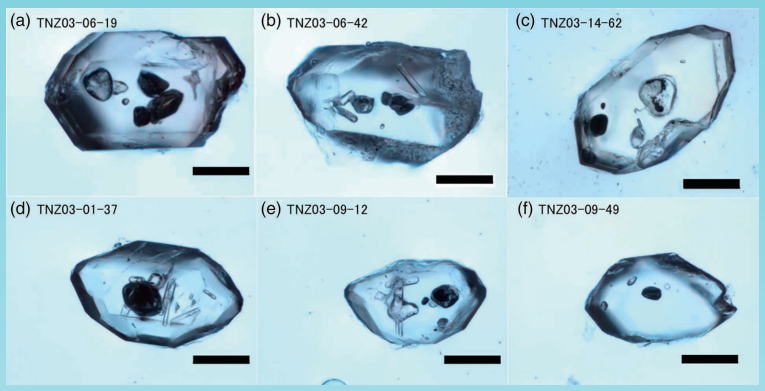
Earth, Planets and Space

Recent Advances in Environmental Magnetism and Paleomagnetism



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PREFACE

Open Access

Special issue on "Recent advances in environmental magnetism and paleomagnetism"

Hirokuni Oda[1*], Yuhji Yamamoto[2], Xixi Zhao[3,4], Satria Bijaksana[5] and Qingsong Liu[6]

Introduction

This special issue is based primarily on Session SE04 "Recent advances in paleo-, rock and environmental magnetism" held during the Asia Oceania Geosciences Society (AOGS) 2014 Meeting (28 July–1 August in Sapporo, Japan). The special issue focuses on various topics in environmental, rock, and paleomagnetism including applications, instruments, and databases and is not limited to the presentations at the Session. In total, 13 articles were published in the special issue, which are described below in several categories.

Environmental and rock magnetism: applications

In the special issue, a total of five articles were published on various aspects of environmental magnetism. Liu et al. (2015) presented a characterization of iron oxides in surface sediments from potential dust source regions distributed throughout western and northern China. Magnetic mineral assemblages in the studied samples contain both antiferromagnetic (hematite and goethite) and ferrimagnetic (magnetite and maghemite) minerals with broad grain size distributions indicating multiple origins. Chinese Loess Plateau (CLP) sediments have relatively uniform magnetic properties, whereas the source material does not. The results provide excellent constraints on the initial properties of dust sources that are transported either to the CLP by the Asian winter monsoon or to the North Pacific Ocean by westerly winds.

Huang et al. (2015) presented the environmental magnetic variation around Papua New Guinea for the past 400 ka based on magnetic parameters and the $\delta^{18}O$ record of core MD05-2928. Rock magnetic analyses indicate that magnetic minerals were fewer and finer in interglacial periods, whereas the opposite is the case for glacial periods. Frequency analyses could resolve Milankovitch cycles. The strongest climate signal is the 100-ka period, which indicates that sea-level change played a dominant role in the long-term environmental setting; additionally, the signals of the 40- and 20-ka periods possibly suggest the influence of regional precipitation.

Kars and Kodama (2015) presented a high-resolution rock magnetic record from 169 samples collected at Hole C0008A in the Nankai Trough, offshore southwest Japan, during Integrated Ocean Drilling Program Expedition 316. The rock magnetic study, conducted at a core depth from 110 to 153 m below the sea floor, highlighted the widespread occurrence of magnetic iron sulfides, particularly greigite. Two thick iron sulfide layers containing greigite and pyrrhotite were identified, which are associated with the occurrence of gas hydrate. It is likely that a combination of many factors (availability of reactive iron, microbial activity, etc.) favors the formation of ferrimagnetic iron sulfides in the presence of gas hydrates.

Hayashida et al. (2015) presented the magnetic properties of sediment collected from Lake Ogawara to examine the limnological conditions on the Pacific coast of northeastern Japan shortly after the 2011 Tohoku earthquake and flooding of the lake by tsunami waves. At water depths below 10 m, the magnetic susceptibility and anhysteretic remanent magnetization (ARM) of high organic content greenish-black mud decreased considerably with increasing water depth. ARM increased slightly at water depths greater than 16 m. Although it is not clear whether the ARM carriers were the result of authigenic iron sulfide formation or the deposition of material suspended in the hypolimnion water layer, they suggest that the magnetic properties of the surficial sediments on the lake floor are controlled

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by both their location within the basin and the limnological stratification of the brackish lake water.

Oda et al. (2016) presented volcanic ash particles extracted from tephra-bearing ice samples collected from the Nansen Ice Field south of the Sør Rondane Mountains, Antarctica. Major element concentrations of the volcanic particles show high similarity with those of tephra layers associated with the South Sandwich Islands in the EPICA-Dome C, Vostok, and Dome Fuji ice cores. Rock magnetic experiments show that the magnetic mineral is pseudo-single-domain titanomagnetite, with ulvospinel content of 0.2–0.35, mixed with single-domain (SD) to superparamagnetic (SP) (titano)magnetite. Small blocks of the tephra-bearing ice were magnetized with a DC magnetic field of 25 mT and measured using a SQUID gradiometer, which enabled detection of the magnetic signal including that from samples with imperceptible quantities of tephra particles.

