DECODING MAGNETIC FIELD VARIATIONS

Convection in the liquid-metal outer core gives rise to Earth's geodynamo and sustains our planet's strong magnetic field. The geomagnetic field shields Earth from damaging cosmic radiation and therefore preserves planetary habitability. Marine sediments and the underlying volcanic rocks record geohistorical variations in the magnetic field. Scientific ocean drilling provides magneto-stratigraphic records that—when incorporated in a global database—are an invaluable tool for constraining the timing and rates of a wide range of Earth cycles over millions of years. The cores provide critical data for establishing a common paleomagnetic reference frame, allowing the movement of Earth's tectonic plates and upwelling mantle plumes to be mapped through time.

Rock magnetic studies of seafloor core samples allow us to gain fundamental knowledge about the source of magnetic anomalies preserved in the oceanic crust and about past paleointensities of Earth's magnetic field. Yet, the geomagnetic field and the geodynamo remain one of the least understood planetary phenomena, as the nature of the magnetic field is constantly changing, with long periods of small changes interspersed with major excursions or complete polarity "reversals." Scientific ocean drilling enables us to investigate the causes and consequences of this highly variable geodynamo behavior, across the world's ocean basins and over different timescales. Small irregular changes in the character of the magnetic field on short timescales are reflected in the "wandering" of the magnetic poles, which over the last decades have shown unexplained accelerations—with speeds up to 55 km/yr—that are theorized to result from turbulence or eddies in the outer core convection.

Another poorly understood behavior of the geodynamo concerns changes in the overall strength of the geomagnetic field. Current observations show a decline in strength over the last half century, with implications for how well life on Earth and our infrastructure will be protected from solar flares in the future. The lowest magnetic field intensities currently occur in the "South Atlantic Anomaly" and already are significantly affecting spacecraft and satellite orbits, exposing them to several minutes of damaging strong radiation. Current models suggest a possible link between the presence of this large low-intensity anomaly and the location of the large low shear wave velocity province (LLSVP) in the lower mantle beneath Africa. The occurrences of reversed flux patches that signal instability in Earth's geodynamo and are seen as a harbinger of a (near) future magnetic field reversal are also poorly understood. Scientific ocean drilling cores obtained from areas with high sedimentation rates (e.g., near continents) will provide long-term records with decadal to centurial resolutions that can assist us in ground truthing computer simulations of outer core turbulence. These sediment cores will also enable us to gain insight into similar future magnetic field variations and declines in overall field strength. *Credit: After Figure 82, https://directory.eoportal.org/web/eoportal/satellite-missions/s/swarm, ESA/DTU Space; and Tarduno (2018), https://doi.org/10.1073/pnas.1819025116*