Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SEM037-P01 Room:Convention Hall Time:May 26 14:00-16:30

Piezomagnetic fields arising from the propagation of teleseismic waves in magnetized crust with finite conductivity

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To determine whether the piezomagnetic effect is a plausible mechanism in explaining variations in the magnetic field that occur synchronously with the propagation of teleseismic waves, a set of solutions are derived for the electromagnetic field. The situation is considered in which the Earth's conductivity has a stratified structure and seismic waves are expressed as a plane wave. The piezomagnetic field in this situation is expressed by an analytically closed form. Using the obtained solution, quantitative aspects of the piezomagnetic field that accompanies seismic Rayleigh waves with an amplitude of 1 cm are discussed. It is shown that the finite conductivity of the Earth's crust sometimes acts as an enhancer of the magnitude of the piezomagnetic field. However, the expected piezomagnetic field is substantially small. Even in the case that the initial magnetization around the observation site is as large as 5 $Am^{?1}$, the expected amplitudes in the piezomagnetic field are at most 0.1 nT. This result means that the piezomagnetic effect is not a reasonable mechanism to sufficiently explain variations in magnetic fields that occur synchronously with ground motions, if the initial magnetization is horizontally uniform.

Keywords: Rayleigh wave, piezomagnetic effect, electrical conductivity, electromagnetic field, enhancement

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Characteristics of frequency transfer function between electric field and ground velocity for natural earthquakes

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Several mechanisms have been proposed to account for electromagnetic field variations associated with earthquakes, but most of them are insufficient in explaining characteristic variations observed at the time of seismic-wave arrival. A new mechanism called the seismic dynamo effect has been attracting considerable attention. It claims electric field generation due to the resonance-like motion of ions contained in groundwater excited by seismic wave under the Earth's magnetic field. Although this mechanism is found to be successful in explaining an observational feature of circular polarization of horizontal electric field variation (Honkura et al., 2009), more convincing evidence is still required. For verification of this mechanism, we analyzed data acquired for earthquakes in the vicinity of Wakuya in 2009 and 2010, aftershocks of the 2007 Noto Hanto Earthquake, and aftershocks of the 2008 Iwate-Miyagi Nairiku Earthquake, in terms of transfer functions between the ground velocity as the input and the electric field as the output. To estimate transfer functions, we used data recorded by a short-period seismometer of velocity type and two pairs of Pb-PbCl2 electrodes with data loggers. The sampling rate was 200 Hz. The dipole length was in the range between 15 m and 20 m in both the NS and EW directions.

In the case of aftershocks of the 2007 Noto Hanto Earthquake, we stacked transfer functions for five aftershocks, and then clear peaks appeared at frequencies lower than expected from the mechanism. This result made us realize the necessity of considering the boundary condition at the ground surface. The electric field generation in this case stems from three ions in groundwater: HCO3-, Cl- and Na+. In the case of earthquakes in the vicinity of Wakuya in 2009 and 2010, we estimated the averaged transfer function from 19 datasets. Although the result turned out to be unclear, we could interpret it in terms of the same mechanism operative in a deep groundwater layer together with the ground However, a problem of anisotropy still remains. On the other hand, stacking of transfer functions for 19 traces from 16 aftershocks of the 2008 Iwate-Miyagi Nairiku Earthquake yielded smoother transfer functions, but definitive characteristics were not found, although some groundwater layers seem to be responsible for complicated characteristics, particularly at frequencies higher than 22 Hz.

Keywords: the seismic dynamo effect, electric field variation, earthquakes

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Effect of solar daily variations on MT and GDS signals

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One-dimensional (1-D) electrical conductivity profiles of the oceanic mantle beneath the Pacific Ocean often show a peak in asthenospheric depths irrespective to ages of the seafloor above it (e.g., Lizzaralde et al., 1995; Toh and Motobayashi, 2007; Baba et al., 2010). It, therefore, might be interpreted as a ubiquitous feature of the oceanic mantle, whose cause can be attributed to onset of partial melting, presence of water or a combination of both. However, a so-called 'semi-global reference' electrical conductivity model for the North Pacific Ocean (Utada et al., 2003) lacks in the asthenospheric conductor.

Although their reference model based only on periods longer than 1 day, one may argue that the reference model is valid even for asthenosphric depths because their data are free from noises in electromagnetic (EM) responses by solar daily variations (e.g., Sq). Utada et al. (2010) claimed that magnetotellutic (MT) responses without pertinent removal of Sq noises possibly contain fictitious curvature in the tidal band to give a false peak in the asthenosphere. On the other hand, it is also true that any 1-D electrical conductivity inversions without MT responses have little sensitivity in the upper mantle depths. It, therefore, is still an open question whether the asthenospheric conductor is only a fictitious image due to Sq noises or a real fact revealed by the seafloor MT data. It is required to find a proper correction method for the Sq noises in order to bridge the gap between the MT band and the geomagnetic depth sounding (GDS) band, the latter of which is originated from long-period ($>$ 2 days) temporal variations of the magnetospheric ring current.

To test the effect of solar daily variations on seafloor MT responses, we used a very long ($>$ 3 years) time-series observed by a seafloor geomagnetic observatory (Toh et al., 2004; 2006) in the Northwest Pacific Ocean (NWP). The 1-D electrical conductivity profile beneath NWP is known to be associated with an asthenospheric conductor with a peak depth and conductivity of ~200 km and ~0.1 S/m, respectively. Although the 1-D electrical model is based on an EM time-series carefully detided by BAYTAP-G (e.g., Tamura et al., 1991), we applied a new Sq removal method that subtracts a mean Sq variation estimated from the international five quietest days of each month (http://www-app3.gfz-potsdam.de/kp_index/quietdst/qd20000x.html) to the original time-series. We compared the new time-series with our former time-series in terms of power spectra, EM response functions and 1-D electrical conductivity profiles.

It was found that even though