A preliminary paleomagnetic secular variation from varved sediments of Lake Suigetsu, central Japan

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Studies of paleomagnetic secular variation (PSV) are important to reveal the mechanism of geodynamo acting in the outer core, and in addition PSV can be used as a tool of dating of hundreds to thousands yr resolution. Sediments from Lake Suigetsu, Fukui prefectural, central Japan, have annual layers (varves), and thus precise varve chronology has been established, with small errors, e.g. ±58 years for 20000 years. In addition, the Lake Suigetsu varved sediments have a high accumulation rate of 99 cm/kyr for the last 20000 years. Therefore, high resolution secular variation records can be obtained. The aim of this study is to obtain high-resolution PSV records from Lake Suigetsu varved sediments, and assess the previous PSV records, focusing on the timing of secular variation features.
Varved sediments of Lake Suigetsu were sampled in July to September, 2014, and a total of 274 cores of 1 m length were collected from four holes on the bottom of the lake. In this study, we used 1cm x2cm x2cm double-L channel sub-samples collected from each core. Paleomagnetic analyses were conducted on 43 double-L channel samples, and 16 of 43 are originate samples.
For all samples, we conducted demagnetizations with progressive alternating field up to 80mT and measured magnetizations at 1-cm regular interval. Characteristic remanent magnetization (ChRM) was calculated by principal component analysis. As a preliminary result, inclination and declination variations for last 20000 years were obtained. The PSV of Lake Suigetsu shows many features commonly observed in the Japanese archeomagnetic secular variation for last 2000 years, and also in the Holocene PSV from Japanese lake sediments.

Keywords: paleomagnetic secular variation, varved sediments, Lake Suigetsu, the Holocene

Sedimentary record of the Holocene paleomagnetic secular variation from Beppu Bay, Southwest Japan

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Although considerable efforts have been made for global data compilation and geomagnetic field modeling for paleomagnetic secular variation (PSV), it is desired to further improve the data distribution and quality in the Asia-Pacific region. We have investigated the Holocene PSV records from marine sediments of Beppu Bay, which is a tectonic basin adjacent to active volcanic fields of Kyushu Island in Southwest Japan. Previous studies utilizing multiple piston-core samples from northwestern part showed that the sediments of the Beppu Bay have preserved stable remanent magnetizations suitable for reconstruction of the Holocene PSV. Recently, an age-depth model was developed for the late Holocene sediments in the southwestern part through detailed sedimentologial analysis and AMS radiocarbon dating, particularly for the last 3,000 years. We hence made pass-through measurements of natural remanent magnetizations of u-channel samples from newly obtained piston cores. Although our declination record was discontinued at section boundaries, relative variation within a u-channel sample was comparable with paleomagnetic records from the northwestern part. The inclination records showed consistent variation between the two areas and also correlative to a PSV record from Lake Biwa. It is thus suggested that the paleomagnetic data from Beppu Bay play a key role in synthesizing sedeimentary and archeomagnetic PSV records in Southwest Japan.

Keywords: paleomagnetic secular variation, remanent magnetization, Beppu Bay

Orbital Influences on Geomagnetic field in the Matuyama and the Gauss Chron at IODP site U1314 in the North Atlantic

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We have investigated the detailed geomagnetic field variation during the Matuyama and the Gauss Chron from a sediment core (IODP Site U1314) with high sedimentation rate (≥ 10 cm/kyr) and good age control. Characteristic remanent magnetization directions were well resolved by stepwise alternating field demagnetization. As a proxy of relative paleointensity, natural remanent magnetization (NRM) normalized by anhysteretic remanent magnetization (ARM) was used after testing that the influence of magnetic interaction in ARM is negligible. We discuss the variation of the geomagnetic field with the period close to those of the Earth's orbital elements.

Keywords: geomagnetic excursion, Milankovitch cycle

Archeomagnetic direction and intensity of ancient settlements at Koushin district, central Japan