Environmental and rock magnetism: instruments and software

A frontier letter by Kodama (2015) presented an improved method for measuring dynamic magnetizations of bulk volcanic rock samples induced by a pulsed field using inductive differential coils, a preamplifier, integrator, and a high-speed digital storage scope. The measured M–H curves are comparable to the branches of the corresponding hysteresis loops measured in a static field. The pulse provides the rapid exponential decay with time constant corresponding to magnetic relaxation time. The system has the potential to be a versatile and convenient tool for rock magnetism.

A technical report by Fukuma and Kono (2016) presented a LabVIEW software program to control an automated three-component spinner magnetometer equipped with a thermal demagnetizer TSpin, which is utilized for routine operations in Thellier paleointensity experiments, enabling an overnight Thellier measurement without any user intervention. Due to a continuous series of remanence measurements combined with thermal demagnetization or partial thermoremanent magnetization (TRM) acquisition in a magnetic shield case without manual handling of a specimen, the chance of an orientation error or acquisition of spurious magnetization is almost completely eliminated.

Paleomagnetism: paleointensity

Two articles in the special issue are related to paleointensity studies. Yamamoto et al. (2015) presented an archeointensity study on baked clay samples taken from a reconstructed ancient kiln. Application of the Tsunakawa–Shaw method to the samples showed that those obtained from the floor surface of the kiln provided accurate archeointensity results. These samples mainly consisted of Ti-poor titanomagnetite grains, approximately 10 nm in size, with SD and/or SP states. They concluded that baked clay samples from a kiln floor are considered to be ideal materials for archeointensity studies.

A frontier letter by Sato et al. (2015) presented the rock magnetic properties of 1037 single zircon crystals sampled from the Nakagawa River, which crosses the Tanzawa tonalitic pluton in central Japan, for the purpose of future paleointensity studies. The isothermal remanent magnetization (IRM) intensities of 161 zircon crystals ($>\sim 4 \times 10^{-12}$ Am), which contained enough magnetic minerals, could be measured in a DC SQUID magnetometer. In the case that the crystals had low coercivity (B_c) values (<10 mT) and low natural remanent magnetization to IRM ratios (NRM/IRM) (<~0.1), the main remanence carriers appear to be nearly stoichiometric magnetite with pseudo-single-domain grain sizes, which are expected to be appropriate for the paleointensity study. TRM acquisition experiments on 12 zircon crystals that fulfilled these criteria show NRM/TRM ratios between 0 and 2, indicating that the NRM intensity is comparable with that of the TRM. The paleointensity estimated using the bulk NRM/TRM ratio for a sample with strong TRM showed a field intensity that was consistent with the geomagnetic field intensity over the last 5 Myr.

Paleomagnetism: tectonics

There are two articles in the special issue dealing with tectonics in East Asia. Based on a paleomagnetic study on Miocene sediments from the Oidawara Formation, eastern southwest Japan, Hoshi et al. (2015) revealed that clockwise rotation of southwest Japan occurred mainly between 17.5 and 15.8 Ma, at a rotation rate of ~23°/Myr. Furthermore, Jeong et al. (2015) presented the tectonic evolution of the Korean Peninsula based on the paleomagnetism and U–Pb geochronology of the late Cretaceous Chisulryoung Volcanic Formation. The weighted mean ages obtained by U–Pb zircon dating from the base and top of the formation are 72.8 ± 1.7 and 67.7 ± 2.1 Ma, respectively. Paleomagnetic results from the late Cretaceous ignimbrites show that Korea has been rigidly attached to China at least since the Cretaceous.

Paleomagnetism: database

Two technical reports on the paleomagnetic database GEOMAGIA50.v3 published in this special issue play an important role in paleomagnetism. Brown et al. (2015a) presented the development of a database dealing with paleomagnetic data for archeological and volcanic materials, which contains 14,645 data (declination, inclination, and paleointensity) from 461 studies published between 1959 and 2014. The web-based interface can be

found at http://geomagia.gfz-potsdam.de. In addition, Brown et al. (2015b) presented a new database for sediments built upon the above-mentioned GEOMAGIA50.v3. For sediments, a strong emphasis has been placed on the storage of geochronological data, and this is the first magnetic archive that includes comprehensive radiocarbon age data from sediments. The web-based interface for the sediment database is located at http://geomagia.gfz-potsdam.de/geomagiav3/SDquery.php. The database continues to expand as legacy data are added and new studies are published.

Abbreviations

ARM: anhysteretic remanent magnetization; CLP: Chinese Loess Plateau; IRM: isothermal remanent magnetization; NRM: natural remanent magnetization; SD: single-domain; SP: superparamagnetic; TRM: thermoremanent magnetization.

