Japan Geoscience Union Meeting 2011
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SEM036-01 Room:301B Time:May 26 14:15-14:30

Effects of pressure on the Verwey transition temperature of magnetite

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The Verwey transition of magnetite is one of the basic issues in the rock magnetism, since the magnetic property measurement using low temperature cycle (LTD, field cooling/ zero-field cooling method, and so on) is a powerful tool for identifying magnetic minerals of rocks.

Mori et al. (2002) reported that the Verwey transition temperature (Tv) decrease with applied pressure by measuring the electrical resistivity on single crystalline samples. In contrast, Rozenberg et al. (2007) observed increase in the transition temperature with pressure by X-ray diffraction and Mossbauer experiment under high pressure. Therefore the Tv change with pressure has been controversial. Recent developments of experimental techniques enable us to measure sample magnetizations under high pressure (Gilder et al., 2002; Kodama and Nishioka, 2005; Sadykov et al., 2008). We focus on the Verwey transition of magnetite and conducted systematic experiment under a pressure of up to 0.9 GPa.

In the sample preparation, natural magnetite of large crystal was crushed by hand and sieved in an ultrasonic bath to be 45-60 micrometers in size. The pressure cell used in the present study is made of CuBe and zirconium oxide (Kodama and Nishioka, 2005). Samples are placed into a Teflon capsule As a pressure transmitting fluid, we used a 1:1 mixture of Fluorinert NO. FC70 and NO. FC77. To calibrate the pressure inside the cell we placed small chip of indium whose transformation temperature is given as a function of pressure (Jennings and Swenson, 1958).

We performed thermal demagnetization of a saturation isothermal remanent magnetization (SIRM) imparted in a magnetic field of 2.5 T at 10 K using a Quantum Design Magnetic Property Measurement System (MPMS). Samples were cooled from room temperature to 10 K in zero-field. A 2.5 T field was applied at 10 K and then measurements of the magnetic moment upon warming started. Measurement frequency upon warming from 10 K was 1 K between 90 K and 140 K, with coarser temperature step below 90 K and above 140 K.

Systematic changes in magnetization intensity curve were observed under high pressure in the present study. Under atmospheric pressure, the sample magnetization down sharply at the known Verwey transition temperature. Applying a pressure, there is a little decrease in magnetization in approaching Tv from below, followed by a sharp decline of magnetization due to the Verwey transition. The Tv values identified as a sharply declined temperature gradually shifts to be lower with pressure (2 K/GPa). After decompression, the magnetization curves recovered the original one at an atmospheric pressure.

This supports the results by Mori et al. (2002) and suggests that the Verwey transition may be caused by the electron hopping. Combining other low temperature cycles, we will discuss behaviors of magnetite concerning the Verwey transition.

Keywords: Verwey transition, high pressure

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A new PDRM lock-in model for marine sediments deduced from Be-10 and paleomagnetic records through the M-B boundary

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Geomagnetic field intensity records from marine sediments (relative paleointensity) have contributed to a better understanding of variations in the Earth's magnetic field, and have helped to establish age models for marine sediments. However, lock-in of the geomagnetic signal below the sediment-water interface in marine sediments through acquisition of a post-depositional remanent magnetization (PDRM) adds uncertainty to the temporal synchronization of marine sedimentary records. Although quantitative models enable the assessment of the delayed remanence acquisition associated with PDRM processes, the nature of the filter function and the thickness of the PDRM lock-in zone remain topics of debate. We have performed forward numerical simulations to assess the best-fit filter function and thickness of the PDRM lock-in zone in marine sediments based on a recently published comparison of Be-10 flux and relative paleointensity records. Our simulations reveal that the rate of PDRM lock-in increases in the middle part of the lock-in zone and a Gaussian function with a 16 cm lock-in zone thickness is the most suitable for representing the PDRM lock-in process in the studied core. This explains why the PDRM lock-in is largely delayed relative to the other sedimentary records, but distortion of the geomagnetic signal is relatively small. This result also implies that the PDRM is not simply locked as a result of progressive consolidation and dewatering of marine sediments, and that the arbitrary lock-in functions (linear, cubic, and exponential) that are often used to model PDRM lock-in starting from the base of the surface mixed layer cannot explain the observed paleomagnetic signal in marine sediments.

