SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY

Press Release

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A New Origin for Iron Meteorites Discovered

Honolulu, HI - An article in the prestigious science journal *Nature*, published this week, goes a long way toward resolving a controversy about asteroids and meteorites that has raged in the scientific community since the 1960s. What do key data about the cooling rates of material inside these heavenly bodies indicate about their makeup and formation, and the origins of planets?

Studies of Moon rocks show us that the rocky planets were formed by giant collisions between planetary embryos 4.5 billion years ago that lasted for 50 million years and ended with a mighty impact on the Earth that created the Moon. Now a research team from the University of Massachusetts Amherst (UMA) and the University of Hawaii (UH) has discovered evidence in iron meteorites that shows that planetary embryos, approximately 1000 km is size, formed less than one million years after the birth of the solar system, and quickly began colliding.

Iron meteorites are widely thought to be pieces of once molten cores of about 100 asteroids 5-200 kilometers in diameter that took millions of years to cool and billions of years to collide and break up. But according to researchers, Jijin Yang and Joseph Goldstein (UMA) and Ed Scott (UH), this view is wrong. The molten cores, they argue, formed in planetary embryos up to 1000 km or more in size that broke apart in only a few million years -- long before they cooled.

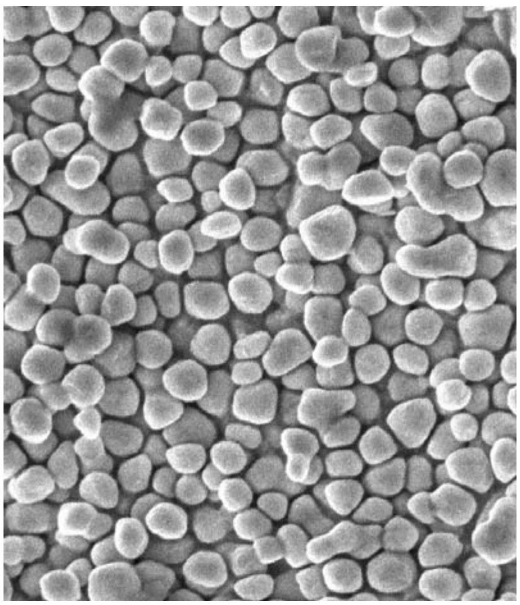
This slice of the Gibeon IVA iron meteorite, 4.6-centimeters wide, displays a Widmanstätten pattern. (Photo by Jeff Gillis-Davis, University of Hawaii)

Scientists have proposed several theories over the decades to rationalize the diverse cooling rates of iron meteorites thought to come from a single core. One is that either the data, or the computer simulations using those data, are faulty. A second theory is that a major impact fragmented the core and scrambled up the pieces. A third idea is that the asteroid was never hot enough for a core to form so that the metal chunks were spread throughout the silicate mantle.

Yang and his coauthors developed a new theory by figuring out how long iron meteorites took to cool down. A set of iron meteorites from a single molten asteroidal core enclosed by a rocky mantle would all cool at the same rate because iron metal conducts heat much more rapidly than rock. But two independent techniques showed that the set of irons cooled at rates that differed by as much as a factor of 50. “We realized” said Scott, “that the accepted explanation for the origin of the iron meteorites must be wrong.”

After trying many different ideas, the researchers discovered that if a metal body 300 km in diameter were to cool without any silicate mantle, samples a few km from the surface would cool 50 times faster than those near the center. But how could a metallic body of this size have formed in the asteroid belt?

Until last year, there was no plausible answer to this question. But a paper published by researchers at the University of California at Santa Cruz showed that Moon-to-Mars sized planetary embryos didn’t just stick together when they collided, as previously inferred. In half the impacts, the smaller bodies would have been torn apart by glancing collisions. Yang, Goldstein, and Scott deduced that a glancing collision by a planetary embryo 1000 km or more across with a molten core could have formed the 300 km metallic body in which the meteorites cooled.



This scanning electron microscope image shows a cloudy taenite intergrowth in a stony-iron meteorite after etching in acid. The rounded particles are 0.5 micrometers across and their size depends on the cooling rate. (Image by Yang and Goldstein, University of Massachusetts, Amherst)

“We used to think that iron meteorites come from asteroids that formed and melted long after the unmelted meteorites called chondrites had formed” said Scott. “But the latest dating techniques show just the reverse. Iron meteorites come from the first generation of bodies that formed less than one million years after the solar system was created, and the chondrites formed over the next few million years. Our work therefore shows that planetary embryos 1000 km across formed in less than one million years and that debris from these bodies survived in the form of meteorites and asteroids.“

Another UH meteorite researcher at the Hawaii Institute of Geophysics and Planetology, Sasha Krot, recently proposed that a group of chondrites once thought to be the oldest meteorites may have formed in a giant collision between planetary embryos over 4 million years after the birth of the solar system. “These are very exciting discoveries” says Klaus Keil who heads the cosmochemistry research group at the University of Hawaii. “They have dramatically changed our understanding of the first few million years of Solar System history.”

This work was funded by NASA.

Article Information: Yang, J., J. I. Goldstein, and E. R. D. Scott (2007) Iron Meteorite Evidence for Early Formation and Catastrophic Disruption of Protoplanets. Nature, v. 446, p. 888-891.

For more information, please also see the Planetary Science Research Discoveries article http://www.psrd.hawaii.edu/April07/irons.html

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