Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-01 Room:301B Time:May 26 14:15-14:30

Effects of pressure on the Verwey transition temperature of magnetite

Masahiko Sato[1*], Yuhji Yamamoto[2], Takashi Nishioka[2], Kazuto Kodama[2], Hideo Tsunakawa[1]

[1]Dept. Earth Planet. Sci., Tokyo TECH, [2]Kochi University

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-02 Room:301B Time:May 26 14:30-14:45

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

Yusuke Suganuma[1*], Jun'ichi Okuno[1], David Heslop[2], Andrew P. Roberts[2], Toshitsugu Yamazaki[3], Yusuke Yokoyama[4]

[1]National Institute of Polar Research, [2]The Australian National University, [3]Geological Survey of Japan, [4]Atmosphere and Ocean Research Institute

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-03 Room:301B Time:May 26 14:45-15:00

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

Frantisek Hrouda[1*], Martin Chadima[1]

[1]AGICO Inc. Brno

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-04 Room:301B Time:May 26 15:00-15:15

Strong-field dynamo action in the Earth's core

Futoshi Takahashi[1*]

[1]Tokyo Institute of Technology

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, $Ra = 3 \times 10^{7}$, 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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-05 Room:301B Time:May 26 15:15-15:30

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

Youhei SASAKI[1*], Shin-ichi Takehiro[2], Kiyoshi Kuramoto[3], Yoshi-Yuki Hayashi[4]

[1]Department of Mathematics, Kyoto Univ., [2]Research Inst. Math. Sci., Kyoto Univ., [3]Dept. Cosmoscience, Hokkaido Univ., [4]Center for Planetary Science

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-06 Room:301B Time:May 26 15:30-15:45

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

Masaki Matsushima[1*]

[1]Tokyo Institute of Technology

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-07 Room:301B Time:May 26 15:45-16:00

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

Yoshio Ueda[1*]

[1]Cosmograv Co. ,Ltd

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

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

Beginning of Dinosaur Magnetism

Nobuaki Niitsuma[1*], Yoichi Azuma[2], Yoshikazu Noda[2]

[1]Institute of Geosciences, Shizuoka Univ., [2]Fukui Prefectural Dinosaur Museum

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-09 Room:301B Time:May 26 16:30-16:45

Orientation errors in paleomagnetic sampling and their effects

Masaru Kono[1*]

[1]Tokyo Institute of Technology

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-10 Room:301B Time:May 26 16:45-17:00

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

Yuhji Yamamoto[1*], Tadahiro Hatakeyama[2]

[1]Kochi University, [2]Okayama University of Science

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).

SEM036-11 Room:301B Time:May 26 17:00-17:15

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

Koji Fukuma[1*], Takeshi Saito[2]

[1]Dept. Env. Sys. Sci., Doshisha Univ., [2]IYREC, Shinshu University

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-12 Room:301B Time:May 26 17:15-17:30

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

Hiroyuki Hoshi[1*], Daiki Kato[2]

[1]Aichi University of Education, [2]Aichi University of Education

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-13 Room:301B Time:May 26 17:30-17:45

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

Chie Kusu[1*], Makoto Okada[2], Kengo Kamoshida[1], Atsushi Nozaki[1], Ryuichi Majima[1]

[1]Yokohama National University, [2]Ibaraki University

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-14 Room:301B Time:May 26 17:45-18:00

Matuyama-Brunhes polarity transition features from Sangiran, Java

Masayuki Hyodo[1*], Ikuko Kitaba[1], Shuji Matsu'ura[2], Yoshihiro Takeshita[3], Megumi Kondo[2], Hisao Kumai[4]

[1]Kobe University, [2]Ochanomizu University, [3]Shinshu University, [4]Osaka City University

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-15 Room:301B Time:May 26 18:00-18:15

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

Tomoko Asami[1*], Naoto Ishikawa[1], Kanako Ishikawa[2]

[1]Graduate School of Human and Environment, [2]Lake Biwa Environmental Research Institu

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.

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-16 Room:301B Time:May 26 18:15-18:30

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

Akira Hayashida[1*], Tomohiro Yamamoto[1], Masahiko Yasuda[1]

[1]Doshisha University

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

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P01 Room:Convention Hall Time:May 26 10:30-13:00

Seasonal changes of magnetic minerals and their grain sizes in the Hiroshima Bay sediments

Noriko Kawamura[1*], Naoto Ishikawa[2]

