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

MTT06-01 会場:301B 時間:5 月 24 日 09:00-09:15

柿岡地磁気観測所の歴史と現状
The History and the Present Shape of Kakioka Magnetic Observatory

源 泰拓 [1*]
MINAMOTO, Yasuhiro[1*]

[1] 源　泰拓
[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.

キーワード: 地磁気, 観測所, 歴史, 柿岡
Keywords: Geomagnetic, Observatory, History, Kakioka

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MTT06-02 会場:301B 時間:5 月 24 日 09:15-09:30

World Data Center for Geomagnetism, Kyoto におけるリアルタイム地磁気データの利用
Application of realtime geomagnetic field data at World Data Center for Geomagnetism, Kyoto

能勢 正仁 [1*], 家森 俊彦 [1], 竹田 雅彦 [1], 藤 浩明 [1]
NOSE, Masahito[1*], IYEMORI, Toshihiko[1], TAKEDA, Masahiko[1], TOH, Hiroaki[1]

[1] 京都大学大学院理学研究科地磁気世界資料解析センター
[1]Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto Uni.

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 会場:301B 時間:5 月 24 日 09:30-09:45

柿岡観測所のデータを用いた地磁気急始変化の解析
Geomagnetic Sudden Commencement (SC) analyzed by using data of Kakioka Geomagnetic Observatory

荒木 徹[1*]
ARAKI, Tohru[1*]

[1] 中国極地研究所
[1]Polar Research Institute of China

(1) 1991 年 3 月 24 日に，大振幅・短継続時間のパルスで特徴付けられる特異な SC が観測された．柿岡の H 成分１秒値は振幅 202nT，継続時間約１分を示した．定常観測の１分値データはこのような短いパルスを記録できない。柿岡の SC 振幅は普通 50nT 以下であるので，これは異常に大きな SC である．この SC は 1 年以上継続する強い放射線帯（内帯）を瞬間的に作り，磁気圏圧縮の荷電粒子加速への寄与の重要さを明確に示した．この SC に刺激されて，我々は 1924 年以降の柿岡の大振幅 SC のリストを作った．それは，この SC の振幅は 2 番目の大きさであり，最大振幅 SC（273nT）は 1940 年 3 月 24 日（同じ日！）に生じていることを示した．他のデータから，この SC は 1867 年以降最大の歴史的 SC であると推察される．

(2)　多くの研究者は，中低緯度の SC の振幅は昼に大きく夜は小さいと考えていた．しかし，我々は，上記の SC リストを見て大振幅 SC は夜に多く発生しているらしいことに気がついた．女満別，柿岡，鹿屋３点で観測された 600 以上の SC の振幅日変化統計解析を行った結果，実際に，夜の振幅が大きいことが確かめられた．これは，我々の SC モデルに使われる沿磁力線電流の磁場効果として解釈される．

キーワード: 地磁気急始変化 (SC), SC 振幅日変化, 最大振幅 SC, 沿磁力線電流, 柿岡地磁気観測所
Keywords: geomagnetic sudden commencement(SC), SC diurnal variation, largest SC, field aligned current, Kakioka geomagnetic observatory

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MTT06-04 会場:301B 時間:5 月 24 日 09:45-10:00

高精度・高時間分解能地磁気観測データを用いた超高層大気波動研究の可能性
Application of high-time resolution geomagnetic data to diagnosis of neutral atmospheric waves in the upper atmosphere

家森 俊彦 [1*]
IYEMORI, Toshihiko[1*]

