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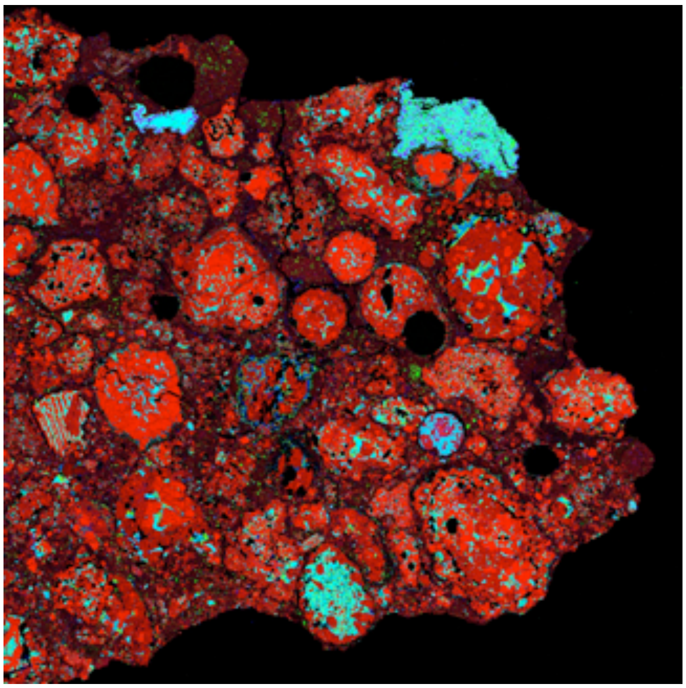
News Notes

Planetary Geology

Early Jupiter spawned early meteorites



When our solar system was forming, back when the sun was a mere whisper of its current self and the planets were just bands of coalescing gas and debris, chondrules were forming. Tiny mineral beads only millimeters across, these ancient grains reside in the most primitive meteorites, and have confounded scientists for a century. Their age is known, but their origin has been notoriously difficult to determine. Now, researchers have generated a model of the early solar system that suggests that Jupiter's formation may have spawned chondrules.

This X-ray thin section of a meteorite shows the elemental composition of both chondrules — tiny ancient mineral grains — and calcium-aluminum-rich inclusions. Red represents magnesium, green is calcium, and blue is aluminum. These primitive materials may have formed from shockwaves produced in the solar nebula. Courtesy of A. N. Krot, University of Hawaii.

One of the leading theories for how chondrules and the solar system formed has been that large shockwaves generated the necessary heat. But "what produces shockwaves in the nebula" has been unknown, says Harold Connolly, an expert on chondrule formation at Kingsborough College and the graduate school of the City University of New York.

Along the spiraling arms of solar nebula material, pressure waves from the disk of matter that was accumulating to form Jupiter may have formed the shockwaves, report Alan Boss of the Carnegie Institution of Washington and Richard H. Durisen of Indiana University in the March 10 issue of *Astrophysical Journal Letters*. The team set up models to see what happens when a disk of materials massive enough to form Jupiter is "turned loose," Boss says.

The new 3-D model shows the chondrules as part of the larger evolution of the solar system, from birth approximately 4.5 billion years ago until the early sun had accreted most inner-nebula materials 3 million years later. The researchers say that gravitational shockwaves from Jupiter's formation may have provided the flash heating necessary to melt iron- and magnesium-rich intra-stellar silicate debris to form the tiny chondrule spherules.

Early studies suggested that the only way to melt the silicates in chondrules in a manner consistent with meteorite observations would have been to heat the grains to melting temperatures multiple times, a process that could be achieved by shockwaves only if they are traveling at least 6 to 9 kilometers per second. According to the new model, the swath of material that would become Jupiter could have driven spiral shockwaves up to 10 kilometers per second, fast enough to produce chondrules. And independent calculations by Durisen and his co-workers seem to confirm that these waves would have caused chondrule-producing shocks in the asteroid belt.

Chondrules, along with larger inclusions and microscopic matrix particles, are the principal components of chondrites, the most primitive meteorites. The new modeling suggests that not only did the shockwaves generate the necessary melting, but that they also did so at a time when the earliest known crystalline materials, calcium aluminum inclusions in meteorites, were forming — suggesting that chondrules may be almost as old. The shockwaves would have continued for several million years, as long as gas remained in the inner-nebula disk, suggesting multiple heating events. “The key is the recent result that some chondrules formed at the same time as some of the earliest solids,” Boss says, “and that chondrule formation lasted for a million years or so after that.”

“This is definitely a major step forward,” says Connolly, who is not affiliated with the new work. While Jupiter was evolving, there were “instabilities” that had to “produce something.” Attributing chondrule formation to that process is “quite visionary,” he says. Questions remain, however, particularly regarding how often an early planetary disk will produce the chondrule-generating shockwaves.

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