[1]Japan Coast Guard Academy, [2]Kyoto University

Frequent outbreaks of red tide have been reported since 1970 in the Hiroshima bay, and the red tide is caused by a bloom of dinoflagellates. Iron is an essential element for dinoflagellates, and is supplied as bivalent or trivalent ions and iron compounds from lands to sea. For damage predictions of red tide, it is important to research the distribution of iron in the bay. The acidification of seawater during summer has been also observed in the Hiroshima Bay. Increase of CO_2 concentration and decrease of dissolved oxygen (DO) content in seawater cause an anoxic condition in the bay. It is known that iron oxides are dissolved and sulfides are formed in an anoxic condition. For clarifying variations of the distribution and mode of iron in sediments and bottom water in the Hiroshima Bay, we investigated kinds of iron compounds in the sediments and the amount of dissolved iron in the bottom and interstitial waters. Sediment cores of 5cm in depth were taken at several sites in the Hiroshima Bay by using a multiple corer from June to August in 2010. Data of oceanographic observations at these sites showed that during the sampling period the temperature of the bottom water increased, whereas DO and pH values decreased. The sediment samples were composed of sandy silt with clay at shallower sites and clayey silt at deeper sites. We measured dissolved iron concentration in interstitial and bottom waters filtered above 0.45 um grains, and performed magnetic hysteresis measurements and high temperature magnetometry on the sediment samples. The presence of magnetite (Fe_3O_4) and hematite (Fe_2O_3) were recognized in all analyzed samples, whereas greigite (Fe_3S_4) appeared at the deeper sites with an anoxic condition in the bottom water. At the deeper sites, the magnetic grain size increased from June to August, while iron concentration increased in the interstitial and bottom waters. It is suggested that magnetite and hematite were dissolved and greigite was formed, associated with the proceeding of the anoxic condition in the bottom water, and that the grain-size of magnetic minerals and the iron concentration of the interstitial and bottom waters also changed. Irons moves between sediments and seawater in the brief period, which may occur sensitively in the bottom of the Hiroshima Bay.

Keywords: marine sediments, iron, magnetic properties

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P02 Room:Convention Hall Time:May 26 10:30-13:00

Paleomagnetic and rock magnetic records of 90-150ka obtained from sediment core BIW08-B in Lake Biwa.

Yusuke Ogura[1*], Naoto Ishikawa[1], Akira Hayashida[2], Keiji Takemura[3]

[1]Grad. HES, Kyoto Univ., [2]Dept. Environ. Sys. Sci., Doshisha Univ, [3]Beppu Geo. Res. Lab., Kyoto Univ.

We obtained a series of core sample (BIW08-B) from central part of Lake Biwa (water depth 53 m) in 2008, intending to reveal detailed records of paleoenvironmental and paleomagnetic variations.

Among core samples of BIW08-B of 100 m long in total, we conducted paleomagnetic and rock magnetic analysis of an interval from 25.48 m to 45.10 m. This interval corresponds to a time period from 90 ka to 150 ka, which is expected to include the Blake excursion (Smith and Foster,1969; etc). It is also suggested that this interval holds environmental record of rapid warming which is represented by variations of oxygen isotope ratio (e.g., Imbrie et al.,1984).

Low and high temperature magnetic measurement show the existence of the maghemitized magnetite and the hematite. The experiment of progressive thermal demagnetization (PTHD) of the anhysteretic remanet magnetization (ARM) indicates that the main ferromagnetic mineral is maghemitized magnetite.

Assessment of stability of natural remanent magnetization (NRM) was made with progressive alternating field demagnetization (PAFD) experiments. Inclination values change from about 30 to 60 through the core, and the average inclination was lower than the expected value (54.7) at the drilling position. Deviations of NRM directions occurring in low intensity interval in about 93ka, 104-108ka, and 133ka may correspond to excursion.

The downcore variation in X_{ARM} / X values, except for volcanic ash, was similar to that of the X_{ARM} ones. It was found that the increase (decrease) in the amount of magnetic minerals was accompanied with their grain re?ning (coarsening) in the grain size of magnetic minerals. The characteristic minimum boundaries were observed at 101-105 ka, 122-125 ka and 132-136 ka. These periods are corresponding to warm and humid interval.

Keywords: Environmental magnetism, paleomagnetism, lake sediment

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P03 Room:Convention Hall Time:May 26 10:30-13:00

Magnetic behaviors of sediments including maghemitized magnetite in thermal demagnetizations of artificial remanences

Naoto Ishikawa[1*], Akira Hayashida[2], Yoshihiko Tanigawa[1], Keiji Takemura[3]

[1]Grad. EHS, Kyoto Univ., [2]Dept. Environ. Sys. Sci., Doshisha Univ., [3]Beppu. Geo. Res. Lab., Kyoto Univ.

Low-temperature oxidized magnetite (maghemitized magnetite: Magh-Mt) has been recognized as a common magnetic mineral in sediments and soils. It is important to identify the presence of Magh-Mt and to clarify its magnetic property for environmental-magnetic and paleomagnetic investigations on sediments and soils. We present results of thermal experiments performed on Magh-Mt bearing sediments, especially progressive thermal demagnetization (PTHD) experiments of artificial remanences. Analyzed samples were taken from a sediment core (BIW07-5) obtained by piston coring in Lake Biwa, central Japan. The core consisted of homogeneous lacustrine clay with 6 tephra layers. Freeze-dried clay samples were used for thermomagnetic experiments.

