Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SEM36-01 Room:201B Time:May 19 09:00-09:15

Paleomagnetic results from the Himaka Formation of the Morozaki Group (Early Miocene sediments), central Honshu

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We present new paleomagnetic results from the sedimentary rocks of the lowest formation (Himaka Formation) of the Lower Miocene Morozaki Group. The paleomagnetism of the upper formations of the group has been previously reported, but there have been no published data for the Himaka. Oriented cores were collected from 16 stratigraphic sites (horizons) from the ca. 90 m sequence on the Saku-shima (Saku Island), 4 sites from the ca. 110 m sequence on the Himaka-jima (Himaka Island), and 2 sites from the ca. 60 m sequence on the southeastern tip of the Chita Peninsula. The sampled sites consist mostly of felsic fine tuff layers, with minor siltstone units. Cylindrical specimens were subjected to stepwise alternating-field or thermal demagnetization in order to extract characteristic remanent magnetization (ChRM) components. With the exception of a few sites where the remanent magnetization has been seriously affected by a normal-polarity secondary overprint, the Himaka Formation sites have reverse-polarity ChRM directions. Taking the magnetostratigraphy of the upper formations of the Morozaki Group into consideration, the Himaka Formation is correlative with Chronozone C5Dr (18.056-17.533 Ma). The site-mean ChRM directions are marked by a paleo-declination that is consistently southwest (reverse polarity). This is compatible with site-mean directions of the upper formations and can be explained by assuming a clockwise tectonic rotation. The paleo-declination of the Himaka Formation is deflected 10-20^o counterclockwise relative to the strike of the nearby Median Tectonic Line (MTL). This is also the case for the Shitara area (ca. 70 km to the northeast) and the Chichibu area (Kanto Mountains), indicating that the MTL had the same strike direction in these three areas in the late Early Miocene.

Keywords: paleomagnetism, Himaka Formation, Morozaki Group, Median Tectonic Line, tectonic rotation, Early Miocene

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SEM36-02 Room:201B Time:May 19 09:15-09:30

Paleomagnetic study of the Okhotsk-Chukotka Volcanic Belt at Magadan, Kolyma-Omolon Superterrane, Russia

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Post-Cretaceous tectonic deformation of Eurasian continent can be estimated by comparison of Cretaceous paleomagnetic pole positions from its western and eastern extreme areas. We choose the Kolyma-Omolon Superterrane as one of the eastern extreme. Late Cretaceous ignimbrites are collected at 19 sites from the Kholchan Suite in the Okhotsk-Chukotka Volcanic Belt at the north of Magadan (60.4N, 151.0E) in the terrane. Characteristic paleomagnetic directions are isolated from 16 sites by AF demagnetization and their primary nature is ascertained through presence of both normal and reversed polarities. Late Cretaceous paleomagnetic direction after tilt correction is D=17.6, I=82.5, k=13.1, a95=10.5, N=16 at Magadan, corresponding to a paleomagnetic pole at Long. = 166.7, Lat. =72.4, A95=18.9. This pole falls on the pole position for the Chukotka, indicating the Kolyma-Omolon Superterrane and Chukotka behaved as a tectonic unit since Late Cretaceous. Compared with Late Cretaceous poles from Europe and the Mongolia block, pole positions from the Mongoria block, Eurasia and Magadan are arranged from the north to south along longitude of 170E. Disagreement of pole positions of western and eastern extreme areas suggests occurrence of deformation of the Eurasian continent later than Late Cretaceous. Pole positions from the Kolyma-Omolon-Chkotska block and Mongol block implies southward displacement of the Kolyma-Omolon-Chkotska block and northward displacement of the Mongol block. Continuation of closure of the Mongol-Okhotsk Ocean is one of post-Cretaceous tectonic deformation aspects within Eurasian continent.

Keywords: paleomagnetism, tectonics, Cretaceous, Asian continent

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SEM36-03 Room:201B Time:May 19 09:30-09:45

Updated three-component spinner magnetometer with thermal demagnetizer ”tspin”

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A three-component spinner magnetometer equipped with a thermal demagnetizer, which is called ”tspin”, is finally used for routine remanence measurements involving thermal demagnetization and the Thellier paleointensity method. The original instrument design and the data reduction procedure based on the spherical harmonic analysis were already developed by Kono et al. (1991).