[1] 京都大学大学院理学研究科
[1]Graduate School of Science, Kyoto University

毎秒値のような高時間分解能地磁気観測データは、主に地磁気脈動や、地球内部に誘導される電流を利用した電気伝導度異常の研究に用いられてきた。ところが、2004 年のスマトラ地震以降、下層大気の擾乱も、地球表面と下部熱圏の間の重力音波共鳴により、約４分前後の周期を持つ地磁気脈動を生じさせることが明らかになった。この共鳴周期は、主に大気の温度構造や、場合によっては超高層大気の風も反映していると考えられる。それゆえ、地磁気観測データから、超高層大気の状態や、大気中の重力音波あるいは内部重力波の発生状況についての情報を取り出すことができる可能性がある。一方、CHAMP 衛星や Oersted 衛星など、低高度衛星による磁場の精密観測から、中低緯度には、特に昼間側に微細な沿磁力線電流が常時流れていて、それらは下層大気中の重力音波や内部重力波起源である可能性が高い (中西他、当大会セッション EM32 参照)。地上においても、高精度・高時間分解能地磁気観測データは、数分周期の微小な振動を殆ど常に示しており、それらは、上に述べた、ゆっくりと時間変化する沿磁力線電流とそれにつながる電離層電流の効果を観測している可能性がある。それゆえ、地磁気観測所での高時間分解能地磁気観測データと、低高度磁場観測衛星による地磁気精密観測を組み合わせることにより、地磁気による超高層大気の診断が可能かもしれない。すなわち、地磁気の精密かつ高時間分解能観測は、超高層大気の研究においても重要な役割を果たす可能性がある。

キーワード: 地磁気, 高時間分解能データ, 重力音波, 沿磁力線電流, 中低緯度, 電離層ダイナモ
Keywords: geomagnetic field, high-time resolution, acoustic gravity wave, field-aligned current, mid and low latitudes, ionospheric dynamo

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MTT06-05 会場:301B 時間:5 月 24 日 10:00-10:20

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

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

Jeffrey Love[1*], E. Joshua Rigler[1], Sarah E. Gibson[2]
LOVE, Jeffrey[1*], E. Joshua Rigler[1], Sarah E. Gibson[2]

[1]USGS Geomagnetism Program, [2]NCAR High Altitutde Observatory
[1]USGS Geomagnetism Program, [2]NCAR High Altitutde Observatory

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.

キーワード: Geomagnetism, Magnetic observatory, Recurrent geomagnetic activity, Solar-terrestrial interaction, Solar wind, Solar dynamo
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 会場:301B 時間:5 月 24 日 10:45-11:00

アナログマグネトグラムの高時間分解能地磁気デジタルデータへの変換
Numerical Conversion of Analog Magnetograms to High-resolution Geomagnetic Digital Data

増子 徳道[1]*, 山本哲也[2], 芥川真由美[1], 源泰拓[1], 原昌弘[1]
MASHIKO, Norimichi[1]*, YAMAMOTO, Tetsuya[2], AKUTAGAWA, Mayumi[1], MINAMOTO, Yasuhiro[1], HARA, Masahiro[1]

[1] 気象庁地磁気観測所, [2] 気象研究所
[1]Kakioka Magnetic Observatory, Japan Meteorological Agency, [2]Meteorological Research Institute, Japan Meteorological Agency

世界中の地磁気観測所では長期間に亘り観測結果を印画紙へ記録してきた。しかし、それらアナログマグネトグラムとして記録された長期間の地磁気観測結果のほとんどは未だ十分に数値化されていない。我々はアナログマグネトグラムを自動的に高時間分解能のデジタルデータに変換する手法を開発した。我々は本手法を気象庁地磁気観測所の観測記録に適用し、従来の手作業による数値化に比べて時間及び振幅分解能を大いに向上できることを確認した。本手法を使用して、気象庁地磁気観測所の長期間のアナログマグネトグラムを数値化する作業を始めている。

キーワード: 地磁気, デジタイズ, マグネトグラム
Keywords: geomagnetism, digitization, magnetogram

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MTT06-07 会場:301B 時間:5 月 24 日 11:00-11:15

地磁気観測とシミュレーションに基づく宇宙天気研究
Space weather studies based on magnetometer observations and simulations

菊池 崇 [1*]
KIKUCHI, Takashi[1*]

[1] 名古屋大学太陽地球環境研究所
[1]Solar-Terrestrial Environment Laboratory, Nagoya University

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.