Keywords: paleomagnetism, paleointensity, post-depositional remanent magnetization, lock-in depth, Matuyama-Brunhes boundary

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Field- and Frequency-Dependent Anisotropy of Magnetic Susceptibility: Deeper Insight into Rock Fabric

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Theory of the Anisotropy of Magnetic Susceptibility (AMS) of rocks is based on the assumption of the linear relationship between magnetization and magnetizing field, resulting in field-independent susceptibility. However, pyrrhotite, hematite and titanomagnetite may show significant variation of susceptibility with field. Three methods were developed for the determination of the field-independent and field-dependent AMS components, all based on standard measurement of the AMS in variable fields within the Rayleigh Law range. The former component basically reflects the magnetic sub-fabrics of mafic silicates and pure magnetite, while the latter component is controlled by the pyrrhotite, hematite or titanomagnetite sub-fabric. Examples are shown of separation of individual magnetic sub-fabrics in some ultramafic rocks.

In some geological processes, such as very low-grade metamorphism, new very fine- grained magnetic minerals may originate. Their fabric can be investigated by means of the frequency-dependent magnetic susceptibility and its anisotropy, which is in environmental science and palaeoclimatology traditionally interpreted as resulting from interplay between superparamagnetic (SP) and stable single domain (SSD) or even multidomain (MD) particles. Through standard AMS measurement at different frequencies, the contribution of SP particles to the whole-rock AMS can be evaluated; appropriate method and program were developed. Various rocks, soils and ceramics, showing frequency-dependent AMS, were investigated. Attempts are made of their fabric interpretation.

Keywords: anisotropy of magnetic susceptibility, field-dependence, frequency-dependence

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Strong-field dynamo action in the Earth's core

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It is generally believed that the geodynamo works in the so-called strong-field regime, where substantial part of the Coriolis force is balanced by the Lorentz force. In this regard, the ratio of the two forces defined as the Elsasser number, $¥Lambda$, is used as a measure of the strength of the dynamo-generated magnetic field. In the strong-field dynamo, it is reasonably hypothesized that $¥Lambda$ is about unity in the Earth's core. From geomagnetic field observations, however, $¥Lambda$ at the core-mantle boundary (CMB) is of the order of 0.1. It is suggested that the geomagnetic field in the outer core is much stronger than that at the CMB. On the other hand, from numerical dynamo models, the volume averaged Elsasser number can be as large as 100. Thus doubt has been casted on validity of the hypothesis of order-one-Elsasser-number.

In this study, we have obtained a strong-field dynamo using dynamo simulation with the following parameter set: Ekman number, E = 10^{-5}, magnetic Prandtl number, Pm = 2, Rayleigh number, Ra = 3 x 10^{7}, and Prandtl number, Pr = 1. In the dynamo solution, the Elsasser number is 1.6, while the magnetic Reynolds number is 76, somewhat smaller than that of the Earth's core. Notably, the magnetic energy is more than 55 times larger than the kinetic energy, indicating that the inertia is minor compared with the magnetic effect. Also, effects of strong self-sustained magnetic field on evolution of core dynamo are investigated. From the present result, it is suggested that the strong-field dynamo is likely when the inertial force as well as the viscous one is sufficiently small compared with the Lorentz force. Such a condition should be well satisfied in planetary core.

Keywords: dynamo, strong-field, Elsasser number

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The effects of the initial magnetic field on MHD dynamo in a rotating spherical shell

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In recent years, three-dimensional numerical simulations of MHD dynamo in rotating spherical shells have been carried out vigorously in order to investigate generation and maintenance mechanisms of magnetic fields in celestial bodies. In most of the parameter studies, the strong magnetic field or the result of magnet-convection calculation with strong magnetic field were adopted as a initial value of dynamo calculation. As a result, they obtained strong-field dynamo solutions. However, as pointed out in some studies, it may depend on the initial value of a magnetic field whether a self-sustained dynamo action is established.