Three components of a remanent magnetization of a standard size (1-inch) specimen can be measured by a single fluxgate sensor without changing specimen orientation. A specimen mounted on a quartz tube holder is rotated by a single axis and translated along the axis. We can obtain the magnetization components on the plane perpendicular to the rotating axis like a conventional spinner magnetometer, and also the axial component determined by the translation. This time the quartz tube is redesigned to be connected to the rotating axis by a chuck, so we can precisely set the specimen by using a laser level and then calibrated the declination value of the in-plane components. The effective sensitivity is currently of 5e-8 Am2 but should be improved by one order if housed in a magnetic shield room.

An electric furnace is available in line to heat a specimen up to 700 deg.C by translating along the axis. Cooling position is located between the furnace and the sensor. After a measurement step, the specimen is inserted into the furnace that is already maintained at the next temperature step. This procedure makes sure that the specimen always follows the same heating treatment, which is especially important for zero- and in-field processes during Thellier experiments. We have done temperature calibrations by attaching K-type thermocouples into and onto a dummy basalt specimen.

Now stepwise thermal demagnetization and the Thellier experiments can be automatically performed using a home-made software coded on LabVIEW. We just need to specify temperature steps and a dwell time in the furnace before running the software. Zijderveld and Arai diagrams are drawn on a display in the course of measurements. Because we do not need to change the specimen orientations and a series of heating, cooling and measurement is performed without taking out the specimen from the mu-metal shield, we can see extremely beautiful straight lines on Zijderveld or Arai diagrams. By introducing ”tspin”, we expect laborious Thellier paleointensity experiments are carried out much more easily and precisely.

Keywords: paleointensity, Thellier method, magnetometer, thermal demagnetization

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SEM36-04 Room:201B Time:May 19 09:45-10:00

Rock magnetism of the volcanic materials recovered from Louiville Seamounts during IODP Expedition 330

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Integrated Ocean Drilling Program (IODP) Expedition 330 recovered volcanic materials from seamounts along the northwestern part of the Louisville hotspot track (50-74 Ma). The recovered materials include basalts which are considered to be erupted under subaerial or shallow submarine conditions. We have been trying absolute paleointensity measurements on them, and we in parallel have studied rock magnetic properties to assess the paleointensity results. In the present study we mainly focus on thermomagnetic properties.

Thermomagnetic analyses using a magnetic balance (Natsuhara Giken NMB-89) in vacuum condition have been made on 57 rock chips from Site U1372, 28 chips from Site U1373, 140 chips from Site U1374, 44 chips from Site U1376, and 19 chips from Site U1377 (288 chips in total). The resultant curves can be classified into the five types (A, B, C, D, and E).

Type A: almost reversible thermomagnetic curves observed in 38 specimens. They show a single phase of Ti-poor titanomagnetite with Tc (Curie temperature) higher than ~ 500 degC.

Type B: almost reversible thermomagnetic curves recognized in 18 specimens. The difference from type A curves is existence of Ti-rich titanomagnetite phases with Tc lower than ~ 500 degC, in addition to the high Tc (> ~500 degC) phase.

Type C: somewhat irreversible thermomagnetic curves found in 49 specimens. They show a single phase of Ti-poor titanomagnetite with Tc higher than ~ 500 degC, however, cooling curves result in reduction in induced magnetization relative to heating curves in most cases. At ~ 50 degC, amount of the reduction is about 20-60 percent.

Type D: irreversible thermomagnetic curves seen in 50 specimens. They are usually characterized by two phases of titanomagnetite, one with moderate Ti content (Tc ~ 150-300 degC) and the other with low Ti content (Tc > ~ 450 degC). Cooling curves outweigh heating curves in most cases.

Type E: irreversible thermomagnetic curves occurred in 133 specimens. They exhibit relatively low Tc (~ 200-300 degC) components followed by bumps of high Tc (~ 400-500 degC) in heating curves. The bumps are considered to originate from inversion of titanomaghemite. Cooling curves outweigh heating curves in most cases.

Some of the selected specimens will be analyzed using scanning electron microprobe and other instruments. We will report these results together with the thermomagnetic ones.

