MEETING METEORITICAL SOCIETY

Ancient Sky Rocks and an Unblemished Eros

The events of 11 September distracted but did not disrupt the annual meeting of the international Meteoritical Society, held that week in Rome at the Vatican's Pontifical Gregorian University. Attendees heard about an ancient asteroid shower being excavated in Sweden and the mysterious smoothness of the surface of asteroid Eros.

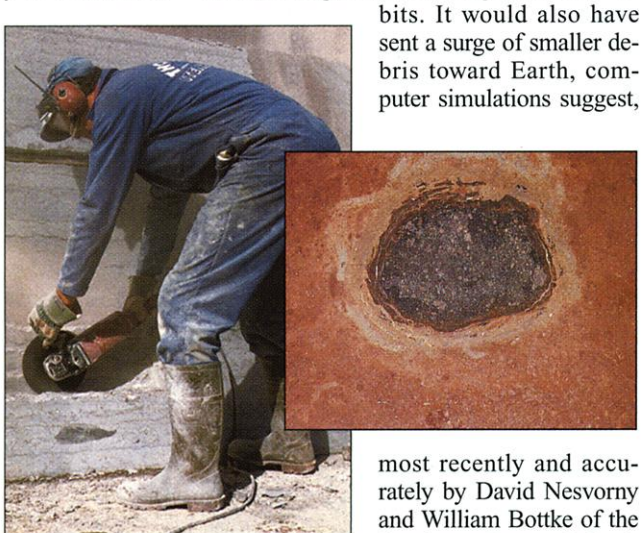
Asteroid Shower Hit Ordovician Earth

Nondescript blobs in limestone from a quarry in southern Sweden have turned out to be fossilized meteorites from what may be Earth's earliest known asteroid shower—a bombardment that took place half a billion years ago following a massive collision in the asteroid belt. The meteorites are "a significant discovery," says meteoriticist Harry McSween of the University of Tennessee, Knoxville. "Earth must have been pelted by a lot of meteorites."

Over the past 10 years, workers at the quarry, near Kinnekulle, have saved 40 of the fossilized meteorites for geochemist Birger Schmitz of the University of Göteborg. Authenticated by their chemical composition and mineralogical texture, the specimens range from 1 to 20 centimeters in diameter, Schmitz and Mario Tassinari of the Väner Museum in Lidköping, Sweden, reported at the meeting. The meteorites come from 12 distinct levels in the quarry, spanning 2 million years, Schmitz estimates. That means the quarry, which was once a shallow sea, could not have been simply the target of a single meteor that shattered on entering the atmosphere. From their abundance, Schmitz and Tassinari calculate that meteorites of this size—and presumably much larger—must have been hitting Earth 25 to 100 times more frequently 480 million years ago than they do today.

Other evidence of the asteroid shower turned up when Schmitz and Tassinari analyzed chromium-rich mineral grains from the fossil meteorites. The minerals—about the only ones not altered during fossilization—show that all the finds fall in the low-iron or L subclass of chondrite meteorites. Today, most chondrites falling to Earth are either L or H (high-iron) types, in equal proportions.

Studies of L-chondrite meteorites show that many suffered a tremendous shock at about the same time the Swedish meteorites fell to Earth. A plausible explanation, Schmitz says, is that a massive collision in the asteroid belt shattered the "parent body" that is the source of all L chondrites. Such a shattering would have created a "family" of asteroid fragments traveling in similar orbits. It would also have sent a surge of smaller debris toward Earth, computer simulations suggest, most recently and accurately by David Nesvorny and William Bottke of the Southwest Research Institute in Boulder, Colorado. The Swedish limestone seems to hold a tiny sampling of that surge, Schmitz says. The lack of H chondrites in the collection so far could simply reflect a low accumulation rate like today's.



E.T. rock in rock. Fossil meteorites from a Swedish limestone quarry suggest a shower of asteroids 480 million years ago.

CREDITS: B. SCHMITZ AND M. TASSINARI

If the fossil meteorite story holds up, "a lot of pieces of the puzzle come together," says Bottke. "It would be nice to have a second site where you see a high [accumulation] rate," says cosmochemist Alan Hildebrand of the University of Calgary in Canada, "but it certainly seems like he has a good story." A possible weak spot, many say, is Schmitz's rough estimate that the quarry's rocks formed over 2 million years. If the actual figure were 20 million years, the calculated flux of meteorites would look much like today's. But Schmitz counters that if the rocks formed over much more than 2 million years, fossil trilobites in them would show signs of having evolved, which they don't.

In fact, the early Ordovician asteroid shower, which presumably included hefty kilometer-size bodies, does not appear to have tweaked evolution at all. Like a comet shower 35 million years ago (*Science*, 30 January 1998, p. 652)—and decidedly unlike the impact 65 million years ago that did in the dinosaurs—it had no obvious effect on life. Let's hope we are so lucky next time.

Asteroid Protection

Something is keeping Eros—and presumably other asteroids—remarkably smooth. Closeup pictures of Eros taken by the NEAR spacecraft startled planetary geologists: Small impact craters several meters in diameter and smaller were scarcer than anyone expected, by a factor of 1000. "This is very different from the moon," says asteroid specialist Clark Chapman of the Southwest Research Institute in Boulder, Colorado; impact craters dominate the lunar landscape down to the scale of a footprint. Either something smoothed the surface after small craters formed on Eros, he told the meeting, or—his preferred explanation—the craters never formed at all.

Whatever mechanism is responsible, notes Chapman, it has to be one that doesn't operate on the moon. One possibility is a large impact that jolts the whole asteroid, shaking down the loose surface "soil" like flour in a cup. But Chapman wonders if enough of a jolt could get through the fractured interior of Eros. Electrostatic charging of fine dust grains by the sun might levitate enough material to fill in low spots like craters, Chapman says, but the obvious examples of that are too few to explain the small-crater shortage. Or the abundance of boulders discovered by NEAR might provide a physical barrier, but it would be too porous to explain the dearth of craters.

Chapman looks to the Yarkovsky effect as the most promising explanation. Recently revived to explain how meter-size rocks escape the asteroid belt (*Science*, 13 August 1999, p. 1002), the Yarkovsky effect is the push a small rock gets when its sun-bathed, hot "afternoon" quadrant rotates into the night side and radiates its heat away. That may nudge small rocks into the zones from which the gravity of Mars or Jupiter can send them out of the belt. If the Yarkovsky effect sweeps out enough small debris, Eros might escape at least the smaller insults visited upon the moon. "That's the qualitative idea," says Chapman. Quantitative modeling is needed now. "We need all the help we can get," he says.

–RICHARD A. KERR