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FRONTIER LETTER Open Access

Pulsed-field magnetometry for rock magnetism

Kazuto Kodama

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Abstract

An improved method is proposed for measuring dynamic magnetizations of bulk volcanic rock samples induced by a pulsed-field of 0.7 T and a duration of 10 ms. The transient magnetization is measured by a sensing system that consists of a pair of inductive differential coils, an analog preamplifier and integrator, and a high-speed digital storage scope. The system was calibrated using a paramagnetic salt (Gd_2O_3) and was tested to different kinds of volcanic rocks with their magnetic properties well-documented previously. The results were comparable with those measured by a quasi-static method using a vibrating sample magnetometer, although there were small discrepancies in hysteresis parameters suggesting the time-dependence of the magnetic properties. The proposed system provides not only the magnetization over the short interval of a pulse but also the rapid (~3 ms) exponential decay after a pulse. The decay time constant was different among the samples under study, indicating the variations of their magnetic relaxation time. Although the present system is not sensitive enough to characterize varieties of natural samples including sediments, it has the potential as a versatile and convenient tool for rock magnetism.

Keywords: Rock magnetism; Pulsed-field; Magnetometry; Dynamic magnetization; Hysteresis

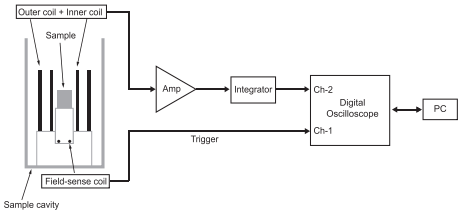

Figure 1

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FRONTIER LETTER Open Access

Rock-magnetic properties of single zircon crystals sampled from the Tanzawa tonalitic pluton, central Japan

Masahiko Sato*, Shinji Yamamoto, Yuhji Yamamoto, Yoshihiro Okada, Masao Ohno, Hideo Tsunakawa and Shigenori Maruyama

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Abstract

This paper reports on the rock-magnetic properties of single zircon crystals, which are essential for future work establishing the reliable paleointensity method using single zircon crystals. Zircon crystals used in this study were sampled from the Nakagawa River, which crosses the Tanzawa tonalitic pluton in central Japan. Rock-magnetic measurements were conducted on 1037 grains of zircons, but many of these measurements are below the limits of the sensitivity of the magnetometers employed. Isothermal remanent magnetizations (IRMs) of 876 zircon crystal are below the practical resolution of this study; we infer that these crystals contain no or only minute quantities of ferromagnetic minerals. The other zircon crystals contain enough magnetic minerals to be measured in the DC SQUID magnetometer. For 81 zircon crystals, IRM intensities (M_{IRM}) are larger than 4×10^{-12} Am^2, while natural remanent magnetization (NRM) intensities (M_{NRM}) are below 4×10^{-12} Am^2, indicating that these crystals are inappropriate for the paleomagnetic study. For the samples that had values of $M_{NRM}\geq4\times10^{-12}$ Am^2 and $M_{IRM}\geq4\times10^{-12}$ Am^2 (80 zircons), combining the rock-magnetic parameter, we proposed the sample-selection criteria for future study of paleointensity experiments using single zircon crystals. In the case that the samples had high coercivity (B_c) values (>10 mT) or high M_{NRM}/M_{IRM} values (>~0.1), main remanence carriers are probably pyrrhotite and these samples are inappropriate for the paleointensity study. In the case that the samples had low B_c values (<10 mT) and low M_{NRM}/M_{IRM} values (<~0.1), main remanence carriers seem to be nearly pure magnetite with pseudo-single-domain grain sizes, and these samples are expected to appropriate for the paleointensity study. Total thermoremanent magnetization (TRM) acquisition experiments were also carried out for 12 samples satisfying the above criteria. The TRM intensity was comparable with that of NRM, and a rough estimation of the paleointensity using NRM/TRM ratios shows field intensities consistent with the average geomagnetic field intensity at the Tanzawa tonalitic pluton for last 5 Myr.

Keywords: Rock-magnetism; Paleointensity; Zircon; Tanzawa tonalitic pluton

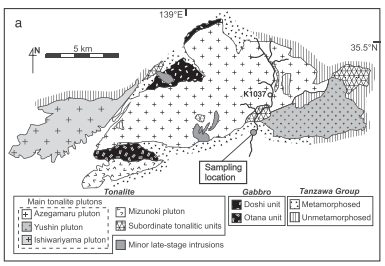

Figure 1

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FULL PAPER Open Access

Characterizing magnetic mineral assemblages of surface sediments from major Asian dust sources and implications for the Chinese loess magnetism

Qingsong Liu*, Youbin Sun, Xiaoke Qiang, Ryuji Tada, Pengxiang Hu, Zongqi Duan, Zhaoxia Jiang, Jianxing Liu and Kai Su

