Paleoenvironmental control on the magnetic mineral assemblage in the Izu rear arc over the last 1 Ma

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During April and May 2014, IODP Expedition 350 drilled a 1806.5 m deep hole at Site U4137 in the Izu-Bonin rear arc, in order to understand, among other objectives, the compositional evolution of the arc since the Miocene and track the missing half of the subduction factory. Mostly fine grained sediments were recovered and variations in magnetic properties and mineralogy are well documented. Routine rock magnetic measurements performed on about 360 samples in the first 120 meters of Hole U1437B showed that pseudo single domain to multidomain (titano-) magnetite is the main carrier of the remanence. The studied interval covers the last 1 Ma, i.e. marine oxygen isotope stages (MIS) 1 to 25. Rock magnetic properties and composition, concentration and grain size variations of the magnetic minerals are compared with the isotopic record in order to investigate the rock magnetic signature of climate changes in the Izu rear arc in the Late Pleistocene. The proxies for magnetic concentration (e.g. magnetic susceptibility, saturation isothermal remanent magnetization) show generally higher values during the interglacials; and lower values during the glacials. This might be partly explained by increasing volcanic activity at the glacial/interglacial transitions as is shown by an increase in the frequency of tephra layers near the time of the transitions. In addition, the composition of the magnetic assemblage also varies with the oxygen isotope record. After the mid Pleistocene transition (1250-700 ka), higher coercivity minerals (such as hematite) dominate the magnetic assemblage in the glacial stages, whereas lower coercivity minerals dominate the interglacial stages. The magnetic assemblage of the Izu rear arc sediments is thus complex with various origins. Ti-magnetite, of detrital and volcanic origins, dominates the interglacials whereas higher coercivity minerals dominate the glacials confirming an increasing supply of Asian dust in the sediments in glacial times. XRF measurements support our observations.

Keywords: Izu rear arc, IODP Exp 350

Microscopic observations of pedogenic nanoparticles causing magnetic enhancement in Chinese loess deposits

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Paleoclimatic signals have been recorded in various ways in Chinese loess-paleosol sequences. Magnetic susceptibility has been used as a reliable proxy for reconstructing Asian summer monsoon intensity because its enhancement is exactly related to paleorainfall through neoformation of magnetic nanoparticles during pedogenesis. However there are no observations which can interpret either formation process or form of such pedogenic nanoparticles exactly.
To investigare this problem, scanning electron microscope (SEM) observations were conducted after some rock magnetic experiments including magnetic susceptibility measurements, IRM composition analysis and thermomagnetic measurements, and we divided bulk samples into three subsamples with different grain size bands (D1: >10 μm, D2: 10~1 μm, D3: <1 μm) in advance so that we can obtain significant informations on grain sizes of pedogenic nanoparticles which may help the microscopic observations. Bulk samples used in this study include less-altered loess and mature paleosol showing extremely low (29 $\times 10^{-8} m^3 kg^{-1}$) and high (116 $\times 10^{-8} m^3 kg^{-1}$) magnetic susceptibility respectively and were selected as specimens from a sequence of loess L8 to paleosol S8 from Lingtai on central part of the Chinese Loess Plateau.
From results of IRM composition analysis and thermomagnetic measurements, pedogenic nanoparticles turned out to be magnetite or maghemite. Besides, results of magnetic susceptibility and its frequency dependence (FD) showed that D2 has the dominant contributions amounting to over 60 % to enhanced magnetic signals in paleosol. Considering FD indicates the total amount of super-paramagnetic (SP) particles whose grain sizes are tens of nm, we can suggest that the detritus grain size band in which pedogenic nanoparticles including some SP particles are concentrated is D2 and such ultra-fine particles exist in detrital particles in the form of inclusions. Based on these results and hypothesis, magnetic extractions were conducted on D2 of both loess and paleosol. A certain amount of particles was obtained from paleosol while particles were hardly obtained from loess, and these magnetically extracted particles from paleosol D2 were subjected to SEM observations. Energy dispersive X-ray spectroscopy (EDS) showed that such magnetically extracted particles include a lot of detritus silicates like chlorite, muscovite and quartz even they are non-magnetic minerals. Watching surface of these silicates with SEM carefully, nanoinclusions of iron oxide were observed. Further results including X-ray diffraction analysis and TEM observation will be shown on the poster.