Low-temperature magnetometric results showed the presence of Magh-Mt in the clay samples. Warning curves from 5 to 300K of isothermal remanence (IRM) imparted at 5K in 1T after zero-field cooling showed a large decrease of IRM between 5 and 40K and suppressed Verway transition of magnetite between 90 and 120K. As S-ratios (maximum field of 2.5T and back filed of 0.3T) of the samples were higher than 0.965, Magh-Mt was regarded as a principal magnetic mineral.

PTHD experiments of artificial remanences in air and Ar were carried out for clarifying magnetic mineralogy. Samples were packed in small quartz cups. IRM was imparted along the cup axis in a DC field of 1.9T, and then anhysteretic remanence (ARM) was imparted perpendicular to the axis by a peak alternating-field of 100mT and a DC field of 0.1mT. PTHD up to 680 or 700^{o}C were performed using a noninductively wound electric furnace in a six-layer mu-metal magnetic shield; the internal stray field was less than 5 nT. The initial magnetic susceptibility (Xo) was measured using a KLY-3S susceptibility meter at each demagnetization step.

During the PTHD in air, decay curves of ARM and IRM components showed inflections at about 280 and 360^{o}C, respectively. The ARM components were unblocked at 620^{o}C. The IRM components were unblocked at 680^{o}C after small or no decrease at 620^{o}C. Xo decreased gradually up to 680-700^{o}C. During the PTHD in Ar, the ARM components increased at 280^{o}C, accompanied with increase of Xo, and were unblocked at 560^{o}C. The IRM components decreased at 560^{o}C and were unblocked at 640-680^{o}C. Xo increased from 280 to 680-700^{o}C. The ARM component is carried initially by Magh-Mt, and carriers of the IRM component are likely carried by Magh-Mt with higher coercivity and primary hematite. It is suggested that the conversion of Magh-Mt occur from 280^{o}C and that magnetite converted during heating in Ar may acquire remanence newly or inherit remanence from parent Magh-Mt.

Additionally, PTHD experiments above 500^{o}C in Ar were performed after demagnetizations in air at lower temperatures (200, 300, 400 and 480^{o}C). Decay curves of ARM and IRM components above 500^{o}C from samples demagnetized at 200^{o}C in air were quite similar to the curves during the PTHD in Ar at all steps, indicating the complete conversion of Magh-Mt to magnetite. Samples demagnetized at 300-480^{o}C in air provided the presence of remanence unblocked between 540 and 620^{o}C during the PTHD in Ar. The amount of the unblocked remanence increased with increasing the demagnetization temperature in air. It is implied that a converted product from Magh-Mt during heating in air is stable for heating and carries the remanence unblocked up to 620^{o}C.

A PTHD experiment of artificial remanences is a simple and useful method for identifying magnetic minerals. However, in the case of Magh-Mt bearing samples, it is inferred that decay curves of artificial remanences do not represent initial magnetic mineralogy because a converted product carries remanence during heating.

Keywords: maghemite, rock magnetism, magnetite

SEM036-P04 Room:Convention Hall Time:May 26 10:30-13:00

Magnetic properties of tephra in Lake Biwa sediments

Yurie Yamamoto[1*], Keiji Takemura[1], Masayuki Torii[2]

[1]Kyoto University, [2]Okayama University of Science

We conducted a series of magnetic and chemical analysis of 27 tephra to examine methodology for identification and to understand the relation between volcanism and magnetic properties. We examined volcanic ashes in a drilling core from Lake Biwa sediments: K-Ah, U-Oki, Sakate. DHg, DSs, AT, SI, DNP, DAP2, Aso-4, K-Tz, Aso-ABCD, Ata, BT29, BT34, BT37, Aso-3B, Aso-2, BT44, BT45, BT48, Ata-Th, BT59, Aso-1, Tky-Ng1, BT67, and Ss-Pk. The followings are results from magnetic measurements of bulk samples and analysis of magnetic minerals using EDS (Electron Dispersive System) electron microprobe.

