3.2 billion-year-old surprise: Earth had strong magnetic field

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Geophysicists at the University of Rochester announce in today's issue of *Nature* that the Earth's magnetic field was nearly as strong 3.2 billion years ago as it is today.

The findings, which are contrary to previous studies, suggest that even in its earliest stages the Earth was already well protected from the solar wind, which can strip away a planet's atmosphere and bathe its surface in lethal radiation.

"The intensity of the ancient magnetic field was very similar to today's intensity," says John Tarduno, professor of geophysics in the Department of Earth and Environmental Sciences at the University of Rochester.

"These values suggest the field was surprisingly strong and robust. It's interesting because it could mean the Earth already had a solid iron inner core 3.2 billion years ago, which is at the very limit of what theoretical models of the Earth's formation could predict."

Geophysicists point to Mars as an example of a planet that likely lost its magnetosphere early in its history, letting the bombardment of radiation from the sun slowly erode its early atmosphere. Theories of Earth's field say it's generated by the convection of our liquid iron core, but scientists have always been curious to know when Earth's solid inner core formed because this process provides an important energy source to power the magnetic field. Scientists are also interested in when Earth's protective magnetic cocoon formed. But uncovering the intensity of a field 3.2 billion years in the past has proven daunting, and until Tarduno's research, the only data scientists could tease from the rocks suggested the field was perhaps only a tenth as strong as today's.

Tarduno had previously shown that as far back as 2.5 billion years ago, the field was just as intense as it is today, but pushing back another 700 million years in time meant he had to find a way to overcome some special challenges. Tarduno, however, isolates choice, individual crystals from a rock, heats them with a laser, and measures their magnetic intensity with a super-sensitive detector called a SQUID—a Superconducting Quantum Interface Device normally used in computing chip design because it's extremely sensitive to the tiniest magnetic fields.

Certain rocks contain tiny crystals like feldspar and quartz—nano-meter sized magnetic inclusions that lock in a record of the Earth's magnetic field as they cool from molten magma to hard rock. Simply finding rocks of this age is difficult enough, but these rocks have also witnessed billions of years of geological activity that could have reheated them and possibly changed their initial magnetic record. To reduce the chance of this contamination, Tarduno picked out the best preserved grains of feldspar and quartz out of 3.2 billion-year-old granite outcroppings in South Africa. Feldspar and quartz are good preservers of the paleomagnetic record because their minute magnetic inclusions essentially take a snapshot of the field as they cool from a molten state. Tarduno wanted to measure the smallest magnetic inclusions because larger magnetic crystals can lose their original magnetic signature at much lower temperatures, meaning they are more likely to suffer magnetic contamination from later warming geological events.

Once he isolated the ideal crystals, Tarduno employed a carbon dioxide laser to heat individual crystals much more quickly than older methods, further lessening the chance of contamination. With the University's ultra-sensitive SQUID he could measure how much magnetism these individual particles contained.

"The data suggest that the ancient magnetic field strength was at least 50 percent of the present-day field, which typically measures 40 to 60 microteslas," says Tarduno. "This means that a magnetosphere was definitely present, sheltering the Earth 3.2 billion years ago."

To further ensure his readings were accurate, Tarduno also checked the alignment of the magnetism in the particles, which record the polarity of the Earth's field at that time and location. By comparing the polarity to that of other samples of similar age and location, Tarduno could ensure that his measurements were not likely from later geological heating, but truly from 3.2 billion years ago.

Tarduno is now pushing back in time to 3.5 billion-year-old rocks to further investigate when the Earth's inner core first formed, giving new insights into early Earth processes that also may have had an effect on the atmosphere and the development of life on the planet.

Source: University of Rochester