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Abstract

Eolian dust plays an important role in the Earth's climate system. Environmental magnetism has been widely used to trace dust variations at different spatial and temporal scales. However, the magnetic properties of sediments from key dust sources have not been well determined. In this study, surface samples from potential dust sources in inner Eastern Asia were systematically investigated. Our results indicate that ferrimagnetic and antiferromagnetic minerals are both present in surface sediments and that they have broad grain size distributions. Ferrimagnetic components are dominated by partially oxidized coarse-grained (pseudo-single domain and multi-domain) lithogenic magnetite particles with minor contributions from pedogenic fine-grained (single domain and superparamagnetic) particles. Antiferromagnetic hematite can be classified into three groups in terms of diffuse reflectance spectroscopy (DRS) band positions ($P_{560\,nm}$, $P_{545\,nm}$, and $P_{535\,nm}$, where numbers indicate the DRS band wavelength for hematite). The first group ($P_{560\,nm}$) is the coarse-grained hematite of lithogenic origin and is mostly confined to western China. The $P_{535\,nm}$ group is of pedogenic origin. The $P_{545\,nm}$ group is an intermediate phase that is present both in surface samples from the source regions and in loess. Therefore, the $P_{545\,nm}$ and $P_{535\,nm}$ groups are related to eolian inputs to the Chinese Loess Plateau and pedogenic processes, respectively. In addition, significant differences exist between the magnetic properties of eolian material from sources and depositional regions due to gravitational sorting. These insights provide strong constraints on interpretation of dust signals recorded by the Chinese loess and marine sediments from the North Pacific Ocean.

Keywords: Eolian dust; Environmental magnetism; Hematite; Diffuse reflectance spectroscopy; Eastern Inland Asia; Chinese loess

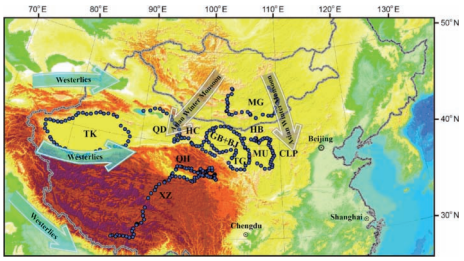

Figure 1

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FULL PAPER Open Access

Archeointensity study on baked clay samples taken from the reconstructed ancient kiln: implication for validity of the Tsunakawa-Shaw paleointensity method

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Abstract

In 1972, a reconstruction experiment of a kiln had been done to reproduce an excavated kiln of the seventh century in Japan. Baked clay samples were taken from the floor surface and −20 cm level, and they have been stored after determinations of the paleomagnetic directions by partial alternating field demagnetizations. We recently applied the Tsunakawa-Shaw method to the samples to assess how reliable archeointensity results are obtained from the samples. A suite of the rock magnetic experiments and the scanning electron microscope observations elucidate that dominant magnetic carriers of the floor surface samples are Ti-poor titanomagnetite grains in approximately 10 nm size with single-domain and/or super-paramagnetic states, whereas contributions of multi-domain grains seem to be relatively large for the −20-cm level samples. From the floor surface samples, six out of the eight successful results were obtained and they give an average of 47.3 μT with a standard deviation of 2.2 μT. This is fairly consistent with the *in situ* geomagnetic field of 46.4 μT at the time of the reconstruction. They are obtained with a built-in anisotropy correction using anhysteretic remanent magnetization and without any cooling rate corrections. In contrast, only one out of four was successful from the −20-cm level samples. It yields an archeointensity of 31.6 μT, which is inconsistent with the *in situ* geomagnetic field. Considering from the *in situ* temperature record during the firing of the kiln and the unblocking temperature spectra of the samples, the floor surface samples acquired full thermoremanent magnetizations (TRMs) as their natural remanent magnetizations whereas the −20-cm level samples only acquired partial TRMs, and these differences probably cause the difference in the archeointensity results between the two sample groups. For archeointensity researches, baked clay samples from a kiln floor are considered to be ideal materials.

Keywords: Archeointensity; Absolute paleointensity; Baked clay; Kiln; Tsunakawa-Shaw method

Figure 1

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FULL PAPER Open Access

Paleomagnetism and U-Pb geochronology of the late Cretaceous Chisulryoung Volcanic Formation, Korea: tectonic evolution of the Korean Peninsula