(1) Titanomagnetite (x=0.1-0.6) exists in all samples and titanohematite (y=0.5-0.9) exsits in some samples. There are also hematite and maghemitized magnetite in some samples. These are not materials of tephra origin but represent contaminants from clay beds of Lake Biwa sediments.
(2) We found contrasting magnetic grain-size distribution between the tephra from Kyushu and San-in region based on King plot and Day plot. Moreover, we noted that data from Kyushu region are plotted on PSD (pseudo-single domain) field and data from San-in region are on MD (multi domain) field. Magnetic grains can reflect the distance from source to the place of deposition.
(3) We classified the tephra based on magnetic minerals species utilizing the behavior of Js-T curves (high-temperature), ZFC and FC curves (low-temperature). We finally divided the tephra into six groups: KA & AT (Kikai caldera and Aira caldera), ATA (Ata caldera), ASO (Aso caldera), DAISEN-A (Daisen volcano), DAISEN-B (Daisen volcano), and SAMBE (Sambe volcano). Thus magnetic mineralogy is useful in identifying source volcano of each tephra. We also applied this classification to so far unclassified BT samples and concluded that BT34 and BT59 were from Aso caldera and BT37, BT44, BT45, BT48, and BT67 were from Daisen volcano. Magmatic temperatures at the time of eruptions were estimated with geothermometer based on coexistence of two Fe-Ti oxide series (Ghiorso and Sack, 1991). Approximate magmatic temperatures are estimated to be 750-850 ^oC (Kikai caldera and Aira caldera), 800-950 ^oC (Ata caldera), 850-1000 ^oC (Shishimuta caldera), 700-950 ^oC (Daisen volcano), and 800 ^oC (Sambe volcano), respectively.

We suggest that precise tephra identification can be possible if we measure magnetic properties such as Js-T curve, ZFC and FC curve, and Curie temperature. Curie temperature higher than 580 ^oC can not be used for identification, because of the following two reasons: high Curie temperature can be a result from hematite and maghematized magnetite contaminated from clay beds of Lake Biwa sediments and hematite can be also formed through high-temperature oxidation during experiments.

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P05 Room:Convention Hall Time:May 26 10:30-13:00

Onboard paleomagnetic results of pelagic sediment cores from the South Pacific Ocean, IODP Expedition 329.

Takaya Shimono[1*], Helen Evans[2], Steven D'Hondt[3], Expedition 329 Shipboard Science Party[4]

[1]University of Tsukuba, Graduate School o, [2]LDEO, Columbia University, [3]University of Rhode Island, [4]Expedition 329 Shipboard Science Party

IODP Expedition 329 surveyed and cored the sediment at 6 sites throughout South Pacific Gyre (SPG) and at 1 site its southern margin. The central SPG has been describes as Earth's largest oceanic desert (Claustre and Maritorena, 2003). The dominant lithology of this expedition is zeolitic metalliferous clay at the deeper water sites on older basement (58 to 120 <= Ma) within the gyre (Sites U1365, U1366, U1369 and U1370). Manganese nodules occur at the seafloor and intermittently within the upper sediment column at these sites. The cored sediment at the shallowest site (U1368) is calcareous nanno fossil-bearing clay. The sediment at Site U1367 is transitional between these 2 lithologies. Site U1371 lies out side the low-chlorophyll region, and its cored sediment is dominantly siliceous ooze with abundant diatom debris.

Paleomagnetists of Expedition 329 measured natural remanent magnetization (NRM) of all archive-half sections from Sites U1365 to U1371 using the three-axis cryogenic magnetometer at 2.5-cm intervals before demagnetization. The archive-half sections were demagnetized by alternating fields (AF) of 10 mT and 20 mT. The primary magnetization of pelagic clay generally degrades at a few meters depth below the sediment water interface. The boundary between the primary and stable magnetic records often occurs in the later part of Gauss chron and coincides closely with the late Pliocene onset of northern hemisphere glaciation (Opdyke and Foster, 1970; Kent and Lowrie, 1970; Prince et al., 1980). Magnetic directions of this expedition are not interpretable throughout most of the pelagic clay (Sites U1365, U1366, U1367, U1368, and, U1370) possibly due to magnetic overprint during coring (high positive inclination), viscous remanent magnetization (VRM), or diagenetic changes in the sediment. In addition, appearance of manganese nodules often hampers indigenous magnetic direction in shallow sediment sections. However, fortunately the pelagic clay sediments of Sites U1369 and the top of U1365 (0-6 m) were less these influences.

The lithology at U1367 changed from metalliferous clay (Unit I) at the top to nannofossil ooze (Unit II) at the bottom. The metalliferous clay unit extends from 0-5.5 mbsf in U1367. Consistently, NRM intensities and magnetic susceptibility in Unit I were in the order of 10?-1 to 10?-2 A/m (more than 100?10?-5 vol. SI) and decreased to about 10?-3 to 10?-2 A/m (10 to 50?10?-5 vol. SI) in Unit II (nannofossil ooze).

Keywords: Integrated Ocean Drilling Program, South Pacific Gyre, magnetic stratigraphy, pelagic clay, rock magnetism, viscous remanent magnetization

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P06 Room:Convention Hall Time:May 26 10:30-13:00

Rock-magnetic study on serpentinite from Tokunoshima Island, southern Kyushu, Japan

Rie Morijiri[1*], Mitsuru NAKAGAWA[1], Makoto Saito[1], Mutsumi Nakai[2]

[1]Geological Survey of Japan, AIST, [2]Daito-Bunka Univ.