In the present study, numerical experiments of a MHD dynamo in a rotating spherical shell are conducted in order to investigate the effects of the initial magnetic fields. We assume the boundaries to be co-rotating. The bottom mechanical boundary condition is always no-slip, whereas the top mechanical boundary condition is free-slip (FR case) or no-slip (RR case). The temperature at each boundary is fixed and isothermal. The outside of the spherical shell and the inner core are electrical insulators. In all the calculations, the Ekman number, the Prandtl number, and the ratio of the inner and outer radii are fixed to 10^{-3}, 1, 0.35, respectively. The magnetic Prandtl number is varied from 1 to 20, and the modified Rayleigh number is increased from 1.5 to 10 times the critical value. For each combination of the parameters, time integration of non-magnetic thermal convection is carried out until a quasi-steady state is established. After quasi-steady state was established, MHD dynamo calculation is performed with three different types of magnetic field as follows:

(a) the energy of the imposed magnetic field is two order of magnitude larger than kinetic energy of the quasi-steady state of non-magnetic thermal convection.

(b) the energy of the imposed magnetic field is equal to the kinetic energy of the quasi-steady state of non-magnetic thermal convection.

(c) the energy of the imposed magnetic field is two order of magnitude smaller than kinetic energy of the quasi-steady state of non-magnetic thermal convection.

The results as follows:

1) As the the energy of initially imposed magnetic field becomes small, larger magnetic Prandtl number is necessary for the establishment of self-sustained dynamo regardless of the dynamical boundary condition.

2) In the RR case, all the obtained dynamo solutions are the alpha-squared dynamo solutions.

3) In the FR case, the alpha-squared dynamo solutions are established when the initial magnetic energy is (a) larger than or (b) equal to the kinetic energy of the initial non-magnetic convection, whereas a two-layer weak dynamo solution is obtained when the initial magnetic energy is (c) smaller than the kinetic energy of the initial non-magnetic convection. In the cases (a) and (b), it is necessary for the establishment of self-sustained dynamo to increase the magnetic Prandtl number compared with the RR case.

Keywords: Convection in a rotating spherical shells, MHD dynamo, Initial magnetic field

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Latitudinal dependence of some effects of anisotropic thermal diffusivity in the Earth's core

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It is likely that turbulent motions occur in the Earth's fluid outer core with very small molecular viscosity. Such small-scale flows, which are highly anisotropic because of the Earth's rapid rotation and a strong magnetic field, can enhance a large-scale thermal diffusive process in the core. This suggests that a thermal eddy diffusivity should not be a scalar but a tensor. We have been carrying out numerical simulations of magnetohydrodynamic (MHD) turbulence in a rapidly rotating system to investigate the effect of anisotropy on dynamics in the core, by prescribing elements of anisotropic thermal diffusion tensor.

We have found that a certain degree of anisotropy has an insignificant effect on the character, like kinetic and magnetic energy, of magnetoconvection in a small region with periodic boundaries in the three-directions. However, in a region with top and bottom rigid boundary surfaces, the same degree of anisotropy can enhance kinetic and magnetic energy in magnetoconvection depending not only on prescribed anisotropic tensor diffusivity but also on location of the computational region expressed in terms of direction of gravity, or latitude. This implies that anisotropic tensor diffusivity, consequent on the anisotropy of turbulent flows, affects dynamics in the core near the boundary surfaces depending on the latitude.

Keywords: anisotropic diffusivity, magnetoconvection, Earth's core

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Evaluation of secular variation models of IGRF11 and its application to an epoch reduction of magnetic anomalies

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Magnetic anomaly of total intensity is defined as the residual from the IGRF model. The IGRF11 is recommended for the IGRF model by IAGA. The secular variations in the vicinity of Japanese Islands observed at the magnetic stations were compared with those of IGRF11. The secular variation model of IGRF11 fairly approximate the real secular variation, however, more than several tens of differences were recognized. In the case of Kakioka magnetic observatory, the differences ranges from -10nT to +140nT between 1955.0 and 2010.0. This result implies that the magnetic anomaly value also varies depending on the observed year. In the case of compiling regional magnetic anomaly map, the data sources usually spans several decades, so the epoch reduction of magnetic anomalies is needed. In corresponding to this demand, author proposes an epoch reduction method. The method is composed of thee steps; in the first step the magnetic anomaly variations between 1960.0 and 2010.0 at the magnetic stations are approximated by the Fourier expansions, in the second step the differences between the epoch date (ex., 2000.0) and the arbitrary date (field observation date) are calculated using the Fourier expansions of the magnetic stations, In the third step a distribution of these differences are approximated by the 2nd order polynomials of latitudes and longitudes, then the correction value at the arbitrary point(field observation point) is estimated from this polynomials. This reduction method was applied for compiling the regional magnetic anomaly maps at the epoch 2000.0.