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Archeomagnetic direction and intensity were estimated from baked soils obtained at four archaeological sites (Idegawa-minami site of the 6th century, Wada-taishido site of 9th century and Takabatake site of 11th-12th century in Matsumoto city and Kamihara site of 9th-10th century in Hokuto city), Koushin district, central Japan. 62 baked soil samples were obtained from heated ground at the ancient housings. These soils are reddened and consolidated because of heating during cooking. It is expected that these soils recorded stable TRM, though these baked soils from ancient kitchens were hardly experienced so high temperature as to those from pottery kilns and furnaces used in iron smelting (studies of Sue ware; Shibuya et al., 2015, JpGU).
As a result of PAFD and PThD, 47 samples from 12 ancient housings had stable TRMs whose directions were parallel to the earth magnetic field at the time when TRM was acquired. Directions from some samples which showed lower NRM intensity and susceptibility were not concentrated to the past magnetic field. Our site-mean directions are almost identical with those from the secular variation curve in Japan (Hatakeyama et al., in prep.) with a few exceptions. Archeomagnetic directions obtained from Matsumoto city are plotted on right side of the secular variation curve, suggesting that declination become higher due to local magnetic anomaly. According to present distribution of earth's magnetic field, declination is slightly higher of about 1-2 degree around Koushin district than surrounding region (GSI, 2010). This may result in eastward distribution of archeomagnetic data from Matsumoto city.
Using Thelier-Coe method (Coe, 1967), archeomagnetic intensities were estimated from 20 specimens with high magnetic susceptibility at Kamihara site. Obtained intensities showed wide range of 16.7~73.9μT. Excluded data from specimens with low magnetic susceptibility and NRM intensity, mean intensities are estimated as follows: 51.9±2.1μT (A.D. 850~900), 57.3±4.4μT (A.D. 850~950). These values are consistent with the values from previous study in Japan (e.g. Sakai, 1980; Yoshihara et al., 2003).

Keywords: secular variation, archeomagnetism, archeomagnetic direction, archeointensity, archaeological site

Reexamination of geomagnetic secular variation in Kinki District using samples from Suemura kilns (IV)

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In 1960s-70s, enormous number of kilns were excavated in Sakai city and its vicinity, Osaka prefecture for a large residential development. Enhanced archeological studies, especially for massive amount of pottery kilns (Sue ware of 5th to 10th century) were carried out by Osaka Prefectural Government. Archeomagnetic researches were also conducted by prof. Kawai and his colleagues of the Osaka University. As the result, the geomagnetic secular variation curve from the 5th century to the 10th century was drawn (e.g. Hirooka 1971; Shibuya 1980). However, there are problems from the present paleomagentic view point. The natural remanent magnetizations (NRM) were measured by astatic magnetometer and demagnetization was not made. Fortunately, those samples are stocked in Osaka Ohtani University, and we moved them to Okayama Science University and Kumamoto University, for conducting systematic remeasurement study of their NRM after alternating magnetic field demagnetization (AFD). We already reported the results in 2012, 2015 JpGU meeting. The preliminary secular variation curve for 5^{th} and 10^{th} century were also reported in 2015 SGEPSS meeting, and 2015 AGU fall meeting. However, the curve has some conflicts with archeological dates in the later part of the interval. This time, we reexamined the archeological age and its reliability of each kiln, and tried redrawing the secular variation curve. The discrepancy between the Sueki typological ages and the archeomagnetic ages inferred from the secular variation curve is smaller for the redrawn one. It is interesting that Hajiki (another category of earthen wares in Japan, which does not have secular typological change, thus hard to be dated by archeology) kilns have magnetic direction aligned in a line after the youngest Sueki kilns. It may indicates that those Hajiki kilns were used for producing earthen wares of daily life after the technique of Sueki had been lost. If it is correct, the secular variation curve can be extended to 12 CE. The density of the kilns and a couple of gaps in age may also be suggestive to the rise and fall of the craftsmen groups of Suemura.

Keywords: Archaeomagnetism, Geomagnetic secular variations, Pottery kilns

A paleointensity study on historical and ^{14}C dated lavas in Hawaii Island using the Tsunakawa-Shaw method

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In 1987 and 1991, historical and ^{14}C dated lava flows distributed in Hawaii Island were collected from 37 sites by Masaru Kono, Hidefumi Tanaka and others. Tanaka and Kono (1991) and Tanaka et al. (1995) reported absolute paleointensities determined for samples from the 7 sites using the Thellier-type method, but many samples have been stored and reserved for a further analysis. We have conducted absolute paleointensity measurements on 172 samples at 36 sites using the Tsunakawa-Shaw method, and obtained 149 successful results. Applying the site-level selection criteria with (1) minimum of three successful results for a site (N >= 3) and (2) the successful results giving site mean paleointensities with their standard deviations less than 15 percent (stdev =< 15 percent), 24 well-defined site mean paleointensities are discriminated. They range between 16.8 and 67.8 microT for a period from -21890 to 1960 yr AD (last 0-24 kyr), and associate with Q_{PI} (Biggin and Paterson, 2144) of 4/5 (AGE=1, STAT=0/1, TRM=1, ALT=1 and MD=1).
For that period, 72 site-mean Hawaiian paleointensities obtained by the Thellier-type method with pTRM checks can be selected from the GEOMAGIA50.v3 database (Brown et al., 2015), applying the same site-level selection criteria. 48 site-means of them are from surface lavas mainly covering the last 5 kyr (4 data, Coe et al. (1978); 5 data, Tanaka and Kono (1991); 12 data, Mankinen et al. (1993); 1 data, Cottrell and Tarduno (1999); 1 data, Chauvin et al. (2005); 18 data, Pressling et al. (2006); 7 data, Pressling et al. (2007)) while the other 24 site-means are from the Hawaiian Scientific Drilling Project (HSDP) cores mainly spanning the last 5-24 kyr (12 data, Teanby et al. (1991); 1 data, Laj and Kissel (1999); 11 data, Laj et al. (2002)). They show a general increasing trend from about 25 microT at around -22000 yr AD toward about 60 microT at around -3000 yr AD, and a high intensity period of the last 5 kyr with the average of 57.2 microT (standard deviation of 12.3 microT). Our new data appear to confirm basically this trend as well as this high intensity period, but to result in somewhat lower paleointensities as is evidenced by the average intensity of 45.8 microT (standard deviation of 10.0 microT) for the last 5 kyr.