Doohee Jeong, Yongjae Yu*, Seong-Jae Doh, Dongwoo Suk and Jeongmin Kim

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Abstract

Late Cretaceous Chisulryoung Volcanic Formation (CVF) in southeastern Korea contains four ash-flow ignimbrite units (A1, A2, A3, and A4) and three intervening volcano-sedimentary layers (S1, S2, and S3). Reliable U-Pb ages obtained for zircons from the base and top of the CVF were 72.8 ± 1.7 Ma and 67.7 ± 2.1 Ma, respectively. Paleomagnetic analysis on pyroclastic units yielded mean magnetic directions and virtual geomagnetic poles (VGPs) as D/I = 19.1°/49.2° (α_{95} = 4.2°, k = 76.5) and VGP = 73.1°N/232.1°E (A_{95} = 3.7°, N = 3) for A1, D/I = 24.9°/52.9° (α_{95} = 5.9°, k = 61.7) and VGP = 69.4°N/217.3°E (A_{95} = 5.6°, N = 11) for A3, and D/I = 10.9°/50.1° (α_{95} = 5.6°, k = 38.6) and VGP = 79.8°N/242.4°E (A_{95} = 5.0°, N = 18) for A4. Our best estimates of the paleopoles for A1, A3, and A4 are in remarkable agreement with the reference apparent polar wander path of China in late Cretaceous to early Paleogene, confirming that Korea has been rigidly attached to China (by implication to Eurasia) at least since the Cretaceous. The compiled paleomagnetic data of the Korean Peninsula suggest that the mode of clockwise rotations weakened since the mid-Jurassic. Such interesting variation of vertical rotations in the Korean Peninsula might result from the strike-slip motions of major faults developed in East Asia (the Tancheng-Lujiang fault to the northwest and the Korea-Taiwan strait fault to the southeast), near-field tectonic forcing of the subducting Pacific Plate beneath the Eurasian Plate, and far-field expressions of the India-Asia collision.

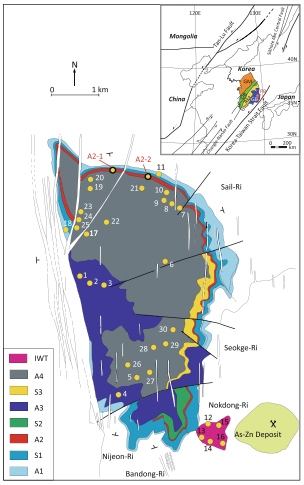

Figure 1

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FULL PAPER Open Access

Timing of clockwise rotation of Southwest Japan: constraints from new middle Miocene paleomagnetic results

Hiroyuki Hoshi*, Daiki Kato, Yoshikazu Ando and Kazuo Nakashima

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Abstract

Southwest Japan rotated clockwise during the late stage of the opening of the Japan Sea, although the exact timing of the rotation is controversial. A recent biostratigraphic study has revealed that the Miocene Oidawara Formation in eastern Southwest Japan was deposited just before 15 Ma; consequently, its paleomagnetic direction may help constrain the timing of rotation. For this purpose, we collected fine felsic tuffs and siltstones at 71 stratigraphic sites (horizons) in the Oidawara Formation. An analysis of alternating field and thermal demagnetization results yielded characteristic remanent magnetization (ChRM) directions for 177 samples. Approximately 80 % (142) of the samples exhibit reverse polarity ChRM directions that are thought to be paleofield directions of reverse polarity Chron C5Br. Normal polarity ChRM directions in 35 samples include primary paleofield records as well as records of secondary magnetization. The data suggest that a short normal polarity interval (microchron or cryptochron) at ~15.8 Ma is present within the dominantly reverse polarity interval of Chron C5Br. Reliable site-mean directions for 19 sites yield a tilt-corrected formation-mean direction of D = 10.5°, I = 41.1°, α_{95} = 7.0°, and k = 23.9, indicating virtually no rotation with respect to a reference paleomagnetic direction for the Asian continent. A rotation versus age plot for Southwest Japan indicates that the clockwise rotation started after 17.5 Ma and ceased largely before 15.8 Ma, yielding a rotation rate of ~23°/Myr.

Keywords: Magnetostratigraphy; Miocene; Mizunami Group; Oidawara Formation; Paleomagnetism; Rock magnetism; Southwest Japan; Tectonic rotation

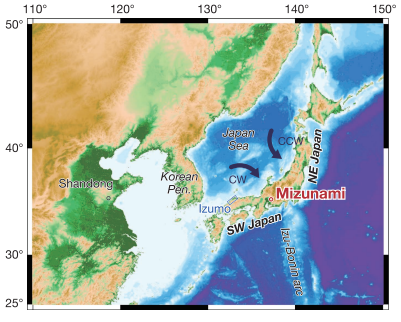

Figure 1

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FULL PAPER Open Access

Rock magnetic characterization of ferrimagnetic iron sulfides in gas hydrate-bearing marine sediments at Site C0008, Nankai Trough, Pacific Ocean, off-coast Japan

Myriam Kars* and Kazuto Kodama

Earth, Planets and Space 2015, **67**:118 DOI: 10.1186/s40623-015-0287-y
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Abstract

A high-resolution rock magnetic study was carried out in Integrated Ocean Drilling Program (IODP) Expedition 316 Hole C0008A located in the Megasplay Fault Zone of the Nankai Trough, SW offshore Japan, in order to document changes in magnetic properties throughout gas hydrate-bearing horizons. A total of 169 Pleistocene discrete samples were collected from ~110 to 153 m core depth below sea floor (CSF), and their magnetic minerals concentration, grain size, composition, and rock magnetic parameters were estimated. Results showed the presence of iron oxides ((titano)-magnetite), iron sulfides (greigite and pyrrhotite), and their mixture, among which single-domain greigite is the most major magnetic mineral present in the samples. Two horizons containing ferrimagnetic iron sulfides (114.5–127.5 and 129.5–150 m CSF) covering almost the entire studied interval were identified, both associated with slight local pore water anomalies, suggesting occurrence of gas hydrates and anoxic conditions. These results are different from the neighboring Hole C0008C (215 m away from Hole C0008A) where four pore water anomalies and six iron sulfide-rich intervals were identified for the same time slice. Comparison of the lithology, physical properties, and geochemical data of the two boreholes at Site C0008 suggests that a combination of processes (e.g., availability of reactive iron, microbial activity) is responsible for such laterally varying distribution of the ferrimagnetic iron sulfides.

