Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

MTT06-01 Room:301B Time:May 24 09:00-09:15

The History and the Present Shape of Kakioka Magnetic Observatory

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[1]Yasuhiro MINAMOTO

Routine Geomagnetic observations in Japan were conducted by the Central Meteorological Observatory (CMO) in Tokyo from 1883 during the 1st International Polar Year (1882-1883). Because of deteriorations of observation conditions, CMO relocated the geomagnetic observatory to Kakioka in Ibaraki prefecture, about 75 km northeast of Tokyo in 1913. Therefore, Kakioka Magnetic Observatory (KMO) has the 100th anniversary of the foundation in January 2013.

Unfortunately all the written records stored at CMO before the Kanto Earthquake of 1923 and the geomagnetic records from January of 1917 to August 1923 were lost by the fire caused by the earthquake. Since the last century KMO has conducted several major and minor developments of magnetic observation instruments.

In 1950, KMO developed a new observation instrument that incorporated a temperature compensation function and achieved a remarkable improvement in variation observation accuracy, which replaced the conventional observation instrument. For absolute observation instruments, KMO developed the A-56 universal magnetometer in 1956.

In 1965, KMO installed the MO-P vector proton magnetometer to drastically enhance the quality of its absolute observation, probably making it world class at the time.

In 1976, the Kakioka automatic standard magnetometer (KASMMER) was installed. KASMMER allowed KMO to provide observation data values with a one-minute resolution. Furthermore highest time resolution data of KMO has been changed into three seconds in 1985 and one-second in 1987.

Today, KMO conducts variation observations with a high-sensitivity tri-axial fluxgate magnetometer, which outputs 0.1 second values. Although the fluxgate magnetometer is equipped with a monitoring device that checks inclination and temperature, the annual temperature variation is kept within 3^{o}C, and the inclination variation is also kept stable. While, magnetic disturbances generated by artificial sources are one of the most serious obstacles to maintain geomagnetic observations at Kakioka. Site of Kakioka is surrounded by residential land and farm, artificial disturbances such as those generated by vehicles, buildings, other magnetic bodies or construction work can affect observations. In order to deal with artificial disturbances, an advanced monitoring system has worked at Kakioka since 2008.

Keywords: Geomagnetic, Observatory, History, Kakioka

Japan Geoscience Union Meeting 2012
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MTT06-02 Room:301B Time:May 24 09:15-09:30

Application of realtime geomagnetic field data at World Data Center for Geomagnetism, Kyoto

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World Data Center for Geomagnetism, Kyoto (WDC Kyoto), which is operated by Data Analysis Center for Geomagnetism and Space Magnetism, Kyoto University, has been providing a leading data service for over 30 years. With the help of recent advances in computing, WDC Kyoto started to collect 1-min geomagnetic field data in quasi-realtime via the GMS satellite/the Internet from 1993. Kakioka magnetic observatory is one of the earliest observatories that transfer data in quasi-realtime. At present, even 1-sec geomagnetic field data are delivered from some observatories to WDC Kyoto with a few minute delay via the Internet. Such collected data are mainly used (1) to display geomagnetic field variations in realtime (i.e., to display realtime magnetograms), (2) to compute the realtime Dst and AE indices, and (3) to automatically detect a specific phenomenon related to substorms in realtime. These 3 products are available from the web page of WDC Kyoto (http://wdc.kugi.kyoto-u.ac.jp). In this talk, we will introduce the logistics of realtime data handling at WDC Kyoto and discuss its future perspective.

MTT06-03 Room:301B Time:May 24 09:30-09:45

Geomagnetic Sudden Commencement (SC) analyzed by using data of Kakioka Geomagnetic Observatory

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(1) A peculiar sudden commencement occurred in March 24, 1991. It was characterized by a large and short duration positive pulse in the very beginning part of the SC. The 1 sec H-component data at Kakioka showed 202 nT amplitude and about 1 min duration for this pulse. This is an abnormally large SC because the amplitude of usual SCs is less than 50 nT at Kakioka. The SC also produced instantaneously the strong inner radiation belt which lasted more than one year and clarified the importance of magnetospheric compression for acceleration of high energy particles. Being stimulated by this SC, we examined all SCs at Kakioka since 1924 and made a list of large amplitude SCs. The list showed that the March 24, 1991 SC is second largest and the largest SC occurred in March 24 (the same day!) , 1940. The H-component amplitude was 273 nT. This SC seems to be the historically largest SC since 1867.