Keywords: magnetic amomaly, IGRF11, secular variation, Regional magnetic anomaly map, Epoch reduction

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SEM036-08 Room:301B Time:May 26 16:00-16:15

Beginning of Dinosaur Magnetism

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We propose new interdisciplinary genre, named as Dinosaur Magnetism, which relates to geomagnetism, rock magnetism, paleontology, sedimentology, rock mechanics in the earth science, and to analyze relation between deformation caused by Dinosaur and detailed magnetic measurements on sedimentary layer with Dinosaur Footprint, to elucidate reliability of paleomagnetism recorded in the sedimentary layer, geomagnetic field in the Dinosaur ages, acquisition of detrital remanent magnetization during formation of footprint by Dinosaur, evolution of Dinosaur, continental drift and living environment of Dinosaur.

We have examined the Dinosaur footprint sample, collected from Kitadani Formation of Tetori Group in Katsuyama City of Fukui Prefecture, central Japan, for the Dinosaur Magnetism.

The fossil bones of Dinosaur were reported from the Kitadani Formation, as Fukuiraptor kitadaniensis with body length of 4.2m of carnivorous Theropods, Fukuititan nipponensis with 10m total length of herbivorous Sauropods, Iguanodon with 4.7m total length of herbivorous Ornithopods.

We measured fine and very fine grained sandstone layer bounded by the thin mudstone layers with footprint of the right leg of Theropods. Because the mud layers were exfoliated easily with water, we use kerosene. The base of the sample was plastered with gypsum for precise oriented cutting. The 2cm cubic samples for the measurements of magnetism were cut from the sample.

We found a significant magnetization of gypsum, 10 times stronger than the sandstone samples, and then we removed the gypsum from the samples of basal part before magnetic measurements.

We measured natural remanent magnetization NRM after 10 mT step alternating field demagnetization, anisotropy of magnetic susceptibility under 22 micro T, anhysteretic remanent magnetization ARM of 29 micro T and 40 mT after 10 mT step alternating field demagnetization with Automatic Paleomagnetic Processor NP2 of Metoba.

We examined demagnetization pass of NRM for sample of side by side and significant divisions with the courses of demagnetization pass, which means the sample had not been remagnetized with uniform secondary magnetization.

The divisions are correlated closely with the deformation of the Dinosaur footprint, especial rising part between the second and the third toes, in which the NRM has uniform directions and the directions are not changed with demagnetization, contrasted with the surrounded parts.

The part is loaded by the total weight of the Theropods Dinosaur as much as several tons, and the sandstone layers were bent few centimeters under the weight centered around the part. The surface of the rising was covered by the web of the leg, and the sediments are estimated to be pressed with several tons weight. The void in the sediments had been vanished and the magnetic particles had been fixed in the sediments. The NRM of the part can be thought as a record of the geomagnetism at the time of the Dinosaur walking at 100 Ma.

The further study of the measured result will be able to realize the mechanism of the deformation and magnetization which are useful to understand the behavior of the Dinosaur. The paleomagnetic direction is useful for the evolutionary trend of Dinosaur.

Keywords: Dinosaur, Theropods, footprint, paleomagnetism, Tetori Group, gypsum

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Orientation errors in paleomagnetic sampling and their effects

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In paleomagnetic studies, samples often have shapes of cylindrical cores which are obtained by engine drills. In this case, two angles measured in the field (plunge of cylindrical axis from horizontal plane, and the angle between a horizontal direction in the core and the true north) will enable the transformation of direction of magnetic remanence to geographic coordinates. It is not difficult to perform the angle measurements with an error of about 1 degree or less. The angular error in paleomagnetic directions are measured by Fisher's semi-angle of 95% confidence, which is typically a few to ten degrees. It appears therefore that the orientation errors are negligibly small.

However, this it not quite correct. There is no problem about the measurement of plunge, but the angle in the horizontal plane is often measured by a magnetic compass, which can be source of large errors. In particular, volcanic rocks often carry strong magnetization which can cause a large local magnetic anomalies. This was known for a long time, but the absence of relevant data prohibited quantitative estimate of orientation errors.