Serpentinite occur in Cretaceous Accretionary complex on the Tokunoshima Island. They are intruded by Paleogene granitic rocks, and are covered by Quaternary calcareous sediments. Because of the narrow distribution of the serpentinite, their petrologic and rock magnetic study had been insufficient. Then, we report 1. Original rock of serpentinite in Shimanto Terrane, and 2. Magnetic characterization of contact metamorphosed serpentinite.

The serpentinite distribute along 3 NNE-SSW faults in central to southern part of the Island. The serpentinite shows a hardly sheared, dark green with glossy occurrence or alteration together with pale green layers has become the talc due to thermal effect of contact metamorphism. Based on the relict minerals, dunite and clinopyroxenite are suggested in the original rock. Olivine is finely crashed, and is part of what is altered to the serpentine showing mesh-structure. Fine-beads magnetite is remarkably observed in the former, the latter less extreme.

The serpentinization process is that olivines react with water and produce serpentines and magnetites. The volume of reacting water affects volume of magnetite produced by serpentinization when these rock bodies come from the same peridotite series. We collected samples from three sites in Tokunoshima Island. Main magnetic carrier of these rocks is presumed to be magnetite. Curie temperature of these samples indicates about 560 degrees.

The serpentinite of Tokunoshima Island originated from the dunite and clinopyroxenite, suffering moderate serpentinization and contact metamorphism. Rock-magnetic study revealed that stable magnetization. It may get TRM after contact metamorphism.

Keywords: serpentinite, Tokunoshima Island, rockmagnetism

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P07 Room:Convention Hall Time:May 26 10:30-13:00

Paleointensity study of the 570Ma Grenville dike, Canada: a preliminary result

Yuki Nakayama[1], Norihiro Nakamura[1*], Hironobu Hyodo[2]

[1]Earth Science Dep. Tohoku Univ., [2]Res. Inst. Nat. Sci., Okayama Univ. Sci.

Recent numerical simulation for the long-term evolution of the geodynamo revealed that high heat flux at the core-mantle boundary (CMB) generates a continuous high virtual dipole moment of $6*10^{22}Am^2$ throughout an Earth's history (nearly 3.8Ga~present) and that low heat flux at CMB shows secular weakening of the moment to less than $2*10^{22}Am^2$. The Pre-Cambrian paleointensity study can solve this enigmatic result but is still luck of reliable data due to heavy alteration and metamorphism. Although a single silicate grain paleointensity method is a best way for the study, more primitive but basic test to reveal a reliable primary thermal remanent magnetization is a full paleomagnetic field test such as full baked contact test with hybrid zones. The Grenville dike is of the Ediacaran Grenville dike swarm intruding tonalitic gneiss (1Ga) of the Grenville Structural Province (Ontario, Canada). Hyodo and Dunlop (1993) reported a successful result of full baked contact test with hybrid zone. Here we report a preliminary result of Thellier-Thellier type paleointensity measurement for the chilled margin samples of the 570Ma ($^{40}Ar/^{39}Ar$ age) Grenville dike. The characteristic component of the Grenville dike yields a virtual geomagnetic pole position at 51N and 145W, being different from the compiled VGP positions of the other Grenville dike (Murthy 1971). We obtained paleointensity results of nearly $0.5*10^{22}Am^2$ from three samples of chilled margin (quality factor of 17.00~74.67), being much lower than low heat flux model at CMB. Although the number of our successful samples is limited, it seems that the Grenville dike samples possess a potential to reveal reliable ancient paleointensity data.

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P08 Room:Convention Hall Time:May 26 10:30-13:00

Frequency spectrum of AC magnetic susceptibility: A new rock magnetic method to estimate grain size distribution

Kazuto Kodama[1*]

[1]Center for Advanced Marine Core Research

A new measurement system has been developed for detecting frequency spectrum of low-field alternating current (AC) magnetic susceptibility for rock and mineral magnetic studies. The measurement method is principally the same as that of the previous system developed for obtaining frequency dependence of natural samples (Kodama, G-cubed, 11, 2010, Q11002), but the new system has been improved so as to measure AC susceptibility at frequencies in the range of 10 kHz to 100 kHz. The wide range of operating frequency, along with the capability of measuring both in-phase and out-of-phase components of AC susceptibility, permits to estimate the grain size distribution of superparamagnetic particles. Preliminary measurements were made on natural materials, including volcanic rocks containing SD/MD particles, Chinese loess/paleosol samples, as well as several synthetic materials. The result from the Chinese loess/paleosols, for example, shows a stronger frequency dependence for the paleosol than for the loess, over the frequency range considerably broader than ever reported. This result suggests that the measurement of wide band frequency spectrum of AC susceptibility can be useful, especially in environmental magnetism, as a new rock magnetic experimental method to help quantify the distribution of superparamagnetic nano-particles in a variety of soils and sediments.