(2) Most of people believed that the SC amplitude is larger in daytime than night time in low and middle latitude stations. Looking at the list of the large SCs, however, we noticed that the large SCs occur more frequently in nighttime than daytime. We made statistical analyses of diurnal variation of amplitude of SCs observed at Memambetsu (35.4 deg. geomag. lat.), Kakioka (27.4) and Kanoya (21.9) and confirmed that the SC amplitude at these stations really larger in night time than day time. We could interpret it in terms of geomagnetic effects of the field aligned current used in our SC model.

Keywords: geomagnetic sudden commencement(SC), SC diurnal variation, largest SC, field aligned current, Kakioka geomagnetic observatory

Japan Geoscience Union Meeting 2012
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MTT06-04 Room:301B Time:May 24 09:45-10:00

Application of high-time resolution geomagnetic data to diagnosis of neutral atmospheric waves in the upper atmosphere

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High-time resolution geomagnetic data such as 1 second sampling data have been used mainly for the study of geomagnetic pulsations of magnetospheric origin or for the study of conductivity anomalies by the analysis of the induction effects. After the Great Sumatra earthquake in 2004, it has become clear that the atmospheric disturbances also cause geomagnetic pulsations having some specific periods around 4 minutes through the vertical acoustic wave resonance between the Earth's surface and lower thermosphere. The resonance frequency may reflect the thermal structure of the atmosphere and the neutral wind in the upper atmosphere, and hence, the geomagnetic data could provide the information of the upper atmosphere and the acoustic gravity wave activity. On the other hand, precise magnetic measurements by low-altitude satellites such as the Champ or the Oersted revealed a ubiquitous existence of small scale field-aligned currents even in mid- or low-latitude on the day side, and most probably they are caused by the lower atmospheric waves such as the acoustic gravity waves or the internal gravity waves (see Nakanishi et al., EM32, this meeting). The precise and high-time resolution magnetic measurements at geomagnetic observatories show almost always very small amplitude oscillations with period around several minutes, and they could be the effect of the slowly varying field-aligned currents mentioned above and the ionospheric currents connected to the field-aligned currents. Therefore combining the ground and satellite data, geomagnetic diagnosis of neutral atmospheric waves in the upper atmosphere could be possible, and the stable and high-time resolution data from geomagnetic observatory may play an important role in the study of the upper atmosphere.

Keywords: geomagnetic field, high-time resolution, acoustic gravity wave, field-aligned current, mid and low latitudes, ionospheric dynamo

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MTT06-05 Room:301B Time:May 24 10:00-10:20

Geomagnetic detection of the sectorial solar magnetic field and the historical peculiarity of minimum 23-24

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Analysis is made of the geomagnetic-activity aa index covering solar cycle 11 to the beginning of 24, 1868-2011. Autocorrelation shows 27.0-d recurrent geomagnetic activity that is well-known to be prominent during solar-cycle minima; some minima also exhibit a smaller amount of 13.5-d recurrence. Previous work has shown that the recent solar minimum 23-24 exhibited 9.0 and 6.7-d recurrence in geomagnetic and heliospheric data, but those recurrence intervals were not prominently present during the preceeding minima 21-22 and 22-23. Using annual-averages and solar-cycle averages of autocorrelations of the historical aa data, we put these observations into a long-term perspective: none of the 12 minima preceeding 23-24 exhibited prominent 9.0 and 6.7-d aa recurrence. We show that the detection of these recurrence intervals can be traced to an unusual combination of sectorial spherical-harmonic structure in the solar magnetic field and anomalously low sunspot number. We speculate that 9.0 and 6.7-d recurrence is related to transient large-scale, low-latitude organization of the solar dynamo, such as seen in some numerical simulations.

Keywords: Geomagnetism, Magnetic observatory, Recurrent geomagnetic activity, Solar-terrestrial interaction, Solar wind, Solar dynamo

Japan Geoscience Union Meeting 2012
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MTT06-06 Room:301B Time:May 24 10:45-11:00

Numerical Conversion of Analog Magnetograms to High-resolution Geomagnetic Digital Data

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Geomagnetic observatories all over the world have recorded geomagnetic observation results onto photographic papers. But most of long-term geomagnetic observation results recorded as analog magnetograms have not yet been fully digitized. We developed a method to automatically convert analog magnetograms to high-time-resolution digital data. We applied our method to the observation records of Kakioka Magnetic Observatory (KMO) and confirmed that the resolution of time and amplitude could be greatly improved by numerical conversion compared with conventional data conversion by hand scaling. We have started numerical conversion of long-term analog magnetograms at KMO using this method.