Keywords: Iron sulfides; Greigite; Pyrrhotite; Gas hydrate; C0008; IODP Expedition 316; Nankai Trough

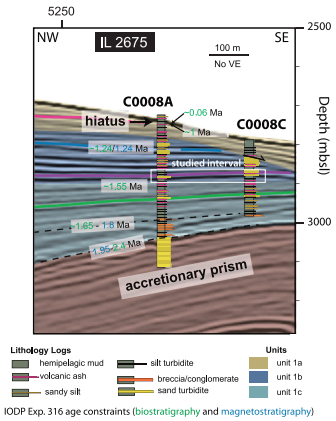

Figure 1

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FULL PAPER Open Access

Orbital-scale variation in the magnetic content as a result of sea level changes in Papua New Guinea over the past 400 ka

Yin-Sheng Huang*, Teh-Quei Lee and Shu-Kun Hsu

Earth, Planets and Space 2015, **67**:128 DOI: 10.1186/s40623-015-0300-5
Received: 30 January 2015, Accepted: 3 August 2015, Published: 14 August 2015

Abstract

We describe the orbital-scale environmental variation around Papua New Guinea (PNG) for the last 400 ka based on the environmental magnetism. Six magnetic parameters and the $\delta^{18}O$ record of the core MD05-2928 are presented in the study. Results of magnetic analyses reveal opposite responses to different environmental conditions: Magnetic minerals were relatively fewer and finer in interglacial periods and were more and coarser in glacial periods. The reason could be suggested: In interglacial periods, sediments coming from central New Guinea were transported by the coastal currents in the northern Coral Sea and then imported to the core site location. Magnetic minerals would be relatively fewer and finer due to this longer transportation process. In glacial periods, the routes of the currents might regress seaward with reduced current intensity because of lower sea level. Main sediment sources would shift to the Papuan Peninsula relatively near the core site, and therefore, the magnetic minerals became more and coarser. Further, period analyses using the eccentricity, tilt, and precession (ETP) curves and the wavelet spectra were applied to the study to analyze the periodicities embedded in the parameters. Results of both period analyses clearly present the Milankovitch periods, indicating the dominance of the orbital forcing in this area. The strongest signal of 100-ka period reveals that sea level change played the dominant role in long-term environmental setting for the past ~400 ka. However, influences of 40- and 20-ka periods, possibly related to regional precipitation, should also be considered though they might be second factors affecting the environmental variation around PNG.

Keywords: Papua New Guinea; Coral Sea; Wavelet analysis; Orbital forcing; Milankovitch cycles

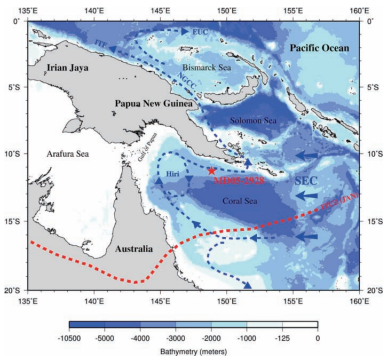

Figure 1

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FULL PAPER Open Access

Magnetic properties of surficial sediments in Lake Ogawara on the Pacific coast of northeastern Japan: spatial variability and correlation with brackish water stratification

Akira Hayashida*, Ryoma Nakano, Aya Nagashima, Koji Seto, Kazuyoshi Yamada and Hitoshi Yonenobu

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Received: 31 January 2015, Accepted: 14 October 2015, Published: 23 October 2015

Abstract

To examine limnological conditions in Lake Ogawara on the Pacific coast of northwestern Japan, we investigated the magnetic properties of dredged bottom sediment originally collected from the lake in the summer of 2011. We used non-destructive methods to measure the low-field magnetic susceptibility shortly after sampling, and anhysteretic remanent magnetization (ARM) was assessed in 2012 and 2015. The ARM acquisition and demagnetization curves from littoral sites showed several patterns that reflect the provenance of the sediments. At water depths below 10 m, the magnetic susceptibility and ARM of greenish black mud with high organic content decreased considerably with the increase in water depth, but ARM increased slightly at water depths greater than 16 m. We also found that the magnetic concentrations of mud samples were reduced markedly during a period of storage for about 3 years. We attributed these reductions to diagenetic loss of magnetic minerals, which had been enhanced at deeper sites. It is possible that the ARM carriers in deeper areas were derived from authigenic formation of iron sulfide or from deposition of suspended matter in the hypolimnion water. We propose that the magnetic properties of surficial sediments are controlled by limnological stratification of the brackish lake water, thus possibly providing an analog for down-core variations of magnetic parameters associated with the modification of magnetic minerals during reductive diagenesis.

