The Earth's Polarity Can Flip Within a Hundred Years

Geomagnetic polarity reversal occurred frequently in the history of the Earth. Lacking highly sensitive magnetic archives and dating technologies, the details of the reversal transition are poorly understood. With highly sensitive magnetic archives and dating technologies combined with a non-destructive high-resolution synchrotron X-ray microscope, rapid geomagnetic oscillations and centennial polarity reversal events during geomagnetic excursion 100,000 years ago have been discovered inside a stalagmite.

Over the past century, the intensity of the Earth's magnetic field has decreased 10–15%, which might constitute possible pre-evidence for geomagnetic polarity reversal. The transition duration and detailed process of a reversal event have remained unclear because of the absence of highly sensitive magnetic archives and dating techniques. Chuan-Chou Shen (National Taiwan University) and Yu-Min Chou (Southern University of Science and Technology), combined leading-edge U-Th radioisotopic dating with precision of a few decades and highly sensitive palaeomagnetic analysis of magnetic minerals in a stalagmite with a non-destructive synchrotron X-ray microscope with high spatial resolution; the results reveal details of repeated asymmetric inter-hemispheric polarity oscillations with durations from centuries to millennia,[1] as shown in **Fig. 1**. The unique saw-tooth polarity oscillation behavior was named a Chou Oscillation according to the common word in the two corresponding author's names. A surprisingly abrupt centennial reversal transition 98,000 years ago that occurred in just 144 ± 58 years is also shown in **Fig. 1**; this event was ten times as rapid than was previously thought.

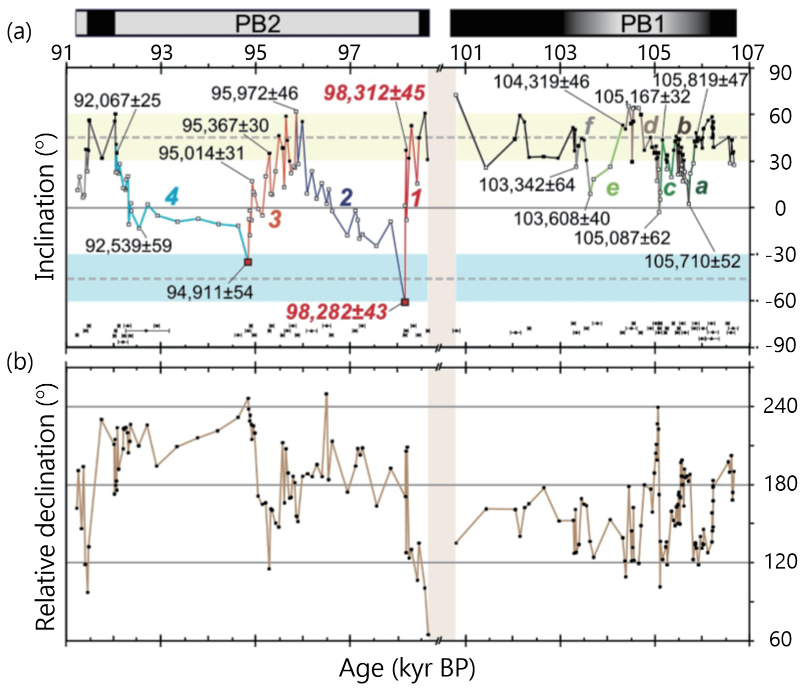

Fig. 1: Palaeomagnetic record for Sanxing stalagmite SX11 at 107–91 ka. (a) Inclination record with ^{230}Th ages and 2s errors. Horizontal dashed lines are inclinations for a geocentric axial dipole field at the site. Yellow and blue bars, respectively, denote regional normal and reversed polarity palaeosecular variation ranges. Inclination data points for secular variation ranges of normal and reversed polarity are labelled with black and red squares, respectively; data outside the normal range of palaeosecular variation are indicated with hollow squares. Two excursions, PB1 and PB2, are indicated in the magnetostratigraphic column. (b) Relative declination record. [Reproduced from Ref. 1]

In this work, the magnetic minerals embedded inside a stalagmite were precisely positioned with difficulty and hard to be studied using other destructive techniques, such as an electron microscope. The authors used a synchrotron transmission X-ray microscope (TXM, **TLS 01B1**) and white X-ray microscope (WXM, **TLS 01A1**) for the imaging and positioning of the magnetic minerals embedded inside the stalagmite, non-destructively. The fracture shape of the magnetic minerals embedded inside the stalagmite provides important evidence to clarify the source of the magnetic minerals, which was from detritus of the topsoil or rock, but not authigenically neoformed after the deposition. The magnetic minerals inside the stalagmite can thereby record the geomagnetic history with great precision.