Keywords: AC magnetic susceptibility, frequency spectrum, grain size distribution, superparamagnetism

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P09 Room:Convention Hall Time:May 26 10:30-13:00

Paleomagnetic thermal history of faulting: constraints from the Taiwan Chelungpu-fault Drilling Project

Shoko Tachibana[1*], Norihiro Nakamura[1], TCDP hole-B Research Group[2]

[1]Earth Sci., Thoku Univ., [2]TCDP hole-B Research Group

The September 21, 1999, the Chi-Chi earthquake (Mw = 7.6) attacked Taiwan. The Chelungpu fault caused this earthquake, and fault type is a thrust fault with left-lateral component. In the southern part of the fault, ground accelerations were higher, even though the ground velocities and displacements were less than the north at Chi-Chi earthquake (Chung and Shin, 1999). To understand faulting mechanism of the Chi-Chi earthquake, the Taiwan Chelungpu-fault Drilling Project (TCDP) was conducted to obtain shear zone samples at depth. Two cores called as hole A and hole B were drilled and three different shear zones were found in these boreholes.

Many studies to investigate the faulting history of the active Chelungpu fault have been reported, e.g., in-situ temperature measurements by using borehole (Kano et al, 2006); measurements of compositions of elements and isotope ratios (Ishikawa et al., 2008); thermomagnetic analyses (Mishima et al., 2006). These studies imply that these signatures are attributed to the latest event of faulting (i.e. Chi-Chi earthquake), on the other hand this active fault has been activated many times since 0.7 Ma (Chen et al., 2000). Therefore there is a contradiction for the timing of the earthquake occurrence. Electron spin resonance (ESR) signals are also in turn used to reconstruct the temperature rise of frictional heat (Fukuchi, 2003). Although their methods could apply to the estimation of a single event of temperature rise, they give little information for thermal history and its timing on repetitive frictional heating of the active fault. Additionally, ESR is generally accepted as effective dating method, and has been used for fault gouge dating (Fukuchi, 2001; Murakami et al., 2002). However, ESR dating age does not always mean the age of the latest fault movement, because frictional heating not always reach high-temperature to reset ESR. Here, I conducted systematic paleomagnetic analysis of fault zone rocks of TCDP hole B to trace faulting history of the Chelungpu fault. Remanences are very sensitive to feeble thermal changes, therefore it could be useful to trace the thermal history of repeated faulting by thermal demagnetizations.

In my previous work, anomalous high remanent magnetizations had been found from fault rock samples around core surface. I reargued these anomalous remanences by comparison between surface and interior of core, and found they are almost of origin from drilling-induced remanent magnetization (DIRM) except for some gouge in the 1136-m fault zone and BM disk samples. The fault gouge should be exposed frictional heating, so that samples without DIRM carry original faulting-induced remanences. To investigate their thermal history, thermal demagnetizations for these samples were conducted and exhibited mostly three remanent components unblocked 580 ?C, 300 ?C and 250 ?C. Thermomagnetic analyses for these samples yielded that they comprise magnetite and pyrrhotite as remanence carrier. Primary component unblocked at 580 ?C and secondary components unblocked at 300 ?C should be carried by magnetite and pyrrhotite respectively, and acquired during each mineral was produced. From time-temperature relation in remanence, tertiary components unblocked at 250 ?C should be acquired flash reheating about 260 ?C or 300 ?C in the case of pyrrhotite or magnetite being magnetic carrier respectively. Since the initiation age of the Chelungpu fault activity is 0.7 Ma within Brunhes normal chron (Chen et al., 2000), faulting-induced TRM acquired in earth field should indicate normal polarity. However remanent components of some gouge and BM disk samples indicate reverse polarity, accordingly, these reverse components might be acquired in excursion events. The youngest excursion with high reliability is at 0.3 Ma, therefore the formation events to yield major fault gouge zones should have dated back to Mono Lake excursion at least 0.3 Ma.

Keywords: Paleomagnetism, Taiwan Chelungpu-fault Drilling Project (TCDP)

SEM036-P10 Room:Convention Hall Time:May 26 10:30-13:00

Multicomponent natural remanet magnetization from red chert in the Tsukumi area, eastern Kyushu

Kazumasa Hamada[1*], Koji Uno[1], Tetsuji Onoue[2]

[1]Okayama Univ., [2]Kagoshima Univ.

