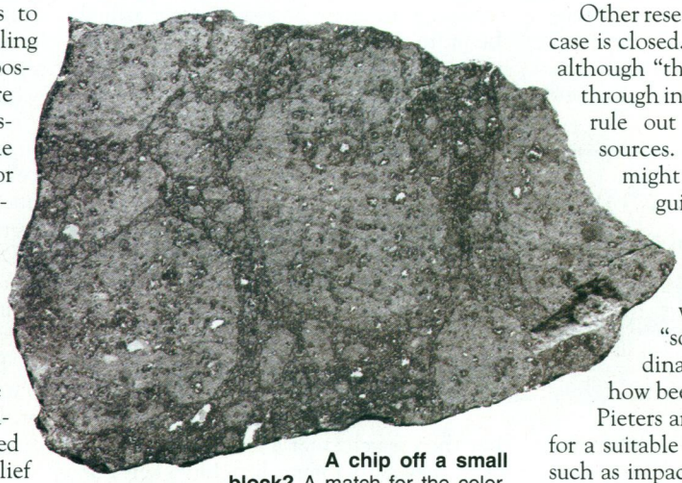
PLANETARY SCIENCE

A Source Found for Earth's Commonest Meteorites

Since 80% of the meteorites that fall to Earth are rocky lumps of primordial solar system material, known as ordinary chondrites, they should be the commonest kind of space junk. But out in space, the source of these chondrites was nowhere to be found. When astronomers looked at the asteroid belt, where collisions among asteroids presumably create the debris that eventually falls to Earth, they could find nothing resembling the familiar meteorites. That left three possibilities: Either the parent bodies were somehow camouflaged, or they had escaped notice because they are among the asteroid belt's smallest members—or something was deeply wrong with astronomers' understanding of where meteorites come from.

No one has solved the puzzle yet, but at least the third, and most radical, hypothesis can now be set aside. This week, astronomers announced that they had identified the first asteroid with the distinctive spectral signature of an ordinary chondrite: a 7-kilometer body named Božněmcová. "There's a huge sigh of relief that this stuff is out there," says astronomer Richard Binzel of the Massachusetts Institute of Technology (MIT), who along with Shui Xu and Schelte Bus of MIT and colleagues at three other institutions made the announcement at the meeting of the Meteoritical Society in Vail, Colorado. Božněmcová, named for a nineteenth-century central European writer, not only seems to have the right stuff, it's in the right place: hard against the narrow zone in the inner asteroid belt where Jupiter's gravity stirs any asteroid—and any debris from asteroid collisions—into chaotic orbital gyrations that can send it toward Earth.

As delighted as astronomers are with the new discovery, Božněmcová cannot by itself account for all ordinary chondrites. Indeed, the new find has rekindled a debate over whether ordinary chondrite meteorites come solely from asteroids the size of Božněmcová and smaller or whether much larger parent bodies must exist as well. Nevertheless, the small asteroids were the obvious place to begin looking, says Binzel, because they are the asteroid belt's terra incognita. For most asteroids smaller than 30 kilometers in diameter, no more than their brightness and orbit around the sun is known. They have remained obscure partly because large telescopes aren't available for time-consuming asteroid surveys. But Binzel and his colleagues at the Michigan-Dartmouth-MIT Observatory on Kitt Peak in Arizona were able to make the best of modest-sized telescopes by equipping them with a sensitive charge-coupled device (CCD) as a detector, which allowed the researchers to determine accurately the color of faint asteroids smaller than 20 kilometers.



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A chip off a small block? A match for the color, and therefore the composition, of this meteorite—a member of the most common type found on Earth—has finally been spotted in a tiny asteroid.

Of the 80 asteroids studied since the survey began in 1991, only one—Božněmcová, first observed late that year—had the reddish tint seen in laboratory spectra of ordinary chondrites. To clinch the identification, the group recorded broader spectra of the asteroid last January and again in March. The complete spectrum is unique among asteroids, and "it's a very good match" with spectra of two of the three subclasses of ordinary chondrites, says astronomer Michael Gaffey of Rensselaer Polytechnic Institute. "I think [Binzel] has a very good case" that Božněmcová is an ordinary chondrite source, he adds.

As Binzel and others go on scrutinizing obscure members of the asteroid belt, everyone agrees, they are sure to turn up more small chondrite asteroids. But that won't settle the debate about whether or not all chondrite sources are small. Astronomer Jeffrey Bell of the University of Hawaii believes they are. "I predicted this discovery in 1987," he says. "It's where I said it was, and it exactly fits my notion that [chondrite sources] would show up at smaller sizes." All that's needed to explain the abundance of ordinary chondrite meteorites, claims Bell, is more of these tiny ordinary chondrite asteroids.

Small parent bodies are just what you'd expect, says Bell, because chondrites seem to have escaped the heating, melting, and alteration that has transformed most objects in the solar system since its formation 4.5 billion years ago. If the parent asteroids were too large, they would have retained enough heat during the early days of the solar system to melt and thus be altered. Assuming that a layer of heat-trapping rubble covered newly formed asteroids, Bell figures that the original ordinary chondrite bodies could have been no larger than 50 kilometers. Since then, he says, they would have been broken down to about the size of Božněmcová and smaller.

Other researchers, though, aren't sure the case is closed. Binzel, for example, says that although "this discovery is the first breakthrough in the field in 10 years," it doesn't rule out larger, as yet unrecognized sources. Some think Božněmcová might have larger relatives in disguise. The larger objects among chondrite sources, planetary scientist Carle Pieters of Brown University explains, would be concealed by a fine "soil" of impact debris whose ordinary chondrite color has somehow been altered beyond recognition. Pieters and others have been searching for a suitable "space weathering" process—such as impact melting or solar radiation—that could make the surface of an ordinary chondrite asteroid resemble the commonest type of asteroids, the so-called S types, or other types. In fact, Gaffey and his colleagues have recently identified 19 S-type asteroids, including three of the largest in the class, that in some ways resemble ordinary chondrites and might be chondrite sources in disguise. This subclass of S types is clustered near the chaotic zone. Small asteroids like Božněmcová could still show their true colors, Pieters adds, because they are geologically young, having recently formed from the collisional breakup of larger asteroids, and their color would not have had time to alter.

But Pieters won't swear by this scenario. With just one ordinary chondrite asteroid identified, she says, "[Bell's] story is as convincing as mine." More discoveries of ordinary chondrites in the asteroid belt should resolve the question, says Binzel. If the new finds cluster near a few large asteroids, then the small ones could be taken as fresh, unweathered chips off the larger disguised parent bodies. If, on the other hand, no parent-child relation emerges, Bell might prevail with his small-asteroid source. What astronomers need now, says Binzel, is better CCDs and observing time on larger telescopes, something so far denied to his lowly survey program.

–Richard A. Kerr