キーワード: 磁力計観測, MHD シミュレーション, リングカレントシミュレーション, 磁気圏電離圏電流系, 磁気嵐, サブストーム
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 会場:301B 時間:5 月 24 日 11:15-11:30

南極昭和基地での長期地磁気観測
Long-term geomagnetic field observation at Syowa Station in Antarctica since 1966

佐藤 夏雄 [1*], 門倉 昭 [1]
SATO, Natsuo[1*], KADOKURA, Akira[1]

[1] 国立極地研究所
[1]National Institute of Polar Research

南極の昭和基地は IGY（国際地球観測年）の 1957 年 1 月に開設された。昭和基地では 1966 年以来磁場観測はフラックスゲート磁力計による磁場３成分変動観測とプロトン磁力計による磁場強度観測を連続的に実施している。昭和基地での磁場観測データはオーロラ現象の研究等に重要な情報を提供している。この昭和基地での長期連続観測から、磁場の絶対強度は年々減少していることが明らかになっている。柿岡地磁気観測所は昭和基地の地磁気観測システムの精度維持や観測隊出発前の担当隊員の事前訓練などに大きな貢献をしている。

キーワード: 地磁気, 磁気計, 昭和基地, 南極, オーロラ, 磁気嵐
Keywords: magnetic field, magnetometer, Syowa Station, Antarctica, aurora, magnetic storm

Japan Geoscience Union Meeting 2012
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MTT06-09 会場:301B 時間:5 月 24 日 11:30-11:45

International key comparison of magnetic flux density standards in geomagnetic range
International key comparison of magnetic flux density standards in geomagnetic range

Park Po Gyu[1*], V. Ya. Shifrin[2], Wan-Seop Kim[1]
PARK, Po Gyu[1*], V. Ya. Shifrin[2], Wan-Seop Kim[1]

[1]Korea Research Institute of Standards and Science (KRISS), [2]D. I. Mendeleyev Institute for Metrology(VNIIM)
[1]Korea Research Institute of Standards and Science (KRISS), [2]D. I. Mendeleyev Institute for Metrology(VNIIM)

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.

キーワード: key comparison, magnetic flux density, geomagnetic
Keywords: key comparison, magnetic flux density, geomagnetic

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MTT06-10 会場:301B 時間:5 月 24 日 11:45-12:05

Automatic Magnetic Observatories with AUTODIF
Automatic Magnetic Observatories with AUTODIF

Jean Rasson[1*]
RASSON, Jean[1*]

[1]Institut Royal Meteorologique de Belgique, [2]none
[1]Institut Royal Meteorologique de Belgique, [2]none

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

キーワード: Geomagnetism, Observatory, Absolute observations, Automatic observations
Keywords: Geomagnetism, Observatory, Absolute observations, Automatic observations

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MTT06-11 会場:301B 時間:5 月 24 日 13:45-14:00

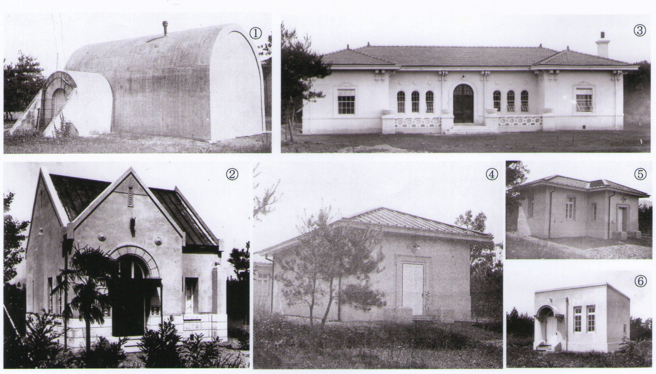
柿岡地磁気観測所構内の歴史的建造物について
As to the landmark architectures in the Kakioka Magnetic Observatory

西村 公宏 [1*]
NISHIMURA, Kimihiro[1*]