Keywords: geomagnetism, digitization, magnetogram

Japan Geoscience Union Meeting 2012
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MTT06-07 Room:301B Time:May 24 11:00-11:15

Space weather studies based on magnetometer observations and simulations

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Ground magnetometer observations provide us with information about current systems in the magnetosphere and ionosphere during SC, PC, DP2, substorms and storms. The current circuit is composed of ionospheric currents, field-aligned currents, ring currents and so on. Combining the magnetometer data with model calculations, we may be able to identify the currents responsible for the ground magnetic perturbations and physical processes of the generation and transmission of the currents. Kakioka and Memambetsu are properly located for the study of the current systems developed during storm and substorms. Kakioka is far from the polar ionosphere and out of the equatorial region, which provides disturbances due to the magnetopause current and ring current. Memambetsu is located only 10 degs poleward of Kakioka, but the magnetic disturbances are well under influence of the ionospheric currents extending from the polar ionosphere and of the field-aligned currents. Furthermore, when we combine these stations with high latitude and equatorial stations, we obtain more realistic current systems in the magnetosphere and ionosphere. Magnetosphere-ionosphere current systems deduced from magnetometer data and simulations will be presented for several space weather events at the meeting.

Keywords: magnetometer observation, MHD simulation, ring current simulation, magnetosphere-ionosphere current system, geomagnetic storm, substorm

Japan Geoscience Union Meeting 2012
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MTT06-08 Room:301B Time:May 24 11:15-11:30

Long-term geomagnetic field observation at Syowa Station in Antarctica since 1966

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Syowa Station was established in January 1957 during the International Geophysical Year (IGY) at 69 deg.00'S and 39 deg.35'E on East Ongul Island, Lutzow-Holm Bay, East Antarctica. Geomagnetic field observation at Syowa Station using fluxgate magnetometer (H, D, Z components) and absolute value observation using proton magnetometer has been continuously operating since 1966. The geomagnetic field observation at Syowa Station is important for the study on geomagnetic disturbances associated with auroral activity and many other related phenomena. One of the interesting features using long-term observation is that the absolute geomagnetic field intensity is decreasing year by year. During the long history of geomagnetic observation at Syowa Station, the KAKIOKA Geomagnetic Observatory has been contributing to keep quality of magnetometer and to operate of the system. The KAKIOKA Geomagnetic Observatory is also contributing training of magnetometer for Antarctic expedition member at the site Kakioka observatory before leave for Antarctica.

Keywords: magnetic field, magnetometer, Syowa Station, Antarctica, aurora, magnetic storm

Japan Geoscience Union Meeting 2012
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MTT06-09 Room:301B Time:May 24 11:30-11:45

International key comparison of magnetic flux density standards in geomagnetic range

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Taking into consideration Resolution 4 of the 21-st CGPM(Confrence Gnrale des Poids et Mesures) concerning the need to use SI units in studies of Earth resources, the environment, human well-being and related issues and the fact that the Global Network of Magnetic Observatories has presently a worst case accuracy level of a few nanoteslas and that it is necessary to obtain an accuracy at the level of 0.1 nT we would like to ask for you support in organizing within the a key comparison of magnetic flux density (MFD) standards in the Earth Magnetic Field(EMF, Geomagnetic) range between 20 micro-tesla and 100 micro-tesla.

The result of this comparison will allow to assess and to implement the SI units based MFD standard in order to carry out calibration of the scalar magnetometers belonging to Magnetic Observatories with the use of the definition standards, and in order to obtain the corrections and to determine the measurement uncertainties for each magnetometer. This corrective action could increase the accuracy, if the stability of the instruments is higher than the correction. Also, the magnetic observatories that carry out the tests of magnetometric instruments will obtain ISO9001 certification for their test sites.

We are asking for your support in organizing and running the comparison campaign with 4 to 6 participating countries of the APMP(Asia-Pacific Metrology Program) region and we expect also participation in this comparison not only of the National Metrology Institutes (NMI), but also the Geomagnetic Observatories.

Keywords: key comparison, magnetic flux density, geomagnetic

MTT06-10 Room:301B Time:May 24 11:45-12:05

Automatic Magnetic Observatories with AUTODIF

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This talk will focus on the automated magnetic observatory and the instrumentation which could be of use there. The main obstacle remaining for automatic operation is the absolute determination of the magnetic Declination and Inclination, which the AUTODIF is able to perform and where up to now a human observer has to manipulate a nonmagnetic theodolite.