Keywords: Chinese loess, pedogenesis, magnetic enhancement, SEM observation

Magnetic mineral distributions in surface sediments taken from the northeastern Japan Sea

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In order to understand how magnetic minerals assemblages are affected by the redox state of overlying bottom waters in the northeastern Japan Sea, rock magnetic and chemical analyses were conducted. Undisturbed surface sediments were taken at six sites with a multiple corer during the R/V Shinsei-maru KS-14-13 cruise in 2014. The sediments consist of silty clay, and water depths of the six sites range between 778 to 2709 m. Dissolved oxygen (DO) of bottom waters were measured directly with a DO meter on board immediately after recovering of the multiple cores. Water samples were taken from the cores using by a plastic syringe and were passed through a filter (pore diameter of 0.45 μm), and water samples 30 mL were stored in Teflon bottles. The water samples were treated with 1 mL of special grade nitric acid (1 mol/L concentration), and pH was adjusted below 1 at room temperature for dissolved iron (DI) analysis. DI was measured with a flameless graphite furnace atomic adsorption spectrometer. Dried and powdered sediment samples of approximately 20 mg were used for total organic carbon (TOC) and total nitrogen (TN) measurements with a CNHS analyzer. Thermal demagnetization of composite IRMs were conducted for determination of magnetic minerals in the samples. The dried powder samples (ca 50 mg) were packed in a small quartz cup (5 mm in diameter and 10 mm in height). A magnetic field of 2.5 T was applied along the vertical direction of the cup, and then fields of 0.3 T and 0.07 T were applied along the two remaining perpendicular axes using a pulse magnetizer. Results show that higher values of TN and TOC contents are recognized at sites which has lower DO in bottom water. Thermal demagnetization results for composite IRMs for samples from all site samples, soft (<0.07 T), and medium (0.07-0.3 T) components are demagnetized completely at around 580 degree which is the Curie point of magnetite. Slight thermal decay of the hard components (<2.5 T) is observed at 675 degree which is the Curie point of hematite in all samples. An inflection in demagnetization curves at around 320-400 degree is recognized in samples from all sites. Authigenic greigite which is not expected to be defined magnetic mineral to form under an oxic water column. The inflection suggests the presence of (titano)maghemite. The remanent magnetization intensities decrease at around 80-120 degree which is the Neel temperature of goethite at a most oxic site. DI concentration of the site show highest value, thus it suggest that suspended solids of iron hydroxides (<0.45 um in diameter) area bundantly present in the relatively oxic bottom waters, and goethite is stable under such condition. Magneto fossils were confirmed by TEM observations, and were classified three major morphologies which are elongate, tear drop, and equant. Morphology ratios varies by the redox state of overlying bottom waters.

Keywords: Magnetic mineralogy, Redox state of overlying bottom water, Magneto fossils

Magnetic Detection and Ferromagnetic Resonance Characterization of Magnetic Minerals in Fossil Coral Skeletons in Ishigaki Island, Japan