Middle Triassic (Anisian) red cherts in the Chichibu Terrane were collected at 27 beds for paleomagnetic study. Progressive thermal demagnetization treatment revealed five distinct remanent magnetization components from the cherts. The first remanent magnetization component is demagnetized at around 200degrees. The component is similar to that of the present Earth's geomagnetic field. The second component appears at around 250degrees and is demagnetized at around 420degrees. The directions of the component, before tilt correction, cluster well and have negative steep inclinations and southwesterly declinations. The third and fourth component is revealed between about 480 and 630degrees. The directions of these components, before tilt correction, cluster well and have positive intermediate inclinations and northwesterly declinations. The fifth component is retrieved at the latest stages of the demagnetization from 650 to 690degrees. The majority of the directions of this component show steep inclinations before tilt correction and show northerly shallow directions after tilt correction. A few of the directions, after tilt correction, have southerly shallow directions. This component is considered to be of primary because both polarities are present and the antipodality between the two polarities is observed.

The observed directions are compared with previously reported red chert directions from the Mino-Tamba Terrane (Inuyama area) that yielded four distinct remanent magnetization components. The directions of the first to fourth component in this study (referred to as components A to D), before tilt correction, are well correlated with the in-situ directions of the first to third components from cherts in the Mino-Tamba Terrane (Shibuya and Sasajima, 1986; Oda and Suzuki, 2000; Ando et al., 2001), although the two regions are 500 km apart from each other.

The fifth component, with low inclination values after tilt correction, is well correlated with the tilt-corrected inclinations of the D component observed in the previous study. The cherts in the present study have formed at around the equator during Middle Triassic times.

Keywords: paleomagnetism, red chert, Triassic

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P11 Room:Convention Hall Time:May 26 10:30-13:00

Multi-component magnetization of the Hosokawa-dani rhyolite around the Gauss-Matuyama chronozone boundary

Takeyuki Ueki[1*]

[1]Geological Survey of Japan, AIST

The garnet-bearing dykes of Hosokawa-dani rhyolite with 2.3 -2.5 Ma K-Ar ages intrudes a green schist of the Tanzawa Group, west Tanzawa Mountains, central Japan. The Hosokawa-dani rhyolite was correlated to garnet-bearing pumiceous tephra beds in lowest Pleistocene around south Kanto Plain. Paleomagnetic and rock magnetic measurements revealed that the Hosokawa-dani rhyolite shows primary normal and secondary reversed magnetization components carried by magnetite in Gauss Chron and maghemite in Matuyama Chron, respectively. Primary reversed magnetization component was found from a silt layer immediately beneath the Mk19 tephra bed in the Nakatsu Group. Such paleomagnetic polarity indicates no correlation between the Hosokawa-dani rhyolite and Mk19 tephra bed. Proximal area of the earliest Pleistocene garnet-bearing pumiceous tephra beds is unknown .

Keywords: Gauss-Matuyama chronozone boundary, secondary magnetization, maghemite, Hosokawadani rhyolite, correlation of dyke and distal tephra, Tanzawa Mountains

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P12 Room:Convention Hall Time:May 26 10:30-13:00

A paleomagnetic study for cores from basement rocks of the Bowers Ridge, in Bering Sea

Tomohiro Gokan[1], Makoto Okada[1*]

[1]Ibaraki University

The IODP Expedition 323 was done between July 5th - September 4th of 2009. Samples used in this study were collected from Core 8X - 19X of Hole U1342D. The Hole U1342D was drilled 127.7 meters below sea floor at 54.5 degree N in latitude, 176.6 degree E in longitude and 818.2 meters in water depth. This site is located on the crest of western part of the Bowers ridge, that has not been revealed its formation processes including age and location. The purpose of this study is to know the paleolatitude where the Bowers ridge formed with paleomagnetic analyses on collected samples.

Lithology of the cores mainly consists of volcano-clastics including volcanic sands and breccias, and lava fragments. Since there is no thick lava flow, which has not rolled after it settled, has been seen on the cores, we conducted the conglomerate and thermal contacted tests for the specimens to assess the quality of thermal remanences to reconstruct paleolatitude. One-inch diameter mini-cores collected at 26 positions and half-inch diameter micro-cores collected at 101 positions from the Hole U1342D cores. Proogressive alternating field demagnetization from 5m T to 60 mT with 5 mT steps, and/or progressive thermal demagnetization from 100 to 600 degree C with 25 to 50 degree C steps were done for specimens from the all positions. Magnetic susceptibility at each step of progressive thermal demagnetization, and anisotropy of magnetic susceptibility were also measured.

As the results, characteristic remanent magnetizations (ChRMs) were extracted from 50 one-inch specimens and 72 half-inch specimens. Among those ChRMs, only 5 specimens from one piece of core show that the ChRMs settle in similar direction of which the average inclination becomes -63.8 degree with 19.7 degree in 95% confidence limit. This value indicates 45.5 degree in average with ranging from 27.3 to 73.9 degrees in paleolatitude. However, a paleolatitude assessment requires time averaged paleomagnetic directions at which the time should be much longer than the period of geomagnetic secular variation (c.a. several thousand of years), suggesting that we can not argue paleolatitude using our results.