We will elaborate on:
- why are automatic observations useful?
- what could be the configuration of an automatic observatory (buildings, land requirements...)?
- description,
- performance and
- commercial availablity of the AUTODIF
- seamless intergration of magnetic variometer, proton magnetometer and AUTODIF

Keywords: Geomagnetism, Observatory, Absolute observations, Automatic observations

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MTT06-11 Room:301B Time:May 24 13:45-14:00

As to the landmark architectures in the Kakioka Magnetic Observatory

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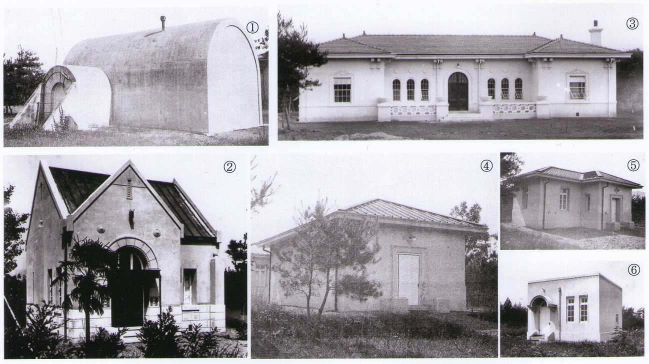
There are six landmark architectures in Kakioka Magnetic Observatory. In December 1912, the variation building (32square meters) was completed. It is the one-story building made of nonmagnetic granite which is characterized by its piled soil on its top (the previous ones those were the basement to avoid a change of the temperature). To endure soil pressure its roof has become the arch. In addition, inside of the building is divided finely into many rooms to reduce the temperature change. It is thought that these characteristics were affected by Observatory Rude Skov (Denmark). In May 1924, the new magnetic laboratory (38 square meters,) was completed. It is the one-story building made with a copper roof, the wall (0.5m) of the nonmagnetic brick and the front decorated with Jugendstil ornament. In August 1925, four new buildings were completed. The office building (215 square meters) of them is the one-story building made of steel reinforced concrete, accompanying an office, a reading room, a clock room, a seismometer room and so on. The roof of the red tile, the wall of a bright color, the window of the arch and the porch are all of Spanish design with the sash and eaves decorated with slightly classic ornaments. The buildings with Spanish design were popular in U.S in those days but rare in Japan. The new variation building (47 square meters) and absolute building (33 square meters) are the one-story house made with a copper roof and a wall (the former is 1.0m and the latter is 0.5m in thickness to reduce the temperature change) of the nonmagnetic brick. The electrometer hut (33 square meters) is also the one-story building made of steel reinforced concrete accompanying Spanish ornament. As to the designs of the office building and so on SadaJiro Sato was in charge, in entrustment of the Ministry of Education. These six landmark architectures of the Kakioka Magnetic Observatory are characterized by their purpose as the magnetic observation or the trend of architecture in those days. They constitute a unique scene in harmony with neighboring beautiful scenery in Kakioka.

Keywords: Magnetic Observatory, Kakioka, Nonmagnetic, Thick wall, Spanish



The landmark architectures in the Kakioka Magnetic Observatory
① variation building ② magnetic laboratory ③ office building
④ variation building(new) ⑤ absolute building(new) ⑥ electrometer hut

MTT06-12 Room:301B Time:May 24 14:00-14:15

Reevaluate of the baseline value in the early years of ”KAKIOKA”

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[1]Kakioka Magnetic Observatory, JMA

Secular variations of horizontal component of geomagnetic filed at Kakioka have step-like changes at 1924-1925, 1931 and a hill-like change of 20 nT at a period from 1941 to 1946. And also, hourly geomagnetic data is unstable in a period from 1924 to 1925. The geomagnetic records from January of 1917 to August 1923 were lost by the 1923 Kanto Earthquake.

We reevaluated the baseline values and hourly data of 1924 to 1946 from original data, such as field notes of magnetic absolute observation, observation notes of geomagnetic data, the magnetograms, and temperature data. We reprocessed for these data as follows.

1. Reexamine of the parameters in Gauss-Lamont method.
2. Revise the observation notes through the recalculate from original data written on the field notes.
3. Reexamine of the scale of magnetograms.
4. Redetermination of gap values.
5. Redetermination of the temperature coefficient in the variation observation data.
6. Recalculation of the observed baseline values and adopted baseline values.
7. Check and correct of reading values of variometer.