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The remanent magnetization of corals has been one of attractive archives because coral frameworks may provide us high-resolution paleomagnetic records from pre-observatory times, due to their high growth rates. The coral skeletons, mainly composed of aragonite, have following two advandages in the reconstruction of the geomagnetic field: 1) they can be dated by radiocarbon and uranium-thorium dating method, 2) a paleomagnetic standard 1-inch core sample gives an avaraged orientation for two-three years because they grow up at a rapid rate. Especially, the annual banded skeleton of *Porites* might have a great potential as a high-resolution paleomagnetic recorder due to their continuous growths through hundreds of years at a growth rate 11–20 mm-yr. Because of these characteristics, they may be able to record short-term geomagnetic paleosecular variation in a decadal or centennial scale, which are difficult to reconstruct with previus samples (e.g., lava flows, burnt archeological artifacts, lake or marine sediments, and speleothems). Unfortunately, in spite of the enormous possibility for paleomagnetic reconstruction, most coral skeletons have shown an extremely weak magnetization, and their magnetic origin has not been determined. However, a measureable magnetization has been reported in deceased coral tsunami boulders along the shorelines of Ishigaki Island where the coral reefs are grown on bedrock of Ryukyu limestone and Jurassic schist, even using a conventional spinner magnetometer. It is necessary to determine the characterization of magnetic assembladges in this coral skeleton to utilize them as a reliable paleomagnetic recorder, because paleomagnetic records are affected not only by past geomagnetic field variations but also by lithologic factors of samples, such as mineralogy, concentration, and grain size of the magnetic phases. Therefore, by using first-order reversal curve (FORC) measurements, ferromagnetic resonance (FMR) spectroscopy and petrological observations by FE-SEM of acid-treated residuals of our corals, we found that the magnetic mineral assemblage consists of a dominant biogenic-origin single-domain magnetite and a minor detrital component. From AF demagnetization of recently-ceased *Porites* coral skeletons, we also found that the characteristic remanence directions of almost all samples are relatively stable with some fluctuations. However, some samples exhibit obviously different remanence directions from its average, suggesting the rotation by a past tsunami event. Our findings suggest that *Porites* coral framework samples have a potential use as a high-resolution paleomagnetic recorder with careful examination of past rotations.

Keywords: rock magnetism, coral skeletons, ferromagnetic resonance

Analyzing the early 19th century's Geomagnetic declination in Japan from Tadataka Inoh's San-Tou-Houi-Ki,10th report.

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The Santou-Houi-Ki is a national treasure of Japan 67 volumes magnetic survey ledger recorded by cartographer Tadataka Inoh in 1800 to 1816,consist of approximately 200,000 magnetic compass land survey azimuth data accuracy of 0 degree 5 min, from the coast of eastern Hokkaido to Yakushima Island in Western Japan. We restarted the analysis stopped after only one analysis in 1917,which done about the magnetic compass survey azimuth data at known position of the retirement home of Tadataka Inoh at Fukagawa in Edo (Tokyo) in 1802-1803,by interdisciplinary simultaneous analysis across geomagnetism, survey science, historical cartography and local history. We can increase precise evidence to verify the real azimuth, geomagnetic declination and the reference point where magnetic compass survey was executed, or survey target points recorded in the Santou-Houi-Ki,than traditional way of study separated in each field. (1) Procedure of analysis. Use the recreation software of scenery and digital map of GSI Japan Denshi Kokudo to know the latitude and longitude accuracy sec of particular survey target points, and the outline position of survey reference point to grasp the outline of each real azimuth from the survey reference point to survey target points. Geomagnetic declination=Real azimuth-Magnetic compass survey azimuth recorded in the Santou-Houi-Ki. Calculate backward the precise position of the survey reference point should be adjusted to the position in accuracy 0.001sec.in latitude and longitude, where all of geomagnetic declination unit of 0.01sec. Calculate from the magnetic compass survey azimuth to each different targets at the reference point are approximately equal to each other. Calculate the average value of each declination unit of 0.001sec.and express it as the geomagnetic declination unit of 1min.on the day and point Tadataka Inoh's magnetic compass survey was executed. To use the consecutive formula of Excell for speed up and Keep accuracy. If it possible to go to the field of the survey reference point, confirm the real scenery and the longitude and latitude by GPS transmitter and recalculate the value of geomagnetic declination. (2)It is able to change Japan as the concentrated area of data
in early 19th century from insufficient area of data and supply data to north east Asia.
Total number of analyzed points exceeded 197. (3) The outline of isogonic line in Japan archipelago and the distribution of the declination in every 15 min in western Japan coast in those days. begin to appear. Compare the isogonic line of declination in those year's Japanese archipelago by analysis of The Santou-Houi-Ki,with the Historical Magnetic Declination map by NOAA(1800,1805,1810,1815)is the NOAA's pace of variation West is almost 5 years later than the analysis of the Santou-Houi-Ki in western Japan. (4)However, from the analysis of Santou-Houi-Ki, we can recognise the magnetic declination supposed as the local geomagnetic declination anomaly in southern coast of eastern Hokkaido, some part of Noto Peninsula, Mt. Asama in Ise, Nobeoka city in Kyushu Island etc., impossible to drew in Historical Magnetic Declination map by NOAA. (5)It is able to restore the precise position of survey reference points where Tadataka Inoh's magnetic compass survey was executed the accuracy of less than sec in latitude and longitude ,valuable in local history. It is so accurate as impossible to achieve by other way of study. The analysis is developed from the coast area of Japanese archipelago to the inland area of Honshu island.