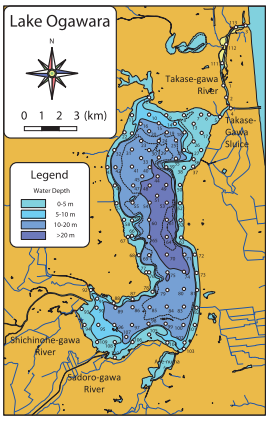

Figure 1

Keywords: Environmental magnetism; Lake sediment; Magnetic properties; Reductive diagenesis; Storage diagenesis

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FULL PAPER Open Access

Volcanic ash in bare ice south of Sør Rondane Mountains, Antarctica: geochemistry, rock magnetism and nondestructive magnetic detection with SQUID gradiometer

Hirokuni Oda*, Isoji Miyagi, Jun Kawai, Yusuke Suganuma, Minoru Funaki, Naoya Imae, Takashi Mikouchi, Takuya Matsuzaki and Yuhji Yamamoto

Earth, Planets and Space 2016, **68**:39 DOI: 10.1186/s40623-016-0415-3
Received: 30 July 2015, Accepted: 17 February 2016, Published: 9 March 2016

Abstract

Nondestructive magnetic detection of tephra layers in ice cores will be an important method to identify and correlate stratigraphic horizons of ice bearing volcanic ash particles. Volcanic ash particles were extracted from tephra-bearing ice samples collected from Nansen Ice Field south of the Sør Rondane Mountains, Antarctica. Particles are fresh glassy volcanic ash with diameters of ~50 μm, and chemical composition of the matrix glass belongs to a low-K basaltic andesite group, ranging from SiO_2 60–62 wt% and K_2O 0.40–0.50 wt%. Considering the grain size of ash particles and chemical composition of volcanic glass, the ash in tephra-bearing ice samples might be originated from the South Sandwich Islands located 2800 km northwest of the sampling sites. Correlations on major element concentrations with tephra layers associated with South Sandwich Islands in EPICA-Dome C, Vostok, and Dome Fuji ice cores show high similarity. Rock magnetic experiments show that the magnetic mineral is pseudo-single-domain titanomagnetite with ulvospinel content of 0.2–0.35 mixed with single-domain to superparamagnetic (titano)magnetite. Small blocks of the tephra-bering ice were measured with a SQUID gradiometer at 1-mm intervals with a spatial resolution of ~3 mm. With DC magnetic field of 25 mT, magnetic signal could be enhanced and detected for all the samples including the one with invisible amount of tephra particles. In order to simulate a thin ash layer in ice core, volcanic ash particles extracted from the tephra-bearing ice were used to fabricate a thin ash layer, which were subsequently magnetized, measured with the gradiometer. The noise level for *Z* axis gradiometer was about 0.6 pT. Detection limit for a half-cylinder with 29 mm radius and a thickness of 1 mm uniformly magnetized in *X* axis direction is ~9×10^{-5} A/m, which could be improved down to ~2×10^{-6} A/m by reducing the sensor-to-sample distance to 0.5 mm.

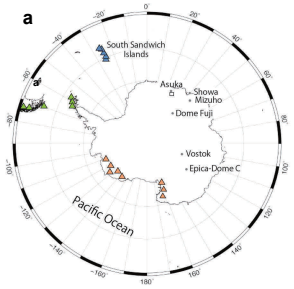

Figure 1

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TECHNICAL REPORT Open Access

GEOMAGIA50.v3: 1. General structure and modifications to the archeological and volcanic database

Maxwell C Brown*, Fabio Donadini, Monika Korte, Andreas Nilsson, Kimmo Korhonen, Alexandra Lodge, Stacey N Lengyel and Catherine G Constable

Earth, Planets and Space 2015, **67**:83 DOI: 10.1186/s40623-015-0232-0
Received: 4 February 2015, Accepted: 17 April 2015, Published: 12 May 2015

Abstract

Background: GEOMAGIA50.v3 is a comprehensive online database providing access to published paleomagnetic, rock magnetic, and chronological data from a variety of materials that record Earth's magnetic field over the past 50 ka.

Findings: Since its original release in 2006, the structure and function of the database have been updated and a significant number of data have been added. Notable modifications are the following: (1) the inclusion of additional intensity, directional and metadata from archeological and volcanic materials and an improved documentation of radiocarbon dates; (2) a new data model to accommodate paleomagnetic, rock magnetic, and chronological data from lake and marine sediments; (3) a refinement of the geographic constraints in the archeomagnetic/volcanic query allowing selection of particular locations; (4) more flexible methodological and statistical constraints in the archeomagnetic/volcanic query; (5) the calculation of predictions of the Holocene geomagnetic field from a series of time varying global field models; (6) searchable reference lists; and (7) an updated web interface. This paper describes general modifications to the database and specific aspects of the archeomagnetic and volcanic database. The reader is referred to a companion publication for a description of the sediment database.

