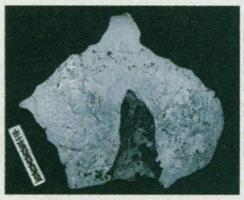
PLANETARY SCIENCE

# New Source Proposed for Most Common Meteorites

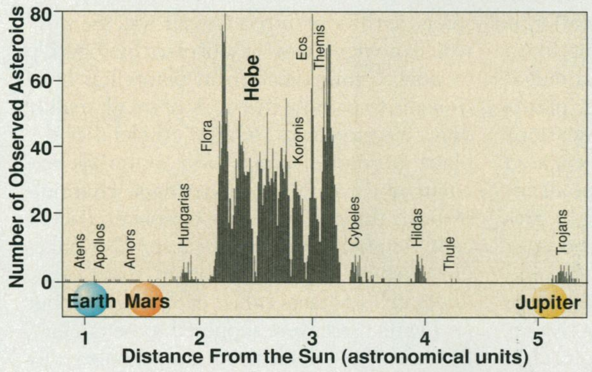



A single, extraordinary asteroid may be the wellspring of countless run-of-the-mill meteorites. These rocky meteorites, chunks of primordial solar system material, fall to Earth in such abundance that they are called ordinary chondrites. But familiar as these space visitors are, no one has been able to pinpoint their source. A few decades ago, astronomers presumed that these meteorites were chips off the most common sort of asteroid, the rocky and metal-rich S-types. More recently, the search has focused on only a handful of such asteroids. Now, one planetary scientist, Michael Gaffey of Rensselaer Polytechnic Institute in Troy, New York, is pointing to a single S-type asteroid, 185-kilometer Hebe, as the sole source of fully half the ordinary chondrites.

Gaffey singled out Hebe this summer at the Meteoritical Society meeting in Berlin, when he presented spectra taken as Hebe rotated that suggest that large parts of Hebe's surface have a color and therefore a composition closely matching that of one large subclass of chondrites. The match is "essentially dead-on spectrally," says Gaffey. That and Hebe's position near an "escape hatch" in the asteroid belt—a zone where any debris splashed off Hebe by impacts can be flung toward Earth by Jupiter's gravity—make this asteroid the probable chondrite source, he says.

A similar claim has only been made once before, when another researcher pointed to a small asteroid as one—but not the sole—source of a different subclass of ordinary chondrites (*Science*, 23 July 1993, p. 427). But Gaffey's striking proposal is being accepted by his colleagues—up to a point. "The significant thing that he's done with Hebe is showing that its silicate mineralogy is at least consistent with ordinary chondrite," says remote-sensing specialist Jessica Sunshine of Science Applications International Corp. of Chantilly, Virginia. Hebe "looks pretty good" as the source of some chondrites, agrees asteroid specialist Clark Chapman of the Southwest Research Institute in Boulder, Colorado. But Chapman and others have trouble with Gaffey's explanation for another peculiarity of Hebe: a reddish tint on parts of its surface. Gaffey attributes these reddish blemishes to puddles of iron melted by past impacts—a scenario other researchers dismiss as improbable.

Zeroing in on one large asteroid as the most probable chondrite source has taken some persistence. Back in 1979 Gaffey recorded the changing visible spectrum of Hebe as it rotated. But it took 10 years and another five attempts—plagued by bad weather, instrument problems, and tight telescope time—before he managed to get the near-infrared spectra. By that time Gaffey was working on other questions, and he put the data aside. Finally, in the past year Gaffey analyzed the spectral data to see what the changing colors say about the composition of separate parts of Hebe's surface. He found that 60% of Hebe's surface has the right ratio of the minerals pyroxene and olivine to be ordinary chondrite, while the other 40% looks like iron metal.




**Source rock?** Hebe's location allows Jupiter to sling debris from the asteroid toward Earth (*above*), and Hebe may be the source of many rocky and mixed rock-iron meteorites (*top*).

Added to earlier calculations showing that Hebe's position in the asteroid belt could allow it to contribute a sizable portion of all meteorites, the finding convinced Gaffey that Hebe was the source of the particularly metal-rich H subclass of ordinary chondrites, which comprises half of all chondrites. That doesn't rule out the possibility that a few other asteroids of similar composition contribute some material, but for those familiar with the new results, Hebe is now at the top of the list.

But what would create this proposed combination of chondritic rock—which by definition has never melted—and free iron, which at some point must have separated from molten, metal-rich rock? Gaffey took a clue from suggestions that certain iron meteorites with bits of chondritic rock embedded in them could have formed when an impact melted part of a chondritic asteroid. The trick, Gaffey decided, was to have the impact melt only a thin layer of the asteroid's surface; the iron would then separate and sink to form a lower layer. A few additional, smaller impacts could chip away the overlying rock and expose the solidified iron puddle.

Gaffey's iron puddles haven't gone over well with his colleagues. He "is totally wrong" about impacts causing melting on Hebe, says meteoriticist Klaus Keil of the University of Hawaii. Based on laboratory experiments, calculations, and analogies with terrestrial craters, Keil says he and his colleagues have concluded that "unless you go to moon-sized objects that collide, you simply can't produce much melt." And any melt that does form solidifies too quickly for the iron to separate, he adds.

Gaffey responds that the greater porosity of asteroids should boost the amount of melting in impacts, at least enough to create scattered ponds of solidified iron. But others, such as Harry McSween of the University of Tennessee, find that hard to envision. And besides, "you don't have to appeal to making little plates of metal," McSween argues. "I have the feeling we can do all this with just space weathering."

Once dismissed as so much "foo-foo dust," space weathering—a slow change in the color of rock exposed to space—got a boost when the Galileo spacecraft passed by asteroids Ida and Gaspra, where it spotted debris thrown from impact craters that has reddened to varying degrees. "The nay-sayers have been silenced," says Sunshine. "Space weathering does exist; the question is: what's the process?" Proposals have included solar radiation damage and micrometeor impacts, but no one has been able to replicate the reddening in the laboratory.

In the absence of a mechanism, Gaffey isn't convinced that space weathering is behind Hebe's red blemishes. "What we see on Ida and Gaspra is more tantalizing than convincing," he says. A clearer answer may come from the Near-Earth Asteroid Rendezvous spacecraft, which will enter close orbit around the asteroid Eros in 1999. "That will be our opportunity to see weathering mechanisms at work," says Beth E. Clark of Cornell University.

Some astronomers are not so sanguine, even about this close encounter (*Science*, 9 February 1996, p. 757). "The more I think about this problem, the less I think it can be solved by any kind of remote sensing," says Jeffrey Bell of the University of Hawaii. He and others will be proposing a new planetary mission to land on an S-type asteroid and return samples to Earth—a mission that could finally end the speculation about Earth's most common extraterrestrial material.

–**Richard A. Kerr**