Keywords: geomagnetic declination , Tadataka Inoh, Santou-Houi-Ki, Survey reference point, Survey target point, interdiscplinary

Mineral inclusions and magnetic properties of single zircon crystals from the Tanzawa tonalitic pluton

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Geomagnetic field paleointensity data provide critical information about the evolution of the core and mantle, and the state of the geomagnetic field are closely related to the condition of surface environment (Tarduno et al. 2014, 2015). Although it is essential to understand the variations in geomagnetic field intensity through the Earth history, data are still scarce to a resolve billion year-scale geomagnetic field variation. This is mainly due to the lack of well-preserved rocks for older eras, which often results in unsuccessful paleointensity experiments. To overcome this problem, recent investigates has focused on paleointensity experiments using single silicate crystals, which often accompany magnetic mineral inclusions, such as plagioclase (Tarduno et al. 2006), quartz phenocryst (Tarduno et al. 2010), pyroxene (Muxworthy and Evans 2012), olivine (Tarduno et al. 2012), and zircon (Tarduno et al., 2015, Sato et al., 2015).
Tarduno et al. (2015) demonstrated that paleointensity data of early Archean to Hedean zircons bearing magnetic inclusions from the Jack Hills conglomerate could be used to reconstruct the early geodynamo, and Sato et al. (2015) reported the rock-magnetic properties of the single zircon crystals sampled from the the Tanzawa tonalite (4-5 Ma). Sato et al. (2015) demonstrated that the various rock-magnetic properties such as natural remanent magnetization (NRM), isothermal remanent magnetization (IRM), hysteresis parameters, and transition temperature could be measured using the standard magnetometers (SQUID magnetometer, MPMS, and AGM). During their rock-magnetic measurements, many of single zircon crystals are below the limits of the sensitivity of the magnetometers employed, but for the 80 in 1037 zircons had values of M NRM $\geq 4 \times 10^{-12}$ Am^2 and M IRM $\geq 4 \times 10^{-12}$ Am^2, containing enough magnetic minerals to be measured in the DC SQUID magnetometer. According to the rock magnetic parameters, the main remanence carriers seem to be nearly pure magnetite and pyrrhotite, while direct identification of mineral inclusions in those zircons are not yet acquired.
In this study, we investigate mineral inclusions in Tanzawa zircons reported in Sato et al. (2015), with an optical microscope, Laser-Raman microspectroscopy and scanning electrom microscope equipped with EDS system. It is confirmed that zircon crystals with strong NRM intensity contain titano-magnetite and pyrrhotite. Significantly, titano-magnetite inclusions display fine exsolution lamellae indicating single- or pseudo-single-domain size. In this presentation, we will discuss the relationship between rock-magnetic properties and magnetic mineral inclusions in the Tanzawa zircons.