Conclusions: The archeomagnetic and volcanic part of GEOMAGIA50.v3 currently contains 14,645 data (declination, inclination, and paleointensity) from 461 studies published between 1959 and 2014. We review the paleomagnetic methods used to obtain these data and discuss applications of the data within the database. The database continues to expand as legacy data are added and new studies published. The web-based interface can be found at http://geomagia.gfz-potsdam.de.

Keywords: Geomagnetism; Paleomagnetism; Archeomagnetism; Database; GEOMAGIA50

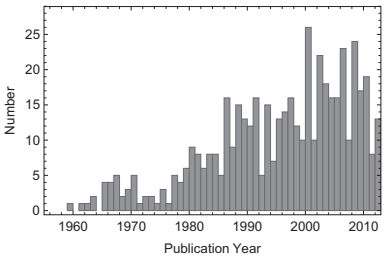

Figure 1

*Corresponding author: Maxwell C Brown, mcbrown@gfz-potsdam.de

TECHNICAL REPORT Open Access

GEOMAGIA50.v3: 2. A new paleomagnetic database for lake and marine sediments

Maxwell C Brown*, Fabio Donadini, Andreas Nilsson, Sanja Panovska, Ute Frank, Kimmo Korhonen, Maximilian Schuberth, Monika Korte and Catherine G Constable

Earth, Planets and Space 2015, **67**:70 DOI: 10.1186/s40623-015-0233-z
Received: 4 February 2015, Accepted: 17 April 2015, Published: 12 May 2015

Abstract

Background: GEOMAGIA50.v3 for sediments is a comprehensive online database providing access to published paleomagnetic, rock magnetic, and chronological data obtained from lake and marine sediments deposited over the past 50 ka. Its objective is to catalogue data that will improve our understanding of changes in the geomagnetic field, physical environments, and climate.

Findings: GEOMAGIA50.v3 for sediments builds upon the structure of the pre-existing GEOMAGIA50 database for magnetic data from archeological and volcanic materials. A strong emphasis has been placed on the storage of geochronological data, and it is the first magnetic archive that includes comprehensive radiocarbon age data from sediments. The database will be updated as new sediment data become available.

Conclusions: The web-based interface for the sediment database is located at http: //geomagia.gfz-potsdam.de/geomagiav3/SDquery.php. This paper is a companion to Brown et al. (Earth Planets Space doi:10.1186/s40623-015-0232-0, 2015) and describes the data types, structure, and functionality of the sediment database.

Keywords: Geomagnetism; Paleomagnetism; Sediment magnetism; Rock magnetism; Environmental magnetism; Database; GEOMAGIA50

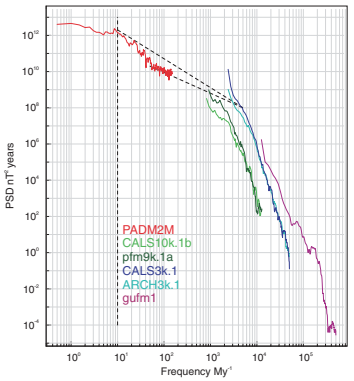

Figure 1

*Corresponding author: Maxwell C Brown, mcbrown@gfz-potsdam.de

TECHNICAL REPORT Open Access

A LabVIEW software for Thellier paleointensity measurements with an automated three-component spinner magnetometer TSpin

Koji Fukuma* and Masaru Kono

Earth, Planets and Space 2016, **68**:43 DOI: 10.1186/s40623-016-0424-2
Received: 13 September 2015, Accepted: 3 March 2016, Published: 16 March 2016

Abstract

The Thellier method is classical but is still regarded as the most reliable method for paleointensity determination. Recently, many types of additional protocols have been advocated to ensure reliability and make laboratory work more laborious and time-consuming. An automated system coupling a magnetometer and an electric furnace is now of prime importance to cope with the increasing demand. Here, we describe a graphics-based program for controlling a fully automatic system combining a spinner magnetometer and a thermal demagnetizer, and for acquiring and processing the magnetization data. A single fluxgate sensor, which can measure the vector magnetization by spinning and translating a standard-sized 1-in. specimen, was calibrated with a rotatable reference specimen that can make the magnetization parallel or perpendicular to the spinning axis. By placing a cooling chamber between the furnace and the sensor for the updated system, the specimen can be heated up more efficiently to ensure an identical thermal history for the double heatings of the Thellier method. The direction of the vector magnetization was precisely obtained as well as the intensity, the results being comparable with those from an ordinary spinner magnetometer. We present an application of the fully automatic system for a Thellier measurement on a recent lava flow, which took about 24 h for approximately ten-step double heatings without manual operation.

Keywords: Paleointensity; Thellier method; Magnetometer

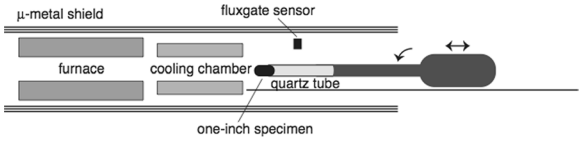

Figure 1

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Contents

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