Keywords: Paleointensity, Hawaii, lava

Volcanic records of the Laschamp geomagnetic excursion from Mt Ruapehu, New Zealand

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We present palaeodirectional records of the Laschamp excursion from the thermoremanent magnetization of lavas on Mt Ruapehu, New Zealand. Fourteen lava flows on the western and southern flanks of Mt Ruapehu, for which $^{40}Ar/^{39}Ar$ dating yields ages between 39.1 ±1.4 and 45.4 ±2.0 ka, were studied. The youngest and older flows have normal polarity magnetizations; however, six flows, dated between 41.8 ±1.8 and 45.4 ±2.0 ka, record excursional field directions. The palaeomagnetic directions of three flows have southerly declinations and inclinations of about -40°, in good agreement with a previously published Laschamp record from the Auckland Volcanic Field (AVF). Together, the AVF and Mt Ruapehu lavas represent the only current volcanic records of the Laschamp excursion outside the Chaîne des Puys region of France. They, thus, provide a vital contribution to the global studies of the Laschamp excursion. Comparison of virtual geomagnetic pole (VGP) positions determined from the New Zealand and French excursion records suggest the dominance of an equatorial dipole dominated field in the early phase of the Laschamp excursion. Meanwhile, differing VGPs for the younger excursional flows from France and New Zealand suggests that either the field lost its predominantly dipole-dominated morphology in the later phase of the excursion, or that the two records are not synchronous. Compatible features of volcanic and sedimentary records of the Laschamp excursion are explored, including the possibility of a precursory palaeodirectional anomaly before the main excursion phase. Overall, $^{40}Ar/^{39}Ar$ ages for the Mt Ruapehu excursion records are slightly older than recently published ages from the northern hemisphere. Although the difference is not significant at the 2s level, if real, it could result from such a precursory phase, or from non-synchroneity of anomalous field directions at near-antipodal locations, or it could indicate a longer overall excursion duration than the currently accepted 1500 years.

Keywords: Geomagnetic excursion, palaeomagnetism, Laschamp

Palaeomagnetic field strength variations suggest a Mesoproterozoic age of inner core nucleation

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The Earth's inner core grows by the freezing of liquid iron at its surface. The point in history at which this process initiated marks a step-change in the thermal evolution of the planet. Recent computational and experimental studies have presented radically differing estimates of the thermal conductivity of the Earth's core with resulting widely ranged dates of inner core nucleation (from less than 0.5 to nearly 2 billion years). Some of these raise serious challenges to explaining how the dynamo responsible for generating the geomagnetic field has been sustained over the whole of observed Earth history. The nucleation of the core leads to a different convective regime, and might be expected to produce different magnetic field structures, producing an observable signal in the palaeomagnetic record and allowing the date of inner-core nucleation to be estimated directly. Previous studies searching for this signature have been hampered by the paucity of palaeomagnetic intensity measurements, by the lack of an effective means of assessing their reliability, and by shorter timescale geomagnetic variations. Here we examine results from an expanded Precambrian database of palaeomagnetic intensity measurements selected using a new set of reliability criteria. Our analysis provides the first intensity-based support for the dominant dipolarity of the time-averaged Precambrian field, a crucial requirement for palaeomagnetic reconstructions of continents. We also present the first firm evidence for the existence of very long-term variations in geomagnetic strength. The most prominent and robust transition in the record is an increase in both average field strength and variability observed to occur between 1 and 1.5 billion years ago. This observation is most readily explained by the nucleation of the inner core occurring during this interval; the timing would tend to favour a modest value of core thermal conductivity and a more conventional thermal evolution of the Earth.

Keywords: inner core, paleointensity