Keywords: Rock-magnetism, Zircon, inclusion

Rock-magnetic properties of single zircon crystals sampled from the Yangtze River

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Geomagnetic field paleointensity data provide critical information about the thermal evolution of the Earth, and the state of the geomagnetic field is closely related to the surface environment. While it is pivotal to understand the variations in geomagnetic field intensity throughout the history of the Earth, data are still too scarce to resolve billion-year-scale geomagnetic field variation. This is primary because of the lack of geological samples for older eras, which often result in unsuccessful paleointensity experiments.
We focus on a paleointensity experiment using single zircon crystal. Zircon crystals play an important role in paleomagnetic studies because they have several mineralogical advantages: (1) they commonly occur in crustal rocks, (2) precise age determinations with U-Th-Pb and (U-Th)/He analyses are possible, and (3) they have highly resilient responses to alterations and metamorphism.
Recently Sato et al. (2015) reported the rock-magnetic properties of the single zircon crystals sampled from the Nakagawa River, which crosses the Tanzawa tonalitic pluton in central Japan. They demonstrated that the various rock-magnetic properties such as natural remanent magnetization (NRM), isothermal remanent magnetization (IRM), hysteresis parameters, and transition temperature could be measured using the standard magnetometers (SQUID magnetometer, MPMS, and AGM). Combining these rock-magnetic parameters, they proposed the sample selection criteria for paleointensity experiments using single zircon crystals.
In this study, we conducted rock-magnetic measurements for single zircon crystals sampled from the Yangtze River. NRM intensity (M_{NRM}) was first measured for the 1034 grains of zircon crystals. Then, low-temperature demagnetization (LTD) treatment was further conducted for 85 grains with M_{NRM} values larger than 5 x10^{-12} Am^2, and the memory (NRM intensity after LTD treatment; $M_{NRM-LTD}$) was measured. For the 85 samples, we also carried out alternating field demagnetization (AFD) treatment at 10 mT, and the memory (NRM intensity after AFD treatment; $M_{NRM-AFD}$) was measured. After the NRM measurements, IRM was imparted with a field of 1 T using pulse magnetizer for the 1034 crystals, and the resultant IRM intensity was measured (M_{IRM}). Subsequently, IRM intensity after LTD treatment ($M_{IRM-LTD}$) and AFD treatment ($M_{IRM-AFD}$) were measured for the sample with M_{NRM} values larger than 5 x10^{-12} Am^2.
M_{NRM} values of the single zircon crystals varied from 10^{-13} to 10^{-10} Am^2, and 101 crystals (9.8%) had M_{NRM} larger than 4 x10^{-12} Am^2. M_{IRM} values of the single zircon crystals also varied by five orders of magnitude, and 402 crystals (38.9 %) showed M_{IRM} larger than 4 x10^{-12} Am^2. The ratios of M_{NRM}/M_{IRM}, $M_{NRM-LTD}/M_{IRM-LTD}$, and $M_{NRM-AFD}/M_{IRM-AFD}$ varied 0.003-2.0, 0.005-2.4, and 0.005-2.4. There were several samples with the $M_{NRM-AFD}/M_{IRM-AFD}$ less than 0.1, which could be suitable for paleointensity experiment. Combining the rock-magnetic parameters, we will discuss the feasibility of the paleointensity experiment using single zircon crystals from the Yangtze River.

