Ancient lunar dynamo may explain magnetized moon rocks

November 9 2011

Moon. Photo courtesy of NASA

The presence of magnetized rocks on the surface of the moon, which has no global magnetic field, has been a mystery since the days of the Apollo program. Now a team of scientists has proposed a novel mechanism that could have generated a magnetic field on the moon early in its history.

The "geodynamo" that generates Earth's magnetic field is powered by heat from the inner core, which drives complex fluid motions in the molten iron of the outer core. But the moon is too small to support that type of dynamo, according to Christina Dwyer, a graduate student in

Earth and planetary sciences at the University of California, Santa Cruz. In the Nov. 10 issue of *Nature*, Dwyer and her coauthors -- planetary scientists Francis Nimmo at UC Santa Cruz and David Stevenson at the California Institute of Technology -- describe how an ancient lunar dynamo could have arisen from stirring of the moon's liquid core driven by the motion of the solid mantle above it.

"This is a very different way of powering a dynamo that involves physical stirring, like stirring a bowl with a giant spoon," Dwyer said.

Dwyer and her coauthors calculated the effects of differential motion between the moon's core and mantle. Early in its history, the moon orbited the Earth at a much closer distance than it does today, and it continues to gradually recede from the Earth. At close distances, tidal interactions between the Earth and the moon caused the moon's mantle to rotate slightly differently than the core. This differential motion of the mantle relative to the core stirred the liquid core, creating fluid motions that, in theory, could give rise to a magnetic dynamo.

"The moon wobbles a bit as it spins--that's called precession--but the core is liquid, and it doesn't do exactly the same precession. So the mantle is moving back and forth across the core, and that stirs up the core, " explained Nimmo, a professor of Earth and planetary sciences at UCSC.

The researchers found that a lunar dynamo could have operated in this way for at least a billion years. Eventually, however, it would have stopped working as the moon got farther away from the Earth. "The further out the moon moves, the slower the stirring, and at a certain point the lunar dynamo shuts off," Dwyer said.

Rocks can become magnetized from the shock of an impact, a mechanism some scientists have proposed to explain the magnetization of lunar samples. But recent paleomagnetic analyses of moon rocks, as well as orbital measurements of the magnetization of the lunar crust, suggest that there was a strong, long-lived magnetic field on the moon early in its history.

"One of the nice things about our model is that it explains how a lunar dynamo could have lasted for a billion years," Nimmo said. "It also makes predictions about how the strength of the field should have changed over the years, and that's potentially testable with enough paleomagnetic observations."

More detailed analysis is needed, however, to show that stirring of the core by the mantle would create the right kind of fluid motions to generate a magnetic field. "Only certain types of fluid motions give rise to magnetic dynamos," Dwyer said. "We calculated the power that's available to drive the dynamo and the magnetic field strengths that could be generated. But we really need the dynamo experts to take this model to the next level of detail and see if it works."

A working model of a lunar dynamo, combined with more detailed paleomagnetic analysis of moon rocks, could give scientists a powerful tool for investigating the history of the moon, Dwyer said. In addition, the study presents a novel mechanism for generating a magnetic field not only on the moon, but also on other small bodies, including large asteroids.

Provided by University of California - Santa Cruz