In summary, geomagnetics play a crucial role to protect life on earth from the attack of high-energy particles from outer space. If the geomagnetic polarity can reverse so quickly, such an abrupt event occurring in the future could disturb animal navigation and radio communications, and damage satellites, electronic power systems and the global internet system. The variation of geomagnetic polarity is worth noting; the behavior can hence be well understood according to the paleo-records inside a stalagmite using this new diagnostic method. (Reported by Chun-Chieh Wang)

*This report features the work of Chuan-Chou Shen, Yu-Min Chou and their co-workers published in Proc. Natl. Acad. Sci. USA **115**, 8913 (2018).*

TLS 01A1 SWLS – White X-ray
TLS 01B1 SWLS – X-ray Microscopy
- TXM, WXM
- Geo-sciences

Reference

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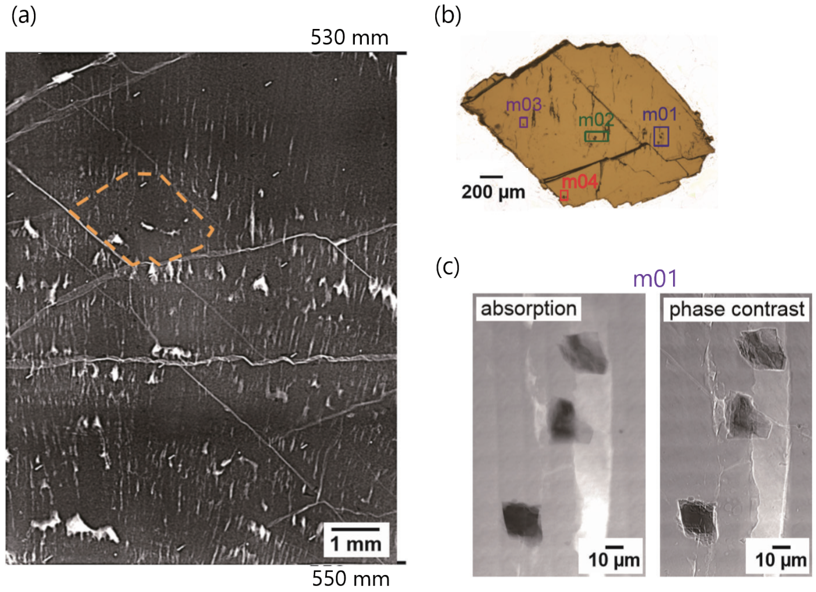

Fig. 2: Images obtained using a synchrotron white X-ray microscope (WXM, **TLS 01A1**), transmission optical microscope (TOM) and a transmission X-ray microscope (TXM, **TLS 01B1**) for the Sanxing stalagmite SX11. (a) WXM image of a thin stalagmite section obtained at 530–550 mm depth. (b) TOM image at 535 mm (dashed-line area in (a)). (c) TXM absorption and phase-contrast images obtained at the m01 zone of (b). Dense particles could be detrital magnetic minerals (dark spot/area in absorption images) with grain sizes 0.1 to tens of µm. [Reproduced from Ref. 1]

Synchrotron-Based FTIR Microspectroscopy Promises a Non-Destructive Measurement *in Situ* of Organic Carbon in Soil to Solve an Environmental Problem

As global awareness of environmental protection increases, this issue of environmental concern is attracting global attention and becoming more serious. Luo et al. are the first team to elucidate spectral evidence of the roles of organic carbon moieties present in the sorption of non-ionic organic compounds in soils using synchrotron-based Fourier-transform infrared (SR-FTIR) microspectroscopy without chemical pre-treatment and extraction of soil samples.

Human activities introduce nitro-aromatic compounds into the environment as a result of the synthesis of many and diverse products, such as dyes, pesticides, polymers and explosives; the environment on which our life relies would be the final destination, especially soil and sediment. Non-ionic organic compounds (NOC) that play a crucial role in soils and sediments in adsorbing organic carbon (OC) involve a main environmental process, including the interactions of soil-sediment environments with human activities and the regions of the surface. To understand the role of sorption of NOC in various environmental processes is hence crucial for a prediction of their environmental fate. So far, the organic carbon moieties as the sorptive target of non-ionic organic compounds such as nitro-aromatic compounds in soils is puzzling because of the extremely complicated compositions of soil matrices. Current studies on the sorption mechanisms rely mainly on conventional batch exper-