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SEM36-05 Room:201B Time:May 19 10:00-10:15

Rockmagnetism of submarine basaltic rocks from IODP Site C0012

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The IODP Expeditions 322 & 333 penetrated sediments-basement boundary and recovered successive cores at Site C0012 situated on a topographic high named Kashinosaki Knoll. The collected basement samples are composed of alternating beds of pillow basalts and hyaroclastite and were retrieved by rotary core barrel drilling system. Paleomagnetic measurements on basaltic basement rocks from Site C0012 show that the stable magnetization has reversed polarity. Rock magnetic experiments were conducted to understand the magnetic minerals contributing to the primary magnetization. Thermomagnetic curves during heating in air shows a hump around 500degC which cannot be seen for the curve in vacuum, Ar or He atmosphere. This can be interpreted as a result of oxidation of the magnetic mineral. The results in air, vacuum, Ar and He show maximum curvatures at 326degC, 332degC, 328degC and 303degC, which might show a Curie temperature of the natural magnetic mineral (titanomaghemite). The peaks at around 402degC, 392degC and 424degC in vacuum, Ar and He might correspond to break down (decomposition) of magnetic minerals (titanomaghemite) by heating. A hump at 493degC for the heating curve in He could not be resolved enough in the heating curve up to 527degC. This might be a result of the multiple heatings and heating rates, which suggest the progressive production of titanomagnetite (from titanomaghemite) and subsequent hematite production (reduction in magnetization intensity). Low-temperature magnetic measurements were also conducted and will be interpreted together with Curie temperatures.

Keywords: rock magnetism, submarine basalt, low temperature magnetometry, Curie temperature, Kashinosaki Knoll

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SEM36-06 Room:201B Time:May 19 10:15-10:30

Paleomagnetic study of the Holocene volcanic rocks from post-caldera central cones of Aso Volcano

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We have conducted a paleomagnetic study on Holocene volcanic rocks from post-caldera central cones of Aso Volcano. On the basis of the previous studies (e.g. Miyabuchi, 2009), these volcanic rocks (lavas and scoria cones) were considered to be formed above the K-Ah tephra (7300 cal year BP). Except a ^{14}C age, no radiometric age is reported for these young lavas and scoria cones.

Paleomagnetic sampling was made at 25 sites of seven units. Nineteen sites gave reliable mean paleomagnetic directions that had a 95% confidence circle of lower than 5 degree. The other sites of large ($>$ 5 degree) 95% confidence circle tend to have a strong natural remanent magnetization, which suggests that local magnetic anomaly at the sites may to be related to the large scatter of natural remanent magnetization (NRM) directions.

Interestingly, different sites from a few lavas, which had been treated as a single unit in the geological map of Aso Volcano (Ono and Watanabe, 1985), gave distinct mean directions at 95% confidence level. For Kishimadake lava, Ojodake lava, lavas from Nakadake young edifice, two or three different mean directions were obtained from multiples sites. These differences in mean directions indicate that multiple flows were extruded with a temporal gap of more than 10 or 100 years. We also found that Kamikomezuka scoria, two sites of Kishimadake lava, two sites of Ojodake lava, and two sites of Nakadake lava gave identical mean directions at 95% confidence level. The concordance of the mean directions suggests that the multiple vents erupted simultaneously, in a time interval of the order of 10 years, and these lavas were extruded over a wide area of the post-caldera central cones. On the basis of the volcanio stratigraphy, the event of the simultaneous eruptions appeared to occur between 3000 and 5000 years BP.

Keywords: paleomagnetic direction, Aso Volcano, lava, scoria, simultaneous eruptions

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SEM36-07 Room:201B Time:May 19 11:00-11:15

Paleomagnetic secular variation record from the Holocene sediment of the Ichi-no-megata marr, Akira Prefecture

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The Ichi-no-megata is a maar lake located in the Oga Peninsula, Akira Prefecture, which has a maximum water depth about 45 m. In 2006, core samples of the sub-bottom sediments were obtained at three holes in the central part. The core sediments, mostly composed of laminated clay or silt intercalating sandy turbidite layers and tephra deposits, provided a composite sedimentary profile of about 37 m long. Results of tephra analysis and radiocarbon dating suggested that the interval above the volcanic products from the adjacent San-no-megata maar (23.7 to 32.3 m deep) covers a time period since about 25 ka with a nearly constant sedimentation rate about 0.71 m/ky.

