which of them are clumps of dust," says Porco. Even S/2004 S6 may turn out to be a loose clump rather than a solid object. Future observations of Saturn will surely reveal new small satellites. Says Cassini's project scientist Dennis Matson of JPL: "The complexity in the rings is just dumbfounding. We will continue to bring you excitement."

Volcanoes, Monsoons Shape Titan's Surface



Rough terrain. Stereoscopic images of Titan's surface from the Huygens probe.

Hiking on Titan would be the ultimate extreme sport. Data from the European Huygens lander show that the surface of the large saturnian moon is a jagged landscape of extremely steep valleys, overshadowed by towering ice cliffs. "It's quite dramatic," says planetary scientist Jonathan Lunine of the University of Arizona's Lunar and Planetary Laboratory in Tucson. "You would need an ice ax to scale the 30-degree slopes." It would be tougher than climbing a glacier, he adds: "The ground beneath your feet would feel more like a crumbly rock slope." But at least early travelers to Titan could consult the first three-dimensional maps of parts of the moon's surface, which Lunine presented at the meeting.

The Huygens lander touched down on Titan on 14 January. During its parachuted descent, it took numerous snapshots of the panorama beneath. Lunine's team has now combined these into stereoscopic images of a 1.5-by-3.5-kilometer swath of terrain, showing deep, precipitous valleys carved out by "methane monsoons," as Lunine's colleague Ralph Lorenz calls them after a description in Arthur C. Clarke's 1975 novel *Imperial Earth*. Taking into account Titan's seasons, atmospheric properties, and solar radiation, Lorenz estimates that the "monsoons" happen every few centuries and last for months. They're like the episodic rainstorms in the Arizona desert, but on a different time scale, he says.

The methane in Titan's atmosphere must be continuously replenished because ultraviolet sunlight is constantly breaking down the gas. Researchers do not yet know whether methane has been stored in the mantle since Titan's formation or whether it is being produced by geochemical processes beneath the surface. According to planetologist Gabriel Tobie of the University of Nantes, France, various forms of outgassing—such as cryovolcanism, which brings water-ammonia ice containing trapped methane to the surface—would then release the gas into the atmosphere episodically. Indeed, radar images of Titan's surface obtained by NASA's Cassini spacecraft—Huygens's mother ship—show evidence of volcanic domes, craters, and flows. Some of the latter resemble flows on the slope of Mauna Loa, Hawaii. "There's major resurfacing going on," says volcanologist Rosaly Lopes of NASA's Jet Propulsion Laboratory in Pasadena, California.

Researchers' views about Titan's surface have also changed since Huygens's landing in January. During touchdown, a protruding penetrometer on the bottom of the lander first encountered much resistance and then went through softer material, leading scientists to conclude that Titan was like a crème brûlée with a thin, brittle crust. Now, John Zarnecki of the Open University in Milton Keynes, U.K., head of the Surface Science Package team, thinks it's more likely that the penetrometer hit an ice pebble similar to the ones seen in Huygens's pictures and then pushed it aside.

It will be a while before travel agents offer trips to Titan, but Jean-Pierre Lebreton, Huygens's project scientist at the European Space Agency, hopes to go back soon. "Huygens has paved the way for future missions to the surface of Titan," he says.

–GOVERT SCHILLING

Govert Schilling is an astronomy writer in Amersfoort, the Netherlands.