Meteorites: To stream or not to stream?

Researchers say they have found compelling evidence that meteorites sometimes fall to Earth in streams. Their report, greeted with skepticism by some experts, bucks the traditional view of how these rocky bodies, which typically represent fragments of an asteroid, make their way to our planet.

The scientists base their findings on the location and chemical analysis of a set of meteorites that struck Earth during the 19th century. Spurred by recent suggestions that some meteorites travel in groups, a team led by Michael E. Lipschutz of Purdue University in West Lafayette, Ind., and Robert T. Dodd of the State University of New York at Stony Brook searched through meticulous records kept at the British Natural History Museum.

The team discovered that 17 meteorites that fell to Earth between 1855 and 1895 formed an intriguing pattern – a broad line in the northern hemisphere that extends for several thousand kilometers. All of the meteorites belong to a primitive class called H chondrites, believed to have formed soon after the formation of the solar system.

"These meteorites seemed to just line up," Lipschutz says. "We knew from the data that this was probably not a random event."

Borrowing samples of 13 of the 17 meteorites from museums in the United States and Europe, Lipschutz and Purdue graduate student Stephen F. Wolf measured the concentrations of certain key elements in the meteorites. By bombarding the samples with neutrons and then recording the decay of radioactive elements created during the process, the researchers found that all 13 of the meteorites had remarkably similar amounts of several trace elements, including thallium, indium, cadmium, and bismuth. In contrast, a "control" group of 45 H chondrite meteorites that were not part of the line-like fall pattern had different amounts.

The chemical similarity and the telltale geometric pattern of the meteorites, which all fell in May during different years in the latter half of the 19th century, strongly suggest that these rocky bodies traveled together through space and originated as fragments of the same parent asteroid, the researchers assert. Dodd and Wolf reported the work this week in Copenhagen, Denmark, at the annual meeting of the Meteoritical Society.

But other scientists maintain that the team's interpretation has a rocky foundation in more ways than one.

Planetary scientist George W. Wetherill of the Carnegie Institution of Washington (D.C.) calls the results "unbelievable." He insists the findings cannot refute the standard picture of meteorite falls, in which each fragment of an asteroid travels alone and hits Earth at random. That scenario, Wetherill notes, relies on elementary principles of physics.

A powerful collision between an asteroid and another body in space may well create a stream of rocky fragments, he says. But each member of the stream will have a slightly different velocity, and some will have an orbit that takes them slightly closer to Earth (or another planet) than others. Thus, Earth's gravity may exert a greater tug on some fragments, pulling them away from other members of the stream. Over a few million years, says Wetherill, gravity acts to completely disperse any stream that originally existed. Thus, he and other researchers conclude, no meteorite stream can stay intact long enough to strike Earth.

Wetherill adds that the stream Dodd and his co-workers claimed to have discovered – some 50,000 to 100,000 kilometers in width – far exceeds the radius of the Earth. If such a stream ever struck Earth, it would most likely rain down uniformly upon the planet, rather than leave the line-like pattern the team found, he argues.

Wetherill notes that when meteor showers – streams of short-lived, dusty debris produced by comets – enter Earth's atmosphere, they indeed surround the whole planet.

"I've had graduate students that may have claimed to have discovered a new law of nature every time they went into the laboratory, and this [work] is in that category," Wetherill says.

Brian G. Marsden of the Smithsonian Astrophysical Observatory in Cambridge, Mass., says he finds the team's chemical finding intriguing but remains skeptical about the stream notion.

But Lipschutz maintains that the chemical and geometric evidence say otherwise. "The conventional wisdom about how we think things get here [to Earth] from asteroids just isn't understood," he insists.

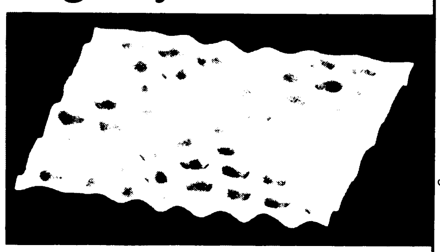
Lipschutz notes that other work, including his own 1986 study that highlighted differences between ancient meteorites in the Antarctic and newer meteorites elsewhere on Earth, also suggests that some meteorites travel in groups rather than alone. "Either Mother Nature is playing a very cruel game, or we're looking at something real," he says.

– R. Cowen

Protein masks for etching tiny holes

The outer wall of the bacterium *Sulfolobus acidocaldarius* acts as a sieve. Its two-dimensional array of regularly spaced, microscopic holes permits the organism to regulate the passage of substances into and out of its body.

When deposited on a smooth graphite surface, this holey layer of protein molecules also provides scientists with a template for rapidly fabricating patterns of tiny holes in a thin, metal-oxide film (SN: 3/24/90, p.191). Now physicists have discovered that the resulting metal-oxide screen can act as a mask in transferring the same pattern of holes to the underlying graphite substrate.



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Atomic force microscope image showing array of holes, 22 nanometers apart, fabricated with a protein-based mask.

This novel method may in certain cases represent an inexpensive, efficient, "bench-top" alternative to the use of electron beams or such techniques as X-ray lithography for etching arrays of holes on graphite, silicon, and other surfaces, says Kenneth Douglas of the University of Colorado at Boulder. Douglas, Genevieve Devaud, and Noel A. Clark describe their work in the July 31 SCIENCE.

The researchers begin by depositing a layer of bacterium-derived protein crystals onto a graphite surface. They coat these crystals with a thin film of titanium, which subsequently reacts with oxygen in air to form a metal-oxide layer about 3.5 nanometers thick.

Using a technique known as "fast-atom beam" milling, the researchers train a stream of accelerated argon atoms and ions onto the metal-oxide coating to gradually wear it away. But the erosion occurs unevenly. More metal-oxide disappears from the hollows representing holes in the protein layer than from the peaks marking the presence of protein. This imbalance produces holes, each only 10 nanometers in diameter, that puncture the metal-oxide layer and penetrate into the underlying graphite substrate, while leaving a network of protein, still coated with titanium dioxide, surrounding the holes.

"There seems to be a kind of self-focusing effect that's created by armoring or reinforcing the biological material, which by itself would normally be too fragile to withstand the ion beam," Douglas says. The researchers suggest that the hole-formation process involves both the removal and the redistribution of metal oxide. *– I. Peterson*