We have obtained quite a large number of data (182 lavas, 903 samples) from Lundarhals area of Iceland. Among them, more than 200 samples have data of three independent horizontal angles; one by sun's direction, the second by reference to some reference point, and magnetic azimuth. Among the rest, more than 600 samples have reference and magnetic azimuths. Only 30 samples are determined by magnetic azimuth alone. From a detailed analysis of these data, the following conclusions were obtained.

(1) The difference between sun and reference azimuths are 0.0 +- 0.6 degrees (the mean and standard deviation, for n=203). This is small enough and can be ignored compared to other errors. Consequently, if either of these angles are available, we have almost error-free data.

(2) The differences between the sun and magnetic azimuths are 0.5 +- 7.8 degrees (n=240), and those between the reference and magnetic azimuths are 0.0 +- 6.9 degrees (n=844). This error is not negligible in the paleosecular variation studies, in which the typical ASD is of the order of 10 to 20 degrees.

(3) In general, samples from the same lava show similar errors. Thus it appears that the main reason for the error is the magnetization of the lavas itself. However, it is hard to find a good correlation between the direction of magnetization and the orientation errors.

Keywords: paleomagnetism, volcanic rocks, orientation error, paleosecular variation

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Geomagnetic field intensity inferred from 4-6 Ma lava sequences in Sudurdalur area, Iceland

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Paleomagnetic core samples were collected from 489 lava flows distributed in different four regions in Iceland. The collections were done in 1993 and 1994 by Masaru Kono, Hidefumi Tanaka and others. One of the regions was the Sudurdalur area. In the area, samples were taken from two sections of MA and MB which are about 10 km distant from each other. The sections MA and MB consist of 47 and 52 lava flows, respectively. These samples were studied by Udagawa (1997 MS) for K-Ar ages and by Kitagawa (1998 MS) for paleomagnetic directions. Udagawa (2000 DS) integrated these results and interpreted that magnetostratigraphy recorded in the MA and MB sections could be correlated to the duration between Chron C3An.1n and Cochiti Normal Subchron. This corresponds to the duration between 4.187 and 6.252 Ma based on the geomagnetic polarity time scale by Lourens et al. (2004). In the present study we have performed absolute paleointensity measurements on these samples using the LTD-DHT Shaw method.

Prior to the paleointensity measurements, hysteresis and thermomagnetic properties were investigated for each one chip sample from every lava flows. Considering these properties, samples from 41 lava flows of the MA section and 36 lava flows of the MB section were subjected to the paleointensity measurements. The measurements were made on 145 (MA) and 117 (MB) individual specimens. Selection criteria discriminated 82 (MA) and 58 (MB) successful results. Further statistical criteria ((1) not less than three successful results were obtained from a flow; (2) a standard deviation calculated from these successful results is within 15 per cent of the flow average) yielded 18 individual virtual dipole moments, giving an average of 3.88 x 10 22 Am2 with a standard deviation of 1.86 x 10 22 Am2. This is about a half of the present geomagnetic dipole moment, and not contradict from an average VDM of 3.20 x 10 22 Am2 (N=23) obtained from 0.5-4.6 Ma volcanic rocks in southern hemisphere by the LTD-DHT Shaw method (Yamamoto and Tsunakawa, 2005; Yamamoto et al., 2007).

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Testing paleointensity determinations in a contact aureole of the Columbia River Basalt

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In order to confirm whether a remanent magnetization records an ancient geomagnetic field or not, directional paleomagnetic data are usually checked by several kinds of field tests such as a fold or reversal test in addition to demagnetization experiments in laboratory. However, any field test is not routinely applied for paleointensity data. Neither fold nor reversal test are applicable to intensity data in principle. Absence of reliable field tests for paleointensity leaves many of the paleointensity data obtained by the Thellier method in question, although complicated experimental procedures have been proposed and detailed criteria for data selection are adopted for laboratory data. Still one kind of field test might remain applicable for paleointensity data: a contact test.