Keywords: Rock-magnetism, Zircon, Paleointensity

Abusolute Paleointensities of about 30Ma from Ethiopian flood basalts

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The Ethiopian traps, distributed in Ethiopia and Yemen, are flood basalts erupted about 30Ma related to the activity of the Afar hot plume, and form about 2000-m-thick sequence of lava flows at the Ethiopia plateau. Rochette et al. (1998) performed paleomagnetic and geochronological studies on samples from 42 lave flows in Lima-Limo and Wegel Tena section at the Ethiopia Plateau. Based on obtained $^{40}Ar/^{39}Ar$ ages of 28-30Ma, they corresponded paleomagnetic polarity changes obtained from the lave sequence to Chron C11r-C11n.2n-C11n.1r in Geomagnetic Polarity Time Scale (GPTS) of Huestis and Acton (1997), and argued that the period of the Ethiopian trap volcanism is about 1Myr or less. In order to reveal detailed geomagnetic variations at about 30 Ma recorded in the Ethiopian traps, we have been performing paleomagnetic analyses on samples collected from 94 lava flows in Lima-Limo sections. In addition to the polarity changes reported by Rochette et al. (1998), we found polarity changes with short intervals and some directional variations like geomagnetic excursion (Ahn,2015). We have been also estimating paleointensities from the samples by using the double heating technique of the Shaw method with low temperature demagnetization (LTD-DHT Show method: Yamamoto et al., 2003). Paleointensity data between 6.3 and 29.1μT are obtained form 11 specimens of 10 flows. A mean of specimens providing higher latitude of Virtual Geomagnetic Pole (VGP) above 45° is 17.6μT, and the value of one specimen with lower VGP latitude is 6.3μT. The mean intensity is lower than the present geomagnetic intensity at Ethiopia (35μT). It is implied that the geomagnetic intensity at about 30Ma is lower than the present, which may be compatible with that a mean VADM between 0.3 and 300Ma is about 60% of that between 0 and 0.3 Ma (Plenier et al., 2003). A weaker intensity of the sample with lower VGP latitude might have represented a temporal feature in geomagnetic excursion or polarity change.

Keywords: Ethiopian trap, geomagnetic polarity change, absolute paleointensity

Orienting paleomagnetic drill cores using a GPS compass

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Azimuths of paleomagnetic drill cores are usually determined with magnetic compasses, and sometimes verified with sun compasses and back-sighting. Weather condition or geographical obstacles often do not allow to perform these subsidiary measurements. Strongly magnetized volcanic rocks can generate local magnetic field that deflects magnetic declination from the regional value. This time we tested a compact GPS compass that is directly mounted on a orientation device and cross-checked the azimuth values of volcanics drill cores by several orienting methods. When placing the GPS compass in a location with good visibility, the azimuth measurement showed excellent performance with the RMS of 0.44 degrees and the angles deviation with the sun compass were less than 2.5 degrees. To achieve such a high precision, we needed to wait about 5 minutes for initializing the RTK measurement and to ensure no obstacle in an angle of elevation more than 35 degrees. Actually orienting drill cores, the azimuths of the GPS compass were consistent with those of the sun compass and back-sighting, although an outcrop itself often acted as an obstacle for the GPS compass. The magnetic compass also provided accurate azimuths after correcting regional magnetic declination, but sometimes showed relatively large deviations more than 5 degrees. The amounts of deviation were variable from sample to sample even within a same single site. When collecting volcanic rocks for archeomagnetic studies, we need to verify the azimuth of each drill core by using a orienting method other than a magnetic compass.

Keywords: paleomagnetism, archeomagnetism, GPS compass

Estimation for rotation history of tsunami boulders in Hachijo Island, by using viscous remanent magnetization

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In Hachijo Island, there are some huge volcanic-origin tsunamigenic boulders. These are about over 3000kg in weight without any sign of organic carbon, such as fossils. Because such huge boulders are mainly moved by extreme tsunami events, they are paid attentions as a key to understanding of past disaster events. If they are the coral boulders, we can estimate the date of past tsunami by using radiocarbon dating. However, we cannot estimate the date by using this theory for the volcanic boulders without any organic fossils. One of an alternative way to date volcanic boulders is the cosmogenic nuclide exposure dating because it simply accumulates on boulder surface. But, the cosmogenic dating can not apply to the boulders if the boulder had experienced multiple rotations. We applied paleomagnetic approach to these volcanic-origin boulders and tried to examine the age of tsunami event, and rotation history of these boulders. This method is useful for all boulders with a bit of magnetic grains regardless of its lithology, and we can determine multiple rotations. Boulders acquire the secondary magnetic component, called viscous remanent magnetization (VRM) after tsunami. This secondary viscous remanence is acquired to the original magnetic vector after the boulder has been removed from the original state. By using Neel's thermal activation theory, the magnetization at low temperature for a long time can be demagnetized at high temperature in a short time. Thus, we can count backward to the age when VRM was acquired (i.e. the past tsunami event). And we can understand how they emplaced, by displacement of direction of magnetization.