Keywords: Paleomagnetism, IODP EXP323, Bering Sea, Bowers Ridge

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P13 Room:Convention Hall Time:May 26 10:30-13:00

Analyzing the early 19th century's geomagnetic declination in Japan from Tadataka Inoh's Santou-Houi-Ki The 5th report

Motohiro Tsujimoto[1*], Akitoshi Omotani[2], Takaaki Inui[3]

[1]Japan cartographer's Association, [2]San-in System Consultant, [3]Matsue municipal Comitee of culture prop

Santou-Houi-Ki,a national treasure of Japan recorded by Tadataka Inoh is 67 volumes data book consisting of approximately 200,000 magnetic compass azimuth data in 1800 to 1816. The recorded points cover almost of mainland Japan. In 1918 the declination of only one point at Inoh's retirement home Fukagawa in Edo(Tokyo)was analyzed,but nobody analyzed the other data.

We've started the analysis of them.

(1)The analysis of the data in Santou-Houi-Ki supplies new data to the northeast Asia and mainland Japan in early 19th century in particular. It makes mainland Japan as one of the area having a lot of accurate data of geomagnetic declination in the World. Currently the number of analyzed points is more than 100,and the outlinne of the distribution of declination in mainland Japan in early 19th century became clear gradually.

(2)The comparison of Santou-Houi-Ki with Gauss and Weber's isogonic Atlas published in 1840,consisted of the observational data in 1830(1828-1832 exactly),it's foundational structure of Gaudd's isogonic lines in Japan is almost similar to the result of analysis from Santou-Houi-Ki. But we can see the contradiction to reverse with secular variation in northern Kyuushuu area and Tsushima Island or the local differences in eastern Hokkaido in Gauss's Isogonic Atlas. The observational data in Japan archipelago did not described in the table of the observational data in the supplement of Gauss's isogonic Atlas. Therefore the supplementation by the result of analysis from Santou-Houi-Ki became very important.To grasp the variation of geomagnetic declination, we concentrated on analysis in western Japan, where easy to grasp the variation of declination because the geographical feature is long from east to west.

(3)Advantages to use the data described in Santou-Houi-Ki. 1.Huge number of survey data. 2.Minute standard of analysis. 3.Data are concentrated in 1800 to 1816. 4.Data cover almost mainland of Japan.

(4)The development and improvwment in analysis method. 1.Calculate the average of remainder as the declination,to deduct the magnetic azimuth recoded in Santou-Houi-Ki from the true azimuth. 2.The important point in deciding the precise position of the reference point should be adjusted so that all of the declination values calculated from azimth to different target at the reference point are approximaely equal to each other. 3.Use GPS transmitter at the reference point for investigation of longitude and latitude. 4.By the request from Motohiro Tsujimoto to make a consecutive formula by use Excel for speed up his process in the above, Akitoshi Omotani realize this important improvement.

(5)Trial to popularize the knowledge of restoring the local geomagnetic declination and the precise position of reference point from Santou-Houi-Ki was started. In Shimane and Totori prefecture,it's inserted in the newspaper San-In Chuou Shinpou's column and the bibliography of local history edited by Takaaki Inui obtain good responce. Their lecture held by Takaaki Inui and Akitoshi Omotani at local lecture class giving very strong impression to the audience.

Keywords: geomagnetic declination, Tadataka Inoh, Santou-Houi-Ki, Isogonic Atlas by Gauss and Weber, secular variation of geomagnetic declination, restoring the precise position of survey's reference point

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM036-P14 Room:Convention Hall Time:May 26 10:30-13:00

Magnetic Charts for the Epoch 2010.0

Satoshi Abe[1*], Isao Ueda[1], Toshio Kawahara[1], Nobuo Takahashi[1], Setsuo Tanoue[1], Nobuhiro Ishikura[1]

[1]GSI of Japan

The GeoSpatial Information Authority of Japan (GSI) has been conducting geomagnetic surveys in Japan since 1948. As a results of surveys, magnetic charts published every 10 years, and the latest charts are 2000.0. We have a plan to provide the new charts (epoch 2010.0) in this year. The most characteristic point is adopting the new spatial-temporal model created until 2010. By the use of the new model, we can get the magnetic charts for arbitrary epoch. Then, we can realize yearly variation of magnetic components in visible.

The magnetic charts provide accurate geomagnetic field values for Japan and are widely used as a reference for the study of local geomagnetic anomalies, for example, we get magnetic anomaly of Japan by subtract IGRF from spatial-temporal model.

This is the last time to provide printed magnetic charts. Next time, we will provide charts on the GSI web site.

Keywords: Magnetic charts, declination, total force, magnetic anomaly