We tried testing paleointensity determinations for the Mayview dike and its contact aureole of the Miocene Columbia River Basalt Group. The about 2 m wide Mayview dike intruded the N2 Grande Ronde Basalt, which is also a formation of the Columbia River Basalt Group. A one centimeter quenched glassy layer is observed along the dike contact. Two or three millimeter thick sliced specimens were prepared from the hand samples bounding the contact and thermomagnetic analyses were performed. Magnetic mineralogy rapidly changes even within a single hand sample both in the dike and the country rock. Glassy samples exhibit the low Curie temperature (~150 deg.C) of titanium-rich titanomagnetite and maghemitization seems insignificant, whereas non-glassy specimens suffered somewhat maghemitization and the degree decreases with increasing the distance from the contact. The country basalt rocks show the Curie temperature (~580 deg.C) of titanium-free magnetite for the nearest specimen to the contact and the Curie temperature decreases as leaving the contact.

Highly maghemitized specimens both from the dike and the country rock gave apparently quite low or sometimes negative paleointensity values. These anomalous values should be artifacts due to alteration during laboratory heating in our Thellier experiments. Low-field susceptibility values, measured at each temperature step of the Thellier experiments, also sharply rise with increasing temperature. We do not count on these anomalously low values any more. Glassy dike specimens showing insignificant maghemitization have relatively high paleointensity values which are still lower than the present geomagnetic field intensity. A basalt specimen nearest to the contact indicate a similar paleointensity value to those of the glassy dike specimens. This may suggest that the geomagnetic field intensity is recorded both in the dike and the country rock.

Keywords: paleointensity, Thellier method, field test, rock magnetism

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Paleomagnetism of the Middle Miocene sediments (Oidawara Formation) of the Mizunami Group, central Japan

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Oriented 1-inch cores were collected from 42 stratigraphic horizons of the Middle Miocene marine sedimentary sequence of the Oidawara Formation, uppermost lithological unit of the Mizunami Group. Magnetic measurement with detailed alternating-field and thermal demagnetizations revealed a magnetic polarity stratigraphy that divides the sedimentary sequence into three polarity zones (lower reversed, middle normal, and upper reversed). This dominantly reversely magnetized sequence can safely be correlated to Chronozone C5Br as the sediments are dated at approx. 15.8-15.6 Ma based on diatom biostratigraphy. The reversed polarity characteristic remanent magnetization (ChRM) directions determined by principal component analysis of stepwise demagnetization data have a SSW declination (approx. 200 deg) after gentle tilt correction, indicating clockwise paleomagnetic rotation. This is consistent with existing paleomagnetic data from the Early Miocene sediments underlying the Oidawara Formation that display more deflected declination. The detected clockwise paleomagnetic rotation is attributed to the clockwise tectonic rotation of the SW Japan arc associated with the Japan Sea opening as has so far been suggested, and the Oidawara Formation records the paleomagnetic information in the course of the clockwise tectonic rotation. The reversed polarity ChRM inclination is significantly shallower than expected at the latitude of the studied area, probably due to inclination shallowing of detrital remanent magnetization. The normal polarity ChRM directions exhibit a northerly declination and a moderate inclination, possibly influenced by a viscous magnetic component that cannot completely be erased by demagnetization.

Keywords: paleomagnetism, Miocene, Oidawara Formation, Mizunami Group, magnetostratigraphy, tectonic rotation

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An upper Olduvai polarity transition record from the Ofuna Formation, Kazusa Group, in Yokohama, central Japan

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We report a detailed geomagnetic record including direction and proxies of paleointensity at around the upper Olduvai polarity transition from an on-land core, named as Core-I, drilled by Yokohama National University at Segami, southern part of the Yokohama City. The 105 meters length core covers a part of the Ofuna Formation, Pleistocene marine sequence, consisting of massive siltstone intercalating ash and thin sand layers. Two ash layers detected at depths of 9 and 27 meters below the surface have been correlated with Kd38 and Kd39 respectively, which are key tephras recognized in Japan as indicating ages just above the upper Olduvai boundary.