Using pass-through methods, we measured magnetic susceptibility and natural remanent magnetization (NRM) of u-channel samples. The magnetic susceptibility data confirmed the hole-to-hole correlation based on lithologic observations. Stepwise AF demagnetization of the NRM showed that the remanence is essentially composed of a single stable component. Because the studied sequence comprises of core segments typically about 80 cm long, a continuous record of declination change was not obtained. Inclination data is characterized by an average value about 50 degree and amplitudes comparable with a paleomagnetic secular variation (PSV). In particular, the inclination variation above 9 m deep shows a good similarity with the Holocene PSV record reported from Lake Biwa. Occurrence of the Kikai-Akahoya tephra (7.3 ka) in both sequences support correlation of the two records, suggesting usefulness of PSV records in high-resolution stratigraphic correlation at a regional scale.

Keywords: paleomagnetic secular variation, annual verve, remanent magnetization, magnetic susceptibility

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SEM36-08 Room:201B Time:May 19 11:15-11:30

Paleodirections and intensities from two old kilns in Okayama prefecture

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The archaeological remains such as kilns of Sueki type potteries record very stable thermo remanent magnetization (TRM), because they were baked at a high temperature more than 1,000 ^{o}C. In addition, their age are well estimated with very high precision in many cases, by using pottery type morphology. Thus, the archaeomagnetism can be used widely to examine the magnetic secular variation of the past several hundred to thousand years. However, there is very little number of data (direction 682 and intensity 63) which are used to construct the standard curve of the magnetic secular variation in Japan. This study aims to estimate a paleomagnetic directions and intensities of two old kilns (Sayama Shin-ike 1st kiln, Sayama Higasiyama-Oku kiln) of Bizen city, Okayama prefecture and contribute to the improvement of archaeomagnetic database.

For the paleomagnetic direction, we got samples of baked earth obtain from two old kilns (floor and wall; remanent magnetization intensities are 10^{-1}~10^{1} A/m) and we decided a principal components of measurements of remanent magnetization with stepwise AF-demagnetization under 0~100mT conditions. In the result, we obtained average magnetization directions, of D=-13.8+-1.8^{o} I=51.6+-1.6^{o} a_{95}=1.1^{o} k=261.7 from Shin-ike (n=59) and D=-11.6+-2.8^{o} I=46.7+-1.9^{o} a_{95}=1.9^{o} k=253.7 from Higasiyama-Oku (n=24).

From rock magnetic analyses, the characteristic magnetic mineral recording the remanent magnetization is likely be magnetite. In addition, these samples were almost not influenced by the heating. These results suggest that these samples are suitable for paleointensity measurements (IZZI method and Tsunakawa-Shaw method). In the paleointensity result, obtained average magnetization intensity by IZZI method is 61.3+-3.2uT (Shin-ike, n=4) and 53.6+-7.1uT (Higashiyama-Oku, n=8). intensity by Tsunakawa-Shaw method indicates the results of 54.1+-10.6uT (Shin-ike, n=2) and 67.1+-10.7uT (Higashiyama-Oku, n=2).

The estimated ages from comparison the average magnetization directions and the secular variation curve are consistent with archaeological era (Sin-ike; latter half of 8C, Higasiyama-oku; 9 to 11C) in the range of errors. Field intensities obtained by IZZI method shows the values that is nearer to intensity standard curve of Japan than Shaw method. Thus, as for the samples used in this study, it is supposed that IZZI method is suitable for the measurement of paleointensity.

Keywords: Archaeomagnetism, Paleomagnetic direction, Paleomagnetic intensity, Old kilns of Sueki Potteries

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SEM36-09 Room:201B Time:May 19 11:30-11:45

Searching a paleomagnetic record of the Laschamp excursion in the Hikageyama lava of the Sanbe volcano

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The Laschamp excursion is one of the best-known geomagnetic excursions in the late Brunhes chron, which was first recognized in lavas from the French Massif Central. According to recent radiometric dating of the lava flows and stratigraphic correlations of the Atlantic sediments with the Greenland ice cores, the Laschamp excursion is dated at about 41 ka and assigned with the interstadial 10. Among widespread tephra deposits in Southwest Japan, the Sanbe-Ikeda (SI) volcanic ash layer is dated at 43 to 46 ka. It is expected therefore that the Laschamp excursion is recorded in volcanic rocks or sedimentary sequences overlying the SI tephra.

