Study finds Earth's magnetic field 'simpler than we thought'

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A composite image of the Western hemisphere of the Earth. Credit: NASA

Scientists have identified patterns in the Earth's magnetic field that evolve on the order of 1,000 years, providing new insight into how the field works and adding a measure of predictability to changes in the field not previously known.

The discovery also will allow researchers to study the planet's past with finer resolution by using this geomagnetic "fingerprint" to compare sediment cores taken from the Atlantic and Pacific oceans.

Results of the research, which was supported by the National Science Foundation, were recently published in *Earth and Planetary Science Letters*.

The geomagnetic field is critical to life on Earth. Without it, charged particles from the sun (the "solar wind") would blow away the atmosphere, scientists say. The field also aids in human navigation and animal migrations in ways scientists are only beginning to understand. Centuries of human observation, as well as the geologic record, show our field changes dramatically in its strength and structure over time.

Yet in spite of its importance, many questions remain unanswered about why and how these changes occur. The simplest form of magnetic field comes from a dipole: a pair of equally and oppositely charged poles, like a bar magnet.

"We've known for some time that the Earth is not a perfect dipole, and we can see these imperfections in the historical record," said Maureen "Mo" Walczak, a post-doctoral researcher at Oregon State University and lead author on the study. "We are finding that non-dipolar structures are not evanescent, unpredictable things. They are very long-lived, recurring over 10,000 years - persistent in their location throughout the Holocene.

"This is something of a Holy Grail discovery," she added, "though it is not perfect. It is an important first step in better understanding the magnetic field, and synchronizing sediment core data at a finer scale."

Some 800,000 years ago, a magnetic compass' needle would have pointed south because the Earth's magnetic field was reversed. These reversals typically happen every several hundred thousand years.

While scientists are well aware of the pattern of reversals in the Earth's magnetic field, a secondary pattern of geomagnetic "wobble" within periods of stable polarity, known as paleomagnetic secular variation, or PSV, may be a key to understanding why some geomagnetic changes occur.

The Earth's magnetic field does not align perfectly with the axis of rotation, which is why "true north" differs from "magnetic north," the researchers say. In the Northern Hemisphere this disparity in the modern field is apparently driven by regions of high geomagnetic intensity that are centered beneath North America and Asia.

"What we have not known is whether this snapshot has any longer-term meaning - and what we have found out is that it does," said Joseph Stoner, an Oregon State University paleomagnetic specialist and co-author on the study.

When the magnetic field is stronger beneath North America, or in the "North American Mode," it drives steep inclinations and high intensities in the North Pacific, and low intensities in Europe with westward declinations in the North Atlantic. This is more consistent with the historical record.

The alternate "European mode" is in some ways the opposite, with shallow inclination and low intensity in North Pacific, and eastward declinations in the North Atlantic and high intensities in Europe.

"As it turns out, the magnetic field is somewhat less complicated than we thought," Stoner said. "It is a fairly simple oscillation that appears to result from geomagnetic intensity variations at just a few recurrent locations with large spatial impacts. We're not yet sure what drives this variation, though it is likely a combination of factors including convection of the outer core that may be biased in configuration by the lowermost mantle."

The researchers were able to identify the pattern by studying two high-resolution sediment cores from the Gulf of Alaska that allowed them to develop a 17,400-year reconstruction of the PSV in that region. They then compared those records with sediment cores from other sites in the Pacific Ocean to capture a magnetic fingerprint, which is based on the orientation of the magnetite in the sediment, which acts as a magnetic recorder of the past.

The common magnetic signal found in the cores now covers an area spanning from Alaska to Oregon, and over to Hawaii.

"Magnetic alignment of distant environmental reconstructions using reversals in the paleomagnetic record provides insights into the past on a scale of hundreds of thousands of years," Walczak said. "Development of the coherent PSV stratigraphy will let us look at the record on a scale possibly as short as a few centuries, compare events between ocean basins, and really get down to the nitty-gritty of how climate anomalies are propagated around the planet on a scale relevant to human society."

The magnetic field is generated within the Earth by a fluid outer core of iron, nickel and other metals that creates electric currents, which in turn produce magnetic fields. The magnetic field is strong enough to shield the Earth from solar winds and cosmic radiation. The fact that it changes is well known; the reasons why have remained a mystery.

Now this mystery may be a little closer to being solved.

More information: M.H. Walczak et al. A 17,000 yr paleomagnetic secular variation record from the southeast Alaskan margin: Regional and global correlations, *Earth and Planetary Science Letters* (2017). DOI: 10.1016/j.epsl.2017.05.022

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