The hourly data obtained from this process were checked through the comparison with data at Niemegk, Honolulu, and Alibag.

The step-like changes of 1924-25 and 1931 disappear in the reevaluated secular change, but the hill-like change in 1941-46 remains. Although the values in 1946 remain the abnormal data, the hill-like change in 1941-42 is truth. It is possible that the variation in 1941-42 is magnetic jerk. This was pointed out as ”propagated variation from earth internal source” by Yanagihara (1976).

Keywords: Geomagnetic observation, baseline value, secular variation of geomagnetic field, geomagnetic jerk, Kakioka

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MTT06-13 Room:301B Time:May 24 14:15-14:30

Kakioka observatory data contribution to paleomagnetism

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Vigorous paleomagnetic measurements on natural volcanic rocks have revealed fascinating features of the geomagnetic field: for example, present-day field may be about twice the time average for the last 5 Myr (Yamamoto and Tsunakawa, 2005); field intensity was reduced to be about 10 percent of the present-day field during the last geomagnetic reversal (e.g. Mochizuki et al., 2011). They are deduced from thermoremanent magnetization (TRM) of the volcanic rocks, which is acquired when the rocks form.

Neel (1949, 1955) established a theoretical basis for TRM on non-interacting uniaxial single domain (SD) magnetic grain assemblages. For the assemblages, it is demonstrated that (1) TRM direction is parallel to the ambient geomagnetic field and that (2) TRM intensity is in linear proportion to the ambient geomagnetic field. It is expected that paleomagnetic measurements on volcanic rocks allow us to deduce not only the direction but also the intensity of the past geomagnetic field.

However, we have known that majority of natural volcanic rocks more or less suffer from non-ideality: for example, they contain interacting and/or large magnetic grains. To test how reliable paleomagnetic results from volcanic rocks are, we have been working on paleomagnetic measurements on Japanese historical lavas. Historical lavas are ideal ‘standard‘ materials because they formed when the IGRF (international geomagnetic reference field) model was effective: that is, we know the ‘answers‘. The ambient geomagnetic fields at the timing of the lava emplacements can be calculated by the IGRF model, particularly based on the Kakioka observatory data.

So far, we have obtained systematic results from the 1914 and 1946 Sakurajima lavas (Yamamoto and Hoshi, 2008) and the 1986 Izu-Oshima lava (Mochizuki et al., 2004). About the paleointensity (past intensity of the geomagnetic field) estimations, we applied the two different methods of Coe-Thellier (Thellier and Thellier, 1959; Coe, 1967) and Tsunakawa-Shaw (Shaw, 1974; Tsunakawa and Shaw, 1994; Yamamoto et al., 2003). These results indicate that (1) paleomagnetic directions can be deduced within the error (standard deviation) of few degrees and that (2) paleointensities can be estimated within the error of about 10 percent. However, old volcanic rocks usually have been weathered and it makes paleointensity experiments often more difficult.

One hundred years of geomagnetic observations at Kakioka have enabled such assessment of the reliability for paleomagnetic measurements on natural volcanic rocks. The observations at Kakioka contributes not only to geomagnetic study after the 20th century but also to paleomagnetic study back to millions years.

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MTT06-14 Room:301B Time:May 24 14:30-14:45

Magnetic observatory data - unique input for probing the Earth's mantle

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Geomagnetic fluctuations originating in the exterior of the Earth are the cause of electromagnetic induction phenomena in its interior. Using the relation between inducing (external) and induced (internal) field variations over periods ranging from several hundred sec and longer, we can infer the electrical conductivity distribution within the Earth's mantle. The field penetration depth (or the skin depth) approximately controls the depth of investigation. Electrical conductivity of materials composing the Earth's mantle highly depends on temperature, abundance of conducting materials such as fluids or melts, content of hydrogen in the lattice of minerals. Since these physical conditions are known to control the dynamic property, the knowledge of conductivity distribution is useful for understanding the deep mantle dynamics.

In the past, such a study began with an estimation of the mean value of the mantle conductivity. Then a number of attempts have been made to obtain one-dimensional profile of the mantle conductivity as a function of depth. Recently, efforts have been carried out to image the heterogeneous mantle conductivity in three-dimensions by inverting data from a number of magnetic observatories or observation stations. This presentation shows an overview of scientific results obtained in the past and the current status and possible future perspectives. Especially, it is emphasized that exploring down to the bottom of the lower mantle is still a difficult task, even when analyzing long time series provided by a few "one-century old" magnetic observatories in the world, as Kakioka celebrates nowadays.