We made paleomagnetic study of the Hikageyama dacite, which is overlying the Ikeda Pumice Deposit, the source of the SI tephra deposit. We collected oriented samples at 9 sites and measured natural remanent magnetization (NRM) on a spinner magnetometer. Stepwise alternating field (AF) demagnetization revealed that NRM of most samples are essentially composed of a single component, while some samples showed highly stable remanence which cannot be demagnetized at peak AF of 100 mT. We also obtained a fission-track date of zircon crystals at 36+/-7 ka.

Among the 9 sites, 4 sites in the eastern part of the Hikageyama yielded consistent site mean directions characterized by shallow inclinations and easterly deflection. These site means exceed a common range of paleosecular variation, providing virtual geomagnetic poles (VGP) at around 50 N and 100 W. It can be assumed therefore that the Hikageyama dacite recorded anomalous geomagnetic field at the time of the Laschamp excursion.

Keywords: Geomagnetic excursion, Laschamp excursion, Virtual geomagnetic pole, Hikageyama lava

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SEM36-10 Room:201B Time:May 19 11:45-12:00

A preliminary study on the geomagnetic paleointensity experiments using single zircon crystal

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Geomagnetic paleointensity data provides critical information such as thermal evolution of the Earth [1]. Also a state of geomagnetic field closely relates to a surface environment [2]. It is pivotal to know the variation of geomagnetic field intensity throughout the history of the Earth.

Paleointensity have been intensively recovered from whole rock samples for several decades [3]. Recently, high-sensitivity superconducting quantum interference device (SQUID) magnetometer has enabled us to measure natural remanent magnetization (NRM) of single silicate crystal extracted from a rock sample [4], increasing the success rate of the paleomagnetic experiments. However, until now, we have not yet obtained enough data to resolve billion-year-scale geomagnetic field variation, and need to obtain more paleointensity data, especially older than 5 Ma [3].

In the present study, we focus on a single zircon crystal. Since river sand originates in rocks widely distributed in river basin, detrital zircons in the sand have various ages [5]. If the geomagnetic paleointensity can be measured using the single zircon crystal, we will probably obtain paleomagnetic data enough to resolve the long-term geomagnetic field variation.

Zircon crystals used in this study were sampled from sands of Nakagawa River, Tanzawa Mountain. We have conducted a suite of basic rock-magnetic measurement on assemblage of 26 zircon crystals: isothermal remanent magnetization (IRM) acquisition, stepwise alternating field demagnetization (AFD) of saturation IRM (SIRM), and low-temperature cycle using a Magnetic Property Measurement System (MPMS). Magnetic properties of the zircon crystals have been resulted in as follows: (1) the crystals contain nearly pure magnetite (Fe_3O_4), and they are in both single-domain (SD) and multi-domain (MD) states, (2) SIRM intensity is about 1 x 10^{-3} Am^2/kg (1x10^{-3} Am^2/kg x 1 mg = 1 x 10^{-9} Am^2), and (3) SIRM has high-coercivity fraction up to 20 mT.

Existence of the SD magnetite contained in the zircon crystals has the potential to recover the paleomagnetic information. Taking into account the existence of MD magnetite, stepwise-demagnetization after low-temperature demagnetization (LTD) is an efficient approach for paleomagnetic measurement. Now, our plan is to conduct LTD/stepwise-AFD measurement of NRM and IRM for single zircon crystal by using SQUID magnetometer. On the basis of the rock-magnetic studies and the NRM/IRM measurements, we will discuss the feasibility of the paleointensity experiment using single zircon crystal.

