【Grant-in-Aid for Scientific Research (S)】

Verification of the impact of geomagnetic reversals on climate and ecosystems

Principal Investigator	Ibaraki University, Faculty of Basic Natural Science, Professor OKADA Makoto	Researcher Number : 00250978
Project Information	Project Number : 24H00016	Project Period (FY) : 2024-2028
	Keywords : geomagnetic reversal, paleomagnetism, paleoclimate, organic molecular fossil, fossil DNA	

Purpose and Background of the Research

●Outline of the Research

We investigate and analyze geologic strata that record geomagnetic signals from the past with high sedimentation rates and stability of magnetic signals, and that have well-preserved fossils on climate and organisms at that time, to reconstruct multiple geomagnetic reversals that occurred at different times and in different environments with ultra-high temporal resolution. Specifically, we will,
(1) determine changes in the direction and intensity of the geomagnetic field associated with geomagnetic reversals,
(2) determine the timing and duration of geomagnetic reversals based on oxygen isotope records and radiometric ages of tephra layers, and
(3) examine the impact of geomagnetic reversals on climate and ecosystems based on microfossils, organic molecular fossils, and fossil DNA analysis.

●Scientific background

The geomagnetic field acts as a barrier against galactic cosmic rays and solar winds, which are harmful to life, and also maintains the ozone layer, which blocks harmful ultraviolet radiation. The geomagnetic field is therefore essential for maintaining life on Earth. However, the geomagnetic field fluctuates greatly, especially during geomagnetic polarity reversals, when its strength is reduced to about 1/10th of its original level, a condition that has persisted for several thousand years or more. However, nothing is known about the effects of geomagnetic reversals on life. On the other hand, when the geomagnetic field is weakened by a reversal, the intensity of galactic cosmic rays reaching the Earth increases.

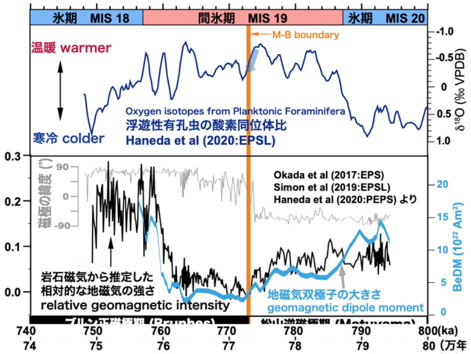

Figure 1. Matuyama-Brunhes (M-B) reversal and paleoclimatic record from the Chiba composite section

There is a theory (the Svensmark effect) that clouds tend to form in the lower troposphere due to ionisation of the atmosphere. The study of the Boso geologic strata used by the applicants in their 'Cibanian' proposal provides a detailed geomagnetic record from the deep-sea sediments of the Chiba Composite Section at the Matsuyama-Brunhes (M-B) geomagnetic reversal boundary (Fig. 1). Here we see a cold event (blue arrow in the figure) at the timing of the reversal. However, allowing for the possibility of coincidence, it is not possible to establish a causal relationship between them by analysing only the M-B boundary.

● Scientific originality and creativity

In this study, palaeomagnetic, various biofossil and chronological analyses of marine sedimentary sequences distributed over the Boso Peninsula will be carried out with extremely high temporal resolution, and geomagnetic reversal records and palaeoclimatic and palaeoecological records will be obtained in parallel from the same samples. In addition, a quantitative environmental reconstruction method using organic molecular fossils and the world's first attempt to extract fossil DNA will be implemented to assess the impact of geomagnetic field weakening on the ecosystem. Using these methods, it is possible to quantitatively calculate seawater and air temperatures and reconstruct changes in UV intensity, which has been difficult using conventional microfossil research alone.

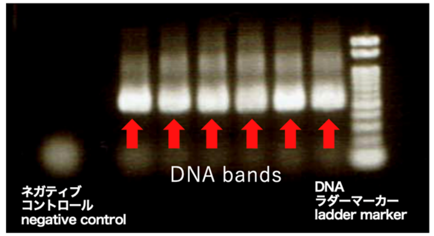

Figure 2. Gel electrophoresis results in mudstone samples from the Kazusa Group

Expected Research Achievements

● Outcrop survey and sampling

Oriented drilling will be carried out at the M-B boundary at site A and at the lower boundary of the Jaramillo normal polarity subchronozone at site B. At the same time, samples will be collected from surface outcrops near points C, D, E and F, at stratigraphic levels near the inversion boundary.

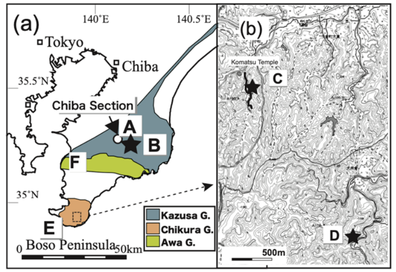

Figure 3. Sampling sites and routes

● Measurements

Organic Molecular Fossil Analysis
Fossil DNA analysis
Tephra layer dating
Reconstruction of geomagnetic reversal records
^{10}Be measurements
Extraction of foraminiferal samples
Oxygen isotope measurements

● Testing whether geomagnetic reversals affect climate and ecosystems

Glacial-interglacial variability (global climate change with changes in the total volume of continental glaciers), detected as variations in oceanic oxygen isotope ratios, is controlled by the amount of solar radiation received by the Earth's surface, which is determined by the shape of the Earth's orbit and the tilt angle of the Earth's axis, and is not related to geomagnetic changes.

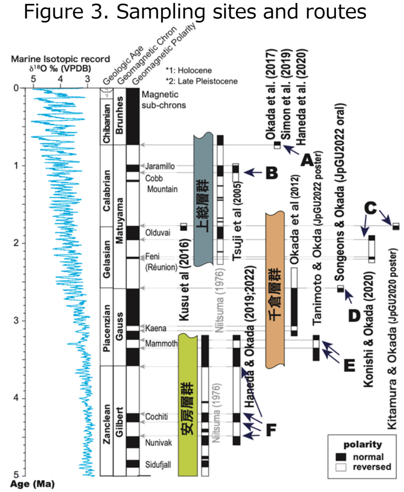

Figure 4. Target geomagnetic reversals

Accurate monitoring of this glacial-interglacial variability removes the influence of glacial-interglacial variability from the climate and biota signals indicated by microfossils, organic molecular fossils and fossil DNA. The link between climate and biota changes and changes in geomagnetic intensity will then be recorded at the time of multiple magnetic field reversals to test whether there is a Svensmark effect of geomagnetic reversal and its impact on biota.

Homepage Address, etc.	https://sites.google.com/view/okadapaleolab/