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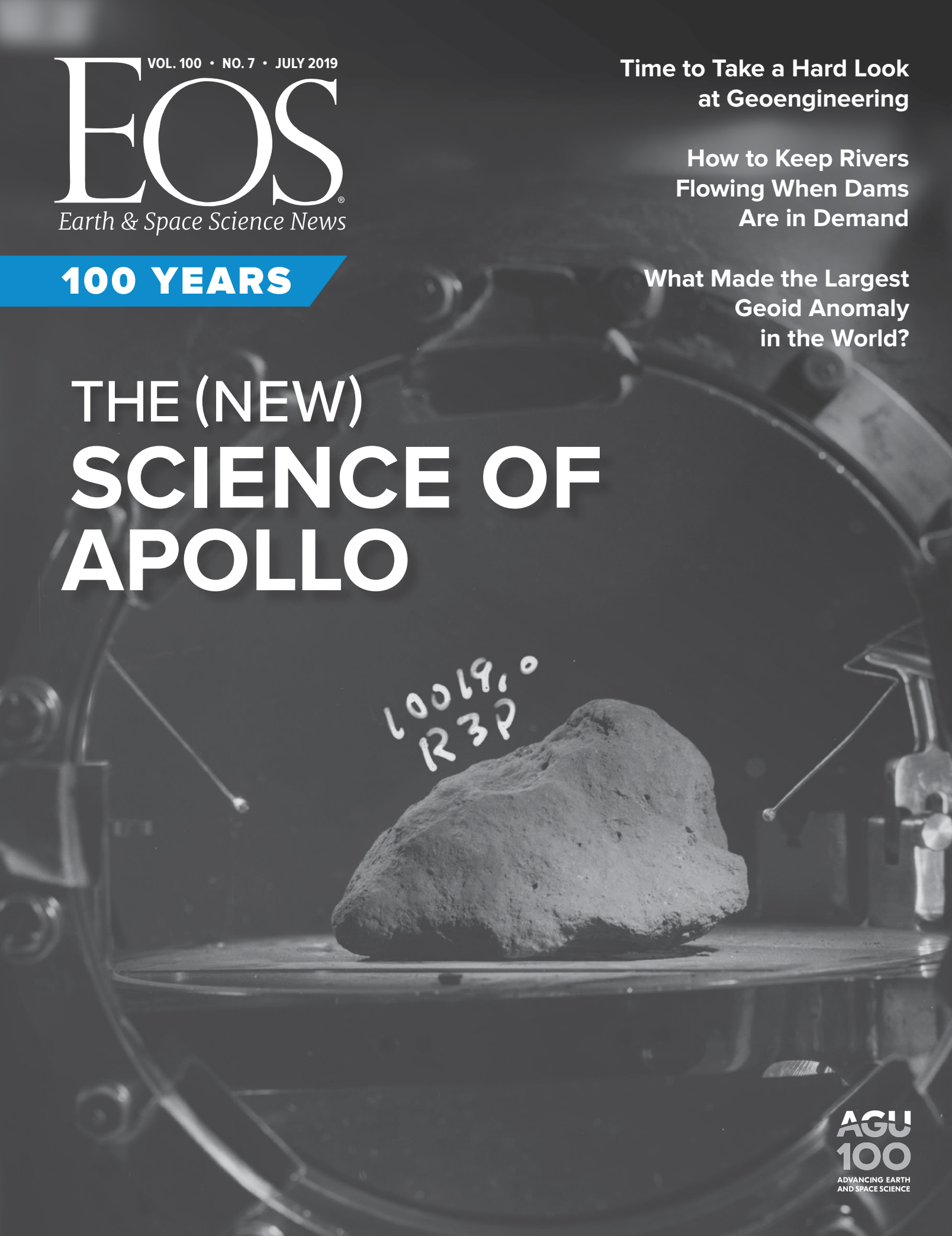
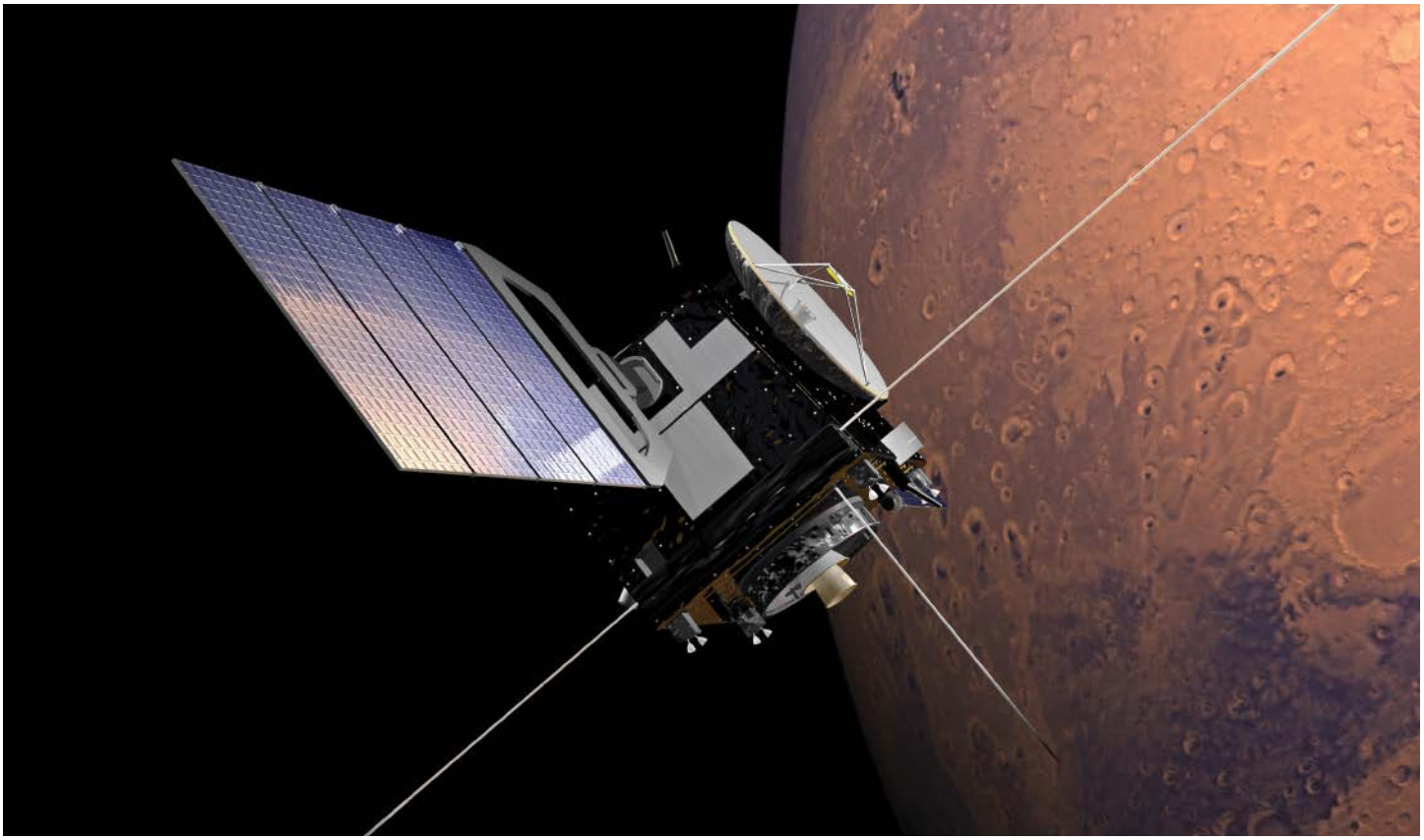