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Keywords: Single Zircon Crystal, Geomagnetic Paleointensity

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SEM36-11 Room:201B Time:May 19 12:00-12:15

Paleointensity determination of welded tuffs: Investigation on the curved NRM-TRM1∗ plots

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There are some widespread tephras identified in marine sediment cores which have been correlated with the oxygen isotope stratigraphy. If we could obtain absolute paleointensites from the welded tuffs which were formed with these tehpras, we can correlate the absolute paleointensites to the oxygen isotope stratigraphy. That is, we can compare the absolute paleointensity and a relative paleointensity on oxygen isotope stratigraphy with no error in age. For this purpose, we are measuring absolute paleointensites from welded tuffs which have been correlated with widespread tephras. In the JpGU 2012 Meeting, we reported paleointensities from Funakura, Ito, Kakuto, Imaichi and Yabakei welded tuffs which were correlated to K-Ah, AT, Kkt, Ss-Az and Ss-Pnk, respectively using the LTD-DHT Shaw method.

In addition to the data noted above, we have been conducting paleointensity measurements on 11 units (19 sites). To date, we have have collected samples from 16 units (30 sites) in total. We have obtained reliavle paleointensities from 9 unis (18 sites). On the other hand we have obtained no paleointensity estimate from 8 sites. In these sites, NRM-TRM1∗ plots are curved, where the correlation coefficient r_N is lower than 0.995. We considered that the cause for the curved NRM-TRM1∗ plots might be NRM, and checked the distribution of blocking temperature and coercivity. Two peaks are observed in the distribution of blocking temperature for the samples from the sites which gave the curved NRM-TRM1∗ plots, while a single peak is observed for the samples from the sites which gave the straight NRM-TRM1∗ plots. We are going to conduct rock magnetic measurements and discuss possible causes of the curved NRM-TRM1∗ plots.

Keywords: paleointensity, welded tuff, LTD-DHT Shaw method, blocking temperature, rock magnetism

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SEM36-12 Room:201B Time:May 19 12:15-12:30

Modelling the Earth's core from geomagnetic observations: toroidal magnetic field near the core surface

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The subject of this study is revealing the structure and dynamics of the Earth's core based on direct observations of the geomagnetic field. In this presentation, we report on an attempt to image the toroidal magnetic field near the core surface. The toroidal field may be predominant inside the core, and play a substantial role in spherical shell dynamos. It is desirable to know the toroidal field distribution for discussing the core dynamics, including the geodynamo. However, the toroidal field is absent at or above the Earth's surface. There is no straightforward way of envisaging the toroidal field in the deep Earth from magnetic observations, contrary to the poloidal field for which a simple downward continuation can be used.

In this work, we develop a method that takes advantage of the magnetohydrodynamics theory for observational imaging of the toroidal field. Inverse modelling of the core surface flow from a secular variation model has already been established by previous studies. Here, we perform the flow modelling while imposing the "tangential magnetostrophy" (TM) constraint (Asari & Lesur, 2011), so the horizontal Lorentz force may be computed from them. Then the poloidal component of the electrical current density is derived from the Lorentz force. Having this as a boundary condition at the core-mantle boundary, we eventually obtain the toroidal field by solving the induction equation in the mantle.

We implement the above procedure in the spectral domain, with all the involved parameters expanded in the spherical harmonics. For the main field model, GRIMM2 (2000.0-2010.0) built from CHAMP satellite data is adopted. The toroidal field imaging is subject to ambiguity, due to the non-uniqueness of the core surface flow modeling. We derive various images of the toroidal field by changing the flow constraint such that the subsequent TM flow models get gradually closer to tangential geostrophy (TG) flow.

The estimated models of poloidal current are assessed in reference to an output of numerical dynamo simulation, as there is otherwise little prior information about the core electrical current. When the TM flow models are close, to a certain extent, to TG flow, a characteristic pattern of the poroidal current appears that is much in common with that of the numerical dynamo. The current is concentrated in the low latitudes where geostrophy is relatively weak, and it has convergences/divergences elongated in parallel with the geographical equator. The TM flow models that are strongly magnetostrophic are regarded as ineligible, having significant current at high latitudes, with no noticeable similarity to the current pattern of the numerical dynamo. The toroidal field associated with the qualified TM flow model exhibits such a characteristic distribution that azimuthal flux dominates in low latitude zone. This is in consistency with the scenario of upwelling flows near the core surface; the intense poloidal field patches near the equator in the Atlantic hemisphere are caused by upwelling flows that distort the toroidal field into manifesting above the core surface.

Keywords: core, dynamo, geomagnetic field, satellite magnetic observation, core flow, inversion