1-inch diameter mini-cores were taken for paleomagnetic and rock-magnetic measurements using a core-piker at 452 stratigraphic levels from Core-I between 75 and 105 meters with intervals of 2 to 10 cm thickness. Measurements for stepwise alternating filed demagnetization (AFD) from 5 mT up to 60 mT with 5 mT steps, anisotropy of magnetic susceptibility (AMS), and anhysteretic remanent magnetization (ARM) were conducted for specimens at all the 452 levels, and stepwise thermal demangetization were done for selected 30 specimens. As the results, at most of the specimens, secondary components were removed up to 25 mT and/or 250 degree C levels and characteristic remanent magnetization (ChRM) components were extracted. The upper Olduvai polarity transition was detected between 82 and 87 meters corresponding with a 7 kyrs time span between 1784Ka and 1777Ka, which were derived by an age model using oxygen isotopic analyses.

Keywords: paleomagnetism, geomegnetic polarity transition, Olduvai subchron, geomagnetic paleointensity

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Matuyama-Brunhes polarity transition features from Sangiran, Java

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Detailed features of the Matuyama-Brunhes (M-B) polarity reversal transition are obtained from a 7-m thick section of fluvio-lacustrine sediments in Sangiran, Java. Besides the previously reported multiple short reversal episodes, relative paleointensity (RPI) was determined with magnetizations of sediments whose magnetic carriers are magnetite (titano-magnetite) and hematite. RPI was calculated with the same coercivity spectra of natural remanent magnetization (NRM) and normalizers. We used a component of NRM demagnetized in a peak alternating field (AF) of 30 mT subtracted by NRM demagnetized in a peak AF of 100 mT (NRM30-100). Two normalizers were used; one is anhysteretic remanent magnetization (ARM) demagnetized in a peak AF of 30 mT (ARM30), and the other is isothermal remanent magnetization (IRM) demagnetized in a peak AF of 30 mT (IRM30). ARM was imparted with a peak AF of 100 mT superimposed on a DC biased field of 50 ?T. IRM was imparted with a DC field of 100 mT. Therefore, not only NRM30-100 but also ARM30 and IRM30 are mainly carried by magnetite, and scarcely contributed by hematite whose remanent coercivity is higher than 100 mT. Magnetic data of 3 to 5 specimens per horizon were averaged. The horizon mean NRM30-100 value varies by 320 times. On the other hand, the horizon mean values of NRM30-100/ARM30 and NRM30-100/IRM30 (RPI proxies) vary by only 13 and 10 times, respectively, being consistent with the range of observed RPI variations across the polarity transition. The two RPI proxy curves quite well agree with each other, showing double minima. The first RPI minimum occurred between the first two short reversal episodes, and the second one in a broad range from the main polarity boundary to the third short episode, followed by a rapid increase in RPI. The RPI variation pattern is quite similar to that of the M-B transition record from rapidly deposited (50-60 cm/ka) sediments of Osaka Bay, Japan. Four excursional fields with VGP latitudes lower than 45 degrees were observed just before the main polarity boundary. The VGPs are distributed in the western south Pacific, overlapping the VGP cluster of the transitional fields from Hawaiian lavas Ar/Ar dated at 776 ka in average, and a Canary Island lava Ar/Ar dated at 780 ka. The base of the M-B transition lies about 5 m above the tektite horizon, which confirms the transition is distinct from the precursor event.

Keywords: geomagnetic polarity transition, Matuyama-Brunhes, relative paleointensity, Java, transitional VGP

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Comparison of magnetic properties of topmost sediments at the first and second depressions in North Basin of Lake Biwa

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Rock-magnetic investigations are performing on topmost sediments in Lake Biwa for clarifying the effect of early diagenesis on magnetic properties of sediments and analyzing environmental changes mainly based on variations in magnetic properties of the sediments. In this time, we present results from rock-magnetic analyses of sediments cored at the second depression off Ohmimaiko (Ie-1, water depth 71m) in North Basin of Lake Biwa and comparison with previously reported magnetic properties of sediments at the deepest area of the first depression in North Basin off Imazu (N4, water depth 91m).

In North Basin, the lake water is stratified from summer to autumn associated with the thermocline formation, and is circulated in a whole in winter. This change causes variations in environmental conditions at the bottom water. At Ie-1 and N4, the amount of dissolved oxygen (DO) shows a seasonal variation: relative high values of DO are observed in February to April at both sites, while low DO values below 1 mg/L at N4 and about 4mg/L at Ie-1 in October and November.

