Magnetic fields record the early histories of planets

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A picture of the first discovered (and therefore eponymous) angrite "Angra dos Reis"; which was observed to fall from the sky in 1869 near the town of Angra dos Reis in Brazil. The black; shiny face was produced from melting of the meteorite's surface during passage through Earth's atmosphere. Scale bar is in centimeters. Photo courtesy / Maria Zucolotto (Museu Nacional; Brasil)

(PhysOrg.com) -- Meteorites that are among the oldest rocks ever found have provided new clues about the conditions that existed at the beginning of the solar system, solving a longstanding mystery and overturning some accepted ideas about the way planets form.

The ancient meteorites, like disk drives salvaged from an ancient computer, still contain magnetic records about the very early history of planets, according to research by MIT planetary scientist Benjamin P.

Weiss.

Weiss, the Victor P. Starr Career Development Assistant Professor of Planetary Sciences in the Department of Earth, Atmospheric and Planetary Sciences, and his five co-authors examined pieces of three meteorites called angrites, which are among the most ancient rocks known. The results of their study are being published in *Science* on Oct. 31.

The analysis showed that surprisingly, during the formation of the solar system, when dust and rubble in a disk around the sun collided and stuck together to form ever-larger rocks and eventually the planets we know today, even objects much smaller than planets — just 160 kilometers across or so — were large enough to melt almost completely.

This total melting of the planet-forming chunks of rock, called planetesimals, caused their constituents to separate out, with lighter materials including silicates floating to the surface and eventually forming a crust, while heavier iron-rich material sank down to the core, where it began swirling around to produce a magnetic dynamo. The researchers were able to study traces of the magnetic fields produced by that dynamo, now recorded in the meteorites that fell to Earth.

"The magnetism in meteorites has been a longstanding mystery," Weiss said, and the realization that such small bodies could have melted and formed magnetic dynamos is a major step toward solving that riddle.

Until relatively recently, it was commonly thought that the planetesimals — similar to the asteroids seen in the solar system today — that came together to build planets were "just homogenous, unmelted rocky material, with no large-scale structure," Weiss said. "Now we're realizing that many of the things that were forming planets were mini-planets themselves, with crusts and mantles and cores."

That could change theorists' picture of how the planets themselves took shape. If the smaller bodies were already molten as they slammed together to build up larger planet-sized bodies, that could "significantly change our understanding" of the processes that took place in the early years of the nascent planets, as their internal structures were forming, Weiss said. This could have implications for how different minerals are distributed in the Earth's crust, mantle and core today, for example.

"In the last five or 10 years," Weiss said, "our understanding of the early history of the solar system has undergone a sort of mini-revolution, driven by analytical advances in geochemistry. In this study we used a geophysical technique to independently test many of these new ideas. "

"Events happened surprisingly fast at the beginning of the solar system," he said. Some of the angrite meteorites in this study formed just 3 million years after the birth of the solar system itself, 4,568 million years ago, and show signs that their parent body had a magnetic field that was 20 to 40 percent as strong as Earth's today. "We are used to thinking of dynamo magnetic fields in rocky bodies as uncommon phenomena today. But it may be that short-lived planetesimal dynamos were widespread in the early solar system."

Source: Massachusetts Institute of Technology

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