AGU 100
ADVANCING EARTH AND SPACE SCIENCE

The Accidental Particle Accelerator Orbiting Mars



This artist's rendering of the Mars Express spacecraft shows the 40-meter-long antenna used by the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS), the craft's powerful ground-penetrating radar, which can also accelerate charged particles in the planet's ionosphere. Credit: Alex Lutkus/ESA

Scientists have known for decades that when you put a powerful radio transmitter into space, the radio waves can energize the plasma that surrounds Earth, creating beams of high-energy ions and electrons. This phenomenon—dubbed sounder-accelerated particles (SAP)—was theoretically proposed in the 1970s and first detected in Earth orbit by the Soviet satellite Interkosmos 19 in 1979.

But it wasn't until the mid-2000s that scientists identified this phenomenon occurring on another planet, thanks to the Mars Express mission. The European Space Agency craft, which reached Mars in 2003, was equipped with a powerful ground-penetrating radar designed mainly to search for underground reservoirs of liquid water. But it could also be used to probe the layers of Mars's ionosphere. Shortly after operations began in Mars orbit, preliminary analysis showed that these pulses of radio waves were also energizing the ions themselves, similar to what had been observed near Earth.

Now *Voshchepynets et al.* have taken a deep dive into over 10 years of data from Mars Express to learn more about the underlying physics behind SAP and how they may differ in the Martian environment.

By combining data from the radar and the craft's ion mass analyzer (IMA), the authors could see when the IMA was detecting oxygen ions that were being accelerated by the radar's pulses, reaching energies as high as 800 electron volts. The data also showed that these beams were usually generated when the radar was transmitting at frequencies close to the plasma's own resonant frequency, the natural frequency at which it pitches and heaves.

This result is similar to what has been observed from Earth-orbiting spacecraft, where spacecraft sounders can form instabilities in the plasma that build up and accelerate particles. However, the authors' analysis of the conditions in Mars orbit shows that this mechanism could accelerate the ions to only a fraction of an electron volt, not the hundreds observed by Mars Express.

To explain the high-energy ions, the team suggests that when the spacecraft's radar is active, the voltage applied to the antenna causes a negative charge to build up on the spacecraft itself. When the radar's pulse is over, positive ions in the ambient plasma are then accelerated toward the spacecraft.

The ability of Mars Express to generate such particle beams could lead to a new way to study planetary ionospheres, the authors say, one where spacecraft actively probe their environments and manipulate the plasma around them to detect hard-to-find ions. (*Journal of Geophysical Research: Space Physics,* https://doi.org/10.1029/2018JA025889, 2018) **—Mark Zastrow, Freelance Writer**