Keywords: magnetic observatory, structure of the Earth, electrical conductivity, geomagnetic field variations, mantle

MTT06-15 Room:301B Time:May 24 14:45-15:05

The Earth's magnetic field: Where do we stand? Where do we go?

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[1]CNES, FRANCE

The Earth's magnetic field is by far the best documented magnetic field of all known planets. The convergence of many different approaches has led to considerable progress in our understanding of the geomagnetic field characteristics and properties. The usefulness of magnetic field charts for navigation has led to the compilation of the longest series of quantitative measurements in the history of science. One of them is provided by the Kakioka observatory, unique series in this part of the Globe, able to bring information about the temporal variations of the geomagnetic field. More recently, the Earth's magnetic field have been measured in much more details than was previously possible, by a few very successful space missions.

Here, an attempt is given for an overview of the current status in terms of observing, interpreting and understanding the behavior of the magnetic field produced within the Earth's core. Ground-base and satellite data are brought in, and the way they can be used to derive the temporal evolution of the core field is discussed. Interpretation of this behavior from very short timescales (less than one year) to those covered by direct measurements (a few centuries) is exposed. Finally, a status-of-the-art of the Swarm mission, scheduled for launch in 2012, is given. The three spacecraft will provide the most detailed data yet on the geomagnetic field of the Earth and its temporal evolution, giving new insights into improving our knowledge of the Earth's interior and climate.

Keywords: geomagnetic field, magnetic observatory, satellite observation, Earth's core, climate

MTT06-16 Room:301B Time:May 24 15:30-15:45

Contributions of the Geomagnetic Observations to Probes and Activity Monitoring of Volcanoes

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The island arc of Japan is located at subduction zones where the Pacific plate and the Phillipine Sea plate subduct beneath the Eurasia plate. Therefore, not only frequent large earthquakes but also very intensive igneous activities have been observed along the subduction zones, and volcanic front have been formed along the subduction zones. Such volcanic phenomena were caused by fluids released from the subducting slab, which are thought to have a strong influence on the generation of melt and magma transport. Under such circumstances, investigations on structures of volcanoes and monitoring of volcanic activities are very important for not only pure volcanology but also mitigation of volcanic hazards.

Geoelectromagnetic methods have contributed much to such volcanic researches mentioned above. For instance, local changes in the geomagnetic fields, which were generated by thermal changes in volcanoes, were observed in association with eruptions of Mt. Mihara in Oshima Island, Unzen volcano, Aso volcano, etc., and provided us very important information on understanding process of volcanic activities related with eruptions. Therefore, the results of these researches show that monitoring local geomagnetic changes around a volcano becomes one of the very important methods to monitor volcanic activities. Moreover, recently, some heliborne magnetic surveys above very near surface of a volcano, as well as geomagnetic continous observation at some sites on the ground of a volcano, have been made to reveal a temporal change in the magnetization structure in a volcano which might be generated by thermal changes in a volcano associated with volcanic activities. To detect temporal changes in geomagnetic anomalies associated with volcanic activities, regional and global secular changes in the geomagnetic fields should be clearly defined.

On the other hand, geoelectromagnetic methods have been also adopted to obtain an image of volcanic structure as an electrical resistivity (electrical conductivity) structure or a magnetization structure. For many cases of active volcanoes, and such as Mt. Kusatsu-shirane, Mt. Fuji, etc., electrical resistivity structures were revealed, in some cases, including magma supply system beneath volcanoes. In this kind of research, geomagnetic data are indispensable.

The researches using geoelectromagnetic methods mentioned above need high quality geomagnetic data having very broad spectral data set of time variations from much shorter periods to much longer periods which were produced for 100 years and will be produced for next 100 years by the Kakioka Observatory.

Keywords: geomagnetic field, electrical conductivity, electrical resistivity, volcano, magnetic anomaly, geomagnetic change

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MTT06-17 Room:301B Time:May 24 15:45-16:00

Geomagnetic secular changes in eastern Hokkaido

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1. Introduction Localized geomagnetic secular changes have been reported in the eastern Hokkaido, previously by repeat surveys, and more recently, by continuous recording (e.g., Oshima et al., 1994; Nishida et al., 2004; Hashimoto et al., 2010). In relation to a strong magnetic anomaly and along the southern coast of this area, Nishida et al. (2004) discussed the piezo-magnetic field due to stress accumulation by plate subduction. To elucidate the nature of such 'anomalous' secular changes in the total field, we started geomagnetic three-component absolute measurements.