[1] 茨城県土木部都市局都市計画課
[1]City Planning Division, Ibaraki Prefectural Government

柿岡地磁気観測所には、6 棟の歴史的建造物が現存している。1912 年 12 月竣工の磁力変化計室 (32m^2) は、非磁性の花崗岩でできており、上に土が盛られている。それまでの磁力計室は、温度の変化を避けるために、地下室になっていたが、柿岡の自記磁力計室は、土を被せることにより、平屋建を実現している。土圧に耐えるため、屋根はアーチになっており、また、部屋を細かく区切ることにより、温度変化をさらに軽減している。これらの工夫はデンマークのルードスーコフ地磁気観測所の影響が窺われる。1924 年 5 月には、実験室 (38m^2) が竣工している。この建物は平屋建で、屋根は銅板葺、厚さ 0.5m の壁は非磁性レンガを積んでおり、正面にはユーゲントシュティル風の装飾が施されている。1925 年 8 月には、新しい建物が 4 棟竣工している。庁舎 (215m^2) は、鉄筋コンクリート造平屋建の建物で、事務室、図書室、時計室、地震計室等が設けられている。赤瓦葺の屋根、明るい色の外壁、アーチの窓や出入口、ベランダ等は、スパニッシュの意匠で、窓枠や軒には、やや古典的な飾りが見られる。これらは、当時のアメリカで流行っていた建築様式で、日本の庁舎では珍しいものである。また、新しい磁力変化計室 (47 m^2) 及び絶対観測室 (33m^2) は、屋根は銅板葺、壁は非磁性レンガの平屋建である。前者は温度変化を抑えるために、壁の厚さは 1m もあり、後者のそれは 0.5m である。さらに、空中電気室 (33m^2) は、鉄筋コンクリート造平屋建の建物で、一部、スパニッシュの意匠が見られる。なお、庁舎等の設計は文部省嘱託の佐藤貞次郎が担当した。このように、柿岡地磁気観測所の歴史的建造物は、磁力観測という用途あるいは当時の建築様式の影響を強く受けており、周囲の風光と調和しつつ、独特の景観を形成している。

キーワード: 地磁気観測所, 柿岡, 非磁性, 厚い壁, スパニッシュ
Keywords: Magnetic Observatory, Kakioka, Nonmagnetic, Thick wall, Spanish



柿岡地磁気観測所構内の歴史的建造物

① 磁力変化計室 ② 実験室 ③ 庁舎 ④ 新磁力変化計室 ⑤ 新絶対観測室 ⑥ 空中電気室

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MTT06-12 会場:301B 時間:5 月 24 日 14:00-14:15

「KAKIOKA」草創期の基線値再評価
Reevaluate of the baseline value in the early years of ”KAKIOKA”

外谷 健[1], 大和田 毅[1], 福井 敬一[1*]
TOYA, Takeshi[1], OWADA, Takeshi[1], FUKUI, Keiichi[1*]

[1] 地磁気観測所
[1]Kakioka Magnetic Observatory, JMA

柿岡の地磁気水平分力の永年変化図（年平均値の時系列）を見ると，1924〜1925 年，1931 年は段差的に急変しており，また，1941〜1946 年は 10〜20nT 程余分の磁場が加わったように盛り上がっている．毎時値の時系列でも初期の 1924〜1925 年は非常に不安定である．これら柿岡草創期 1924〜1947 年の観測結果を原記録に遡り精査し，地磁気水平成分の基線値，毎時値を再評価した．なお，柿岡で観測を開始した 1913 年から 1923 年までの観測原簿は，1923 年 9 月の関東大震災により失われた．

絶対観測野帳をはじめ観測原簿やブロマイドからの読取値，室温などの原記録を基にに，下記の処理を施し，現在，柿岡で行っている処理方法で毎時値を再計算した．

1．Wild-Edelman 磁気儀による Gauss-Lamont 法での常数の見直し
2．絶対観測野帳から再計算し，観測原簿を点検修正
3．変化計記録紙寸法値の見直し
4．ギャップ量の再決定
5．変化計における温度係数の再決定と補正のやり直し
6．観測基線値，採用基線値の再計算
7．変化計読み取り値の点検修正