As a result, some samples from these boulders have acquired VRM components. Especialy, andesitic boulder located on 20m above sea level, showed multiple VRM components, suggesting subsequent tsunamis. However, calculated age was older than geological age of Hachijo island. Thus, combination with other dating method such as cosmogenic nuclide dating, is required to verify a gap of tsunami age, and improve accuracy of paleomagnetic dating method.

Assessment of inhomogeneity of remanent magnetization by measurements with a magneto-impedance spinner magnetometer

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A new version of spinner magnetometer using magneto-impedance (MI) sensor was developed which has a wider dynamic range (10^{-1} to 10^{-6} mAm^2) and a tunable low-pass filter with two (6 Hz and 20 Hz) cut-off frequencies. These new functions allowed the measurement of the fundamental signal (5 Hz) plus the second- (10 Hz) and third-order harmonics (15 Hz). To test how the multipole moments affect the measured waveforms, we measured a set of synthetic samples to simulate the off-centered dipole by changing their direction and offset. The results agreed well with the theoretical waveforms calculated by the offset dipole models. For comparison these synthetic samples were also measured with a conventional, fluxgate spinner magnetometer. It turned out that there are small but significant differences between the results from the two spinner magnetometers. We consider the possible causes for these inconsistencies in terms of theory and instrumentation, and propose the advantage of the MI spinner that can detect the presence and effect of the multipole moment, especially for the case where it is equivalent in the first approximation to the offset dipole model.

Keywords: spinner magnetometer, inhomogeneity of remanent magnetization, multipole moment

The empirical mode analysis of the decadal variations in the geomagnetic Gauss coefficients

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Decadal geomagnetic field oscillations are often considered to be caused by waves in the Earth's outer core. The waves often used in interpreting decadal variations are torsional oscillations and axisymmetric Magnetic-Archimedes-Coriolis (MAC) waves (Braginsky 1993; Buffett, 2014). Both waves are characterized by axisymmetric flows, but decadal variations can, in principle, be explained in terms of non-axisymmetric waves. In order to extract such non-axisymmetric wave components from the Gauss coefficients, we first apply the empirical mode analysis to extract decadal components, and then subtract variations caused by axisymmetric flows.
We use the time series of the last 150 years of the Gauss coefficients with degrees up to 4, from 1865 to 2014. We combine the data from gufm1 model (Jackson, 2000), IGRF-12 and CHAOS-5 model (Finlay, 2015), and apply the empirical mode decomposition (EMD) (Huang et al., 1998) to time series of the Gauss coefficients.
The decomposition shows that the equatorial antisymmetric components of Gauss coefficients have periods of 40 and 80 years. The g-h plots of these components show linearly polarized oscillations, which indicate either forced oscillations, or advection by oscillating flows.
Next we subtract the components which can be caused by advection by axisymmetric flows. The results will be shown at the conference.

Keywords: geomagnetic decadal variations, Gauss coefficients, outer core, torsional oscillations, empirical mode decomposition

Constraint of magnetic models using seismic tomography in Taiwan

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Uncertainty is often one of the sufferings when underlying structure models are constructed by using unitary geophysical data retrieved from field survey. Velocity-susceptibility models are constructed using velocity retrieved from seismic tomography transferring into susceptibility through characteristics of minerals and/or rocks determined by (Vp) together with (Vp/Vs ratio). Simulated values are computed from the models through 2D forward methods to compare with magnetic anomalies processed after field prospection. Two profiles with intense undulation of geomagnetic anomalies over sediment areas in central-west Taiwan and complex geological structures at the rim of the subduction zone in north Taiwan are used to examine consistency between the simulated values and magnetic anomalies. The consistent results suggest that rocks with high susceptibility can be identified in sediment areas and complex geological areas by using velocity tomography. Those models with two-parameter constraints shed light on understanding underlying magnetic structures through more confidence.

Keywords: Magnetic anomaly, Velocity tomography, Magnetic susceptibility