2. Evaluation of the orientation effect Firstly, we evaluated the so-called orientation effect in the simple differential total field, which arises from the locality of magnetic inclination and declination at each station. The reference station that both we and previous studies used for the simple differential total field is Memambetsu magnetic observatory of Japan Meteorological Agency (MMB), which is 50 to 100 km away from our stations. Our absolute measurements revealed that the magnetic orientations at some stations were considerably (1 to 2 degrees) deviated from the one at MMB, and thus, this effect should not be neglected in discussion of long-term changes.

3. Effect of global-scale changes While correcting the orientation effect, we assessed an effect of global-scale secular changes by using the IGRF-11 model. We calculated secular changes in the total field at our stations and MMB from the IGRF model. Significant secular trend was found to remain in the differential field. As a result, considerable part of the observed field can be explained by this component. So the global change seems to contribute much to regional-scale secular changes in eastern Hokkaido. Deviated fields from the global-related secular term showed better agreement with the predicted piezo-magnetic field which was previously proposed by Nishida et al. (2004). However, it is still uncertain that the residual field is significant or not, as well as its origin. A mega-earthquake which will take place at the plate boundary in this region may be an opportunity to examine directly whether the deviated secular changes are of pezo-magnetic origin or not.

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Keywords: geomagnetic field, secular change, eastern Hokkaido, absolute measurement

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MTT06-18 Room:301B Time:May 24 16:00-16:15

Tsunami-induced magnetic fields observed at Chichijima magnetic station of Kakioka magnetic observatory

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Magnetic fields generated by the tsunami from 2011 Tohoku earthquake were observed at the magnetic station on Chichijima (Hamano et al. 2011). The tsunami signal was evident in vertical component of the magnetic field as quasi-periodic signals with periods of about 20 minutes lasting more than several hours. Comparison with the sea level change recorded at Chichijima tide station indicates that the waveforms are very similar in each other and the amplitude of the first wave of about 1.5 nT in magnetic field corresponds to the tsunami height of about 1 m. It is to be noted that the starting time of the magnetic variation is at 6:55 UTC, whereas the arrival time of the sea level change is at 7:15 UTC. This 20 minutes difference can be attributed to the delay of the tsunami signals at the tide station due to the shallow water area surrounding the tide station, whereas the magnetic field sense the electric current system outside the Chichijima, which is induced in the sea water by the motional induction effects due to tsunami flows. Distribution of the induced electric currents calculated from the numerical simulation of the tsunami propagation suggests that the electric currents flowing in the surrounding area extending about 100 km from Chichijima are responsible for the magnetic fields observed at Chichijima (Tatehata and Hamano, 2011).

At Chichijima, many tsunami arrivals have been reported, in which 18 tsunamis are recorded since 2000 by the tide gauge. We examined the tsunami-induced magnetic fields for these tsunami events by comparing 1-second interval geomagnetic field data sets and the tide gauge data sets with 15-seconds interval. The comparison shows that tsunami-induced magnetic fields are evident corresponding to the tsunamis from 7 earthquakes besides the 2011 Tohoku earthquake. These are 2010 Chichijima-kinkai, 2010 Chile, 2009 Iryan-jaya, 2007 and 2006 Kuril islands, 2004 Tokai-oki, and 2003 Tokachi-oki earthquakes. The result suggests that tsunamis with the maximum amplitudes greater than 30 cm in Chichijima tide gauge accompany observable magnetic field variations unless external magnetic field disturbances are too large. The conversion factor from the sea level change to the magnetic field is roughly ~1 nT/m at Chichijima. Close comparison of the waveforms of the sea level change and the magnetic fields indicates that arrival direction of the tsunamis affect the waveforms of the magnetic field variations. In case the tsunamis arrives from north-east or north-west direction, the waveforms of the first several hours of magnetic field variation resemble with the sea level change and the magnetic field variation starts earlier than the tsunami arrival time recorded at the tide gauge by about a few tens of minutes. On the other hand, waveforms of the magnetic field variations of tsunamis arriving from south or south-east direction, are different from that of the sea level change. This difference may suggests that the electric current system induced by tsunami flows, which is responsible for the magnetic field observed on Chichijima, depends on the arrival direction of the tsunamis.