このようにして得られた毎時値をニーメック (独)，ホノルル (米)，アリバーグ (印) の観測値と比較評価し，最終的な修正毎時値とした．

再評価された永年変化を見ると，1924〜1925 年，1931 年の段差的な急変は解消された．一方，1941〜1946 年の盛り上がりは解消されなかった．1946 年は観測基線値が不自然に大きく変動していることもあり，再精査が必要であるが，1941 年と 1942 年の盛り上がりは本物のようである． 1941〜1942 年の盛り上がりについては，柳原（1976）が指摘した「伝搬性地球内部原因磁場変動」，今で言うところのジャークである可能性がある．

キーワード: 地磁気観測, 基線値, 地磁気永年変化, 地磁気ジャーク, 柿岡
Keywords: Geomagnetic observation, baseline value, secular variation of geomagnetic field, geomagnetic jerk, Kakioka

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柿岡観測データの古地磁気学への貢献
Kakioka observatory data contribution to paleomagnetism

山本 裕二 [1*], 望月 伸竜 [2], 綱川 秀夫 [3]
YAMAMOTO, Yuhji[1*], MOCHIZUKI, Nobutatsu[2], TSUNAKAWA, Hideo[3]

[1] 高知大学, [2] 熊本大学, [3] 東京工業大学
[1]Kochi University, [2]Kumamoto University, [3]Tokyo Institute of Technology

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 会場:301B 時間:5 月 24 日 14:30-14:45

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

歌田 久司 [1*], 清水 久芳 [1]
UTADA, Hisashi[1*], SHIMIZU, Hisayoshi[1]

[1] 東京大学地震研究所
[1]Earthquake Research Institute, University of Tokyo

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.

キーワード: 地磁気観測所, 地球内部構造, 電気伝導度, 地球磁場変動, マントル
Keywords: magnetic observatory, structure of the Earth, electrical conductivity, geomagnetic field variations, mantle

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MTT06-15 会場:301B 時間:5 月 24 日 14:45-15:05

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

Mandea Mioara[1*]
MANDEA, Mioara[1*]

[1]CNES, FRANCE
[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.

キーワード: geomagnetic field, magnetic observatory, satellite observation, Earth’s core, climate
Keywords: geomagnetic field, magnetic observatory, satellite observation, Earth’s core, climate

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MTT06-16 会場:301B 時間:5 月 24 日 15:30-15:45

地磁気観測の火山構造探査や火山活動モニタリングへの貢献
Contributions of the Geomagnetic Observations to Probes and Activity Monitoring of Volcanoes

大志万 直人[1*]
OSHIMAN, Naoto[1*]

[1] 京都大学防災研究所
[1]Disaster Prevention Research Institute, Kyoto University

日本列島はプレートの沈み込み帯に位置し、太平洋プレートとフィリッピン海プレートの沈み込みに伴い、地震活動のみならず火山活動が非常に活発で、沈み込むプレートに沿って火山フロントを形成している。この火山の成因解明及びその活動度モニターは、地球科学の重要な研究テーマの一つである。

このような研究にこれまで地球電磁気学が果たしてきた役割は大きい。例えば、地球電磁気学的手法を駆使した火山活動のモニタリングに関しては、伊豆大島の三原山や、雲仙、阿蘇、有珠などで数多くの成果が上がっており、例えば、局所的地磁気変化のソースから火山活動にかかわるソースを明らかにしている。最近では、局所的地磁気変化により火山活動度をモニターする研究は、地表での多点での定点連続観測からヘリコプターなどによる空中磁気測量を用いた、モニターに発展しようとしている。そのような場合、リージョナルさらには全球的な地磁気変化の傾向を把握した上で、火山の作り出す磁気異常の時間変化を明らかにする必要がある。そのためには、今までにも増して良質な地磁気変化データを提供してくれる観測所の存在が重要になる。

また、火山構造を地球電磁気学的に明らかにするという点でも、草津白根や富士山をはじめ多くの火山で重要な情報を比抵抗構造（電気伝導度構造）として、また、磁化構造として提供してきており、火山浅部の熱水循環系や深部構造のマグマ供給系に係わるイメージジングが行われてきている。こういった研究においても磁場データは構造そのものを抽出する際に直接的に必要なだけではなく、研究対象地域での各種ノイズ除去のための参照磁場データとしても重要である。