At Ie-1, sediments cores of 13-30cm long were taken in October 2008, and March and June 2009 by a HR-type gravity corer. The cored sediments consisted of homogeneous claly silt of black to dark greenish gray color, similar to those at N4. Analyzed samples were taken from the cores continuously at 1 or 2 cm intervals and freeze-dried.

Results from high and low temperature magnetic analyses suggested that magnetic minerals in the sediments of Ie-1, as well as N4, are dominantly maghemitized magnetite. Based on downcore variations of magnetic parameters, the sediment cores were divided into the following three units: Unit-A (0-12cm in depth), B (12-20cm in depth), and C (20-30cm in depth). Unit-A was characterized by a downward decrease of coercivity. In Unit-B and C, concentration and magnetic-granulometric proxies for magnetic minerals decreased downward. These magnetic variations at Ie-1 were similar to those at N4, but the depth of the unit boundaries were about 2cm deeper than N4.

Among concentration parameters of magnetic mineral, initial magnetic susceptibility (x), ARM susceptibility (x-ARM), saturation remanence (Mrs) and saturation magnetization (Ms), the parameters but x-ARM were lower at Ie-1 than N4 in the whole units. The difference in x was remarkable, and x-ARM showed no difference. High-field susceptibility values were same at both sites. It is inferred that the amount of magnetic mineral is smaller at Ie-1, and/or that the contribution of super-paramagnetic grains is larger at N4.

Among magnetic granulometric proxies (ARM/Mrs, x-ARM/x and Mrs/x), ARM/Mrs and x-ARM/x were slightly larger at Ie-1 than N4. It is possibly implied that magnetic grain size is relatively smaller at Ie-1.

Among magnetic coercivity proxies, coercivity (Hc), coercivity of remanence (Hcr) and S-ratio (S-0.1T), Hcr and S-0.1T were smaller in Unit-A at Ie-1 than N4, while Hc values were same at both sites. The lower coercivity at Ie-1 may imply the smaller grain size of magnetic minerals, which is inconsistent with the above-mentioned implication based on the magnetic granulometric proxies. The difference in coercivity is also caused by the difference in the maghemitization degree of magnetite. However, based on low-temperature magnetic behaviors of isothermal remanence (IRM), there was little difference in the maghemitization degree between Ie-1 and N4 samples except for samples at both sites in Oct. 2008 when the minimum values of DO in the bottom water were observed.

In Unit-A, a seasonal change of magnetic coercivity was observed at N4, while Ie-1 samples provided no seasonal change. Although the low temperature behaviors of IRM indicated the presence of a magnetic mineral with a distinctive decrease of IRM at 29K in N4 samples of Unit-A and B, the Ie-1 samples did not provide any magnetic behaviors indicating the existence of such a magnetic mineral.

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Magnetic properties of Lake Biwa sediments responding to hydrological and climate changes for the last 46 kyrs

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Magnetic analysis of a piston core sample from Lake Biwa (BIW95-4) revealed that anhysteretic remanent magnetization (ARM) increases in the post-glacial stage and at interstadial intervals in the last glacial period (Hayashida et al., 2007). New core samples recovered from other sites in 2007 and 2008 reproducibly extended the ARM record back to 46 ka, featuring major interstadials of Dansgaard-Oeschger cycles and Heinrich events. It is thus suggested the magnetic mineral content in Lake Biwa sediments represents hydrological changes associated with climate changes.

We made rock magnetic analysis of the core sediments in order to identify magnetic minerals carrying the ARM and responding to the millennial-scale climate changes. Comparison of ARM acquisition curves up to 100 mT suggest that samples with higher ARM values are characterized by higher magnetic coercivity compared to low ARM samples, although the difference is not clearly distinguished by IRM acquisition over 100 mT. The variation of magnetic coercivity correlative to the ARM variation is also shown by measurement of hysteresis loops with a vibrating sample magnetometer. Hysteresis parameters displayed in a Day plot show that most data fall in the region of pseudo-single domain (PSD), where the samples with higher ARM provide lower Hrc/Hc and higher Mrs/Ms data. We suggest possibility that the ARM peaks were yielded by increased flux of fine-grained ferromagnetic minerals, such as pedogenic magnetite, possibly associated with enhanced precipitation during the interstadial intervals and the post-glacial period.

Keywords: Lake Biwa, anhysteretic remanent magnetization, Dansgaard-Oeschger cycles