Acknowledgement

The geomagnetic data used in this study are provided by Kakioka magnetic observatory of Japan Meteorological Agency, and the sea level data is measured and provided by the tide station on Chichijima operated by Japan Meteorological Agency.

Keywords: tsunami, geomagnetic field, motional induction, magnetic observatory, chichijima, Kakioka

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Seismo Electromagnetics; Review

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There have been accumulated a lot of evidence on electromagnetic phenomena associated with earthquakes (EQs), which might be promising for short-term EQ prediction. There include the lithospheric effect (geoelectric variation, geomagnetic variation, ULF emissions, etc.), atmospheric effects and ionospheric effects (VLF/LF propagation anomalies of lower ionospheric perturbation, F lay anomaly etc.)

In this talk we pay particular attention to the ULF (ultra-low-frequency) geomagnetic variations associated with EQs. We first show the famous three ULF events (Spitak, Loma Prieta, Guam EQs) and you can understand the typical temporal evolution of ULF magnetic variations in relation to an EQ. Then, we present some statistical results based on the world-wide observation. Finally, we propose what to do in this particular field in order to better understand the characteristics of seismo-ULF emissions.

Keywords: Seismo Electromagnetics, Earthquakes, Electromagnetic phenomena, ULF magnetic variation

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Earthquake-related ULF Phenomena in Kanto, Japan

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A passive ground-based observation of ULF (ultra low frequency) geomagnetic signatures is considered to be the most promising method for seismo-magnetic phenomena study due to deeper skin depth. In order to clarify the earthquake-related ULF magnetic phenomena, a geomagnetic network has been installed in Japan and plenty of data associated with moderate-large earthquakes have been accumulated. In this study, we have analyzed geomagnetic data observed during the past decade in Kanto area, Japan.

First, the ULF magnetic signals at frequency 0.01Hz have been investigated. We have applied wavelet transform analysis to the 1Hz sampling data observed at three magnetic observatories in Boso Peninsula and Izu Peninsula. The signature at 0.01Hz frequency band has been revealed and daily average energy has been computed. In order to minimum artificial noise, we only use the midnight time data (LT 1:00-4:00). And to remove influences of global magnetic perturbations, we have developed another method to obtain reliable background based on principal component analysis (PCA). Three standard geomagnetic stations (Memambetsu, Kakioka, and Kanoya) operated by the Japan Meteorological Agency have been selected as reference stations and PCA method has been applied to the yearly energy variation of the 0.01Hz signals at the three stations. The first principal component which contains more than 95% energy is considered to be global background.

After comparing the results at the stations with global background, it is found that there are several local energy enhancements which only appear in Boso or Izu area. Especially for the case studies of the 2000 Izu Island earthquake swarm and the 2005 Boso M6.1 earthquake, significant anomalous behaviors have been detected in Z components.

Finally, we have applied superposed epoch analysis to the above results and make a statistical study. The statistical results have indicated that before an earthquake there are clearly larger probabilities of anomalies than that after the earthquake. For Izu area, three weeks and few days before statistical value of anomalies is significant; for Boso region, around ten and few days before it is significant. Based on these results, we conclude that magnetic observations are important for geophysical study and may have potential advantages in short-term earthquake prediction.

Keywords: Seismo-Magnetic Phenomena, superposed epoch analysis, ULF magnetic phenomena, short-term earthquake prediction

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Importance of long term geoelectromagnetic data obtained at Kakioka geomagnetic observatory

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First, The time variation of the amplitude of geomagnetic Sq field was examined for each month in a long period of more than 75 years at Kakioka. It was found that the amplitude is strongly controlled by the solar activity, and the difference between solar cycles including their fine structures reflected in the Sq amplitude, but the seasonal variation of the amplitude in response to the solar activity cannot be simply explained by the conductivity effect. Although most of the effect of solar activity on the amplitude can be explained by the variation of the ionospheric conductivity. Next, long-term variation, including seasonal and local time variations, of the atmospheric potential gradient (PG) was investigated. PG was observed in all seasons to have decreased steadily since 1980, but the decrease was accelerated after 1997. On the other hand, seasonal variation of winter maximum was found through the period probably caused by the regional conductivity variation.

These long term variation is possible by the continuous geoelectromagnetic data of good quality such as provided by Kakioka magnetic observatory. Furthermore, continuous observation is important for the effect of a sporadic event such as the 2011 off the Pacific coast of Tohoku Earthquake.

Keywords: geomagnetism, daily variation, potential gradient, long term variation, seasonal dependence