従って、火山の時間変化に関わる研究においても、また、火山の空間構造に関わる研究においても、その研究の遂行のためには、柿岡地磁気観測所が長期間に渡り提供してきた、秒単位の短周期の変動から数年から数十年に渡る非常に長い周期帯の変動を広くカバーするスペクトルを持つワイドレンジで良質な地磁気データの存在は重要である。

キーワード: 地磁気, 電気伝導度, 比抵抗構造, 火山, 磁気異常, 地磁気変化
Keywords: geomagnetic field, electrical conductivity, electrical resistivity, volcano, magnetic anomaly, geomagnetic change

MTT06-17 会場:301B 時間:5 月 24 日 15:45-16:00

道東地域の地磁気永年変化
Geomagnetic secular changes in eastern Hokkaido

橋本 武志[1*], 茂木 透[1], 西村 三治[2], 有田 真[3], 清水 淳平[4], 井 智史[5], 源 泰拓[3], 長町 信吾[3]
HASHIMOTO, Takeshi[1*], MOGI, Toru[1], Mitsuharu Nishimura[2], ARITA, Shin[3], Jumpei Shimizu[4], Tomofumi I[5], MINAMOTO, Yasuhiro[3], NAGAMACHI, Shingo[3]

[1] 北大理・地震火山センター, [2] 気象庁札幌管区気象台, [3] 気象庁地磁気観測所, [4] 気象庁精密地震観測室, [5] 気象庁網走地方気象台
[1]ISV, Fac. Sci., Hokkaido Univ., [2]Sapporo District Meteorological Observatory, JMA, [3]Kakioka Magnetic Observatory, JMA, [4]Matsushiro Seismological Observatory, JMA, [5]Abashiri Local Meteorological Observatory, JMA

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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キーワード: 地磁気, 永年変化, 北海道東部, 絶対測量
Keywords: geomagnetic field, secular change, eastern Hokkaido, absolute measurement

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MTT06-18 会場:301B 時間:5 月 24 日 16:00-16:15

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

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

浜野 洋三 [1*], 舘畑 秀衛 [2], 市原 寛 [1]
HAMANO, Yozo[1*], TATEHATA, Hidee[2], ICHIHARA, Hiroshi[1]

[1] 海洋研究開発機構, [2] 気象庁
[1]JAMSTEC, [2]JMA

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

Japan Geoscience Union Meeting 2012
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MTT06-19 会場:301B 時間:5 月 24 日 16:15-16:30

地震電磁気； レビュー
Seismo Electromagnetics; Review

早川 正士 [1*]
HAYAKAWA, Masashi[1*]

[1] 電気通信大学　先端ワイヤレスコミュニケーション研究センター
[1]The University of Electro-Communications, Advanced Wireless Communications Research Center

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.

キーワード: 地震電磁気, 地震, 電磁気現象, ULF 磁場変動
Keywords: Seismo Electromagnetics, Earthquakes, Electromagnetic phenomena, ULF magnetic variation

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MTT06-20 会場:301B 時間:5 月 24 日 16:30-16:45

Earthquake-related ULF Magnetic Phenomena in Kanto, Japan
Earthquake-related ULF Phenomena in Kanto, Japan

服部 克巳 [1*], Han Peng[1], Febriani Febty[1], 石黒 雄基 [1]
HATTORI, Katsumi[1*], HAN, Peng[1], FEBRIANI, Febty[1], ISHIGURO, Yuki[1]

[1]Graduate School of Science, Chiba Universtiy
[1]Graduate School of Science, Chiba Universtiy

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.

キーワード: Seismo-Magnetic Phenomena, superposed epoch analysis, ULF magnetic phenomena, 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
Importance of long term geoelectromagnetic data obtained at Kakioka geomagnetic observatory

竹田 雅彦 [1*]
TAKEDA, Masahiko[1*]

[1] 京大・理・地磁気世界資料解析センター
[1]Data Analysis Center for Geomag. & Space Mag., Grad. School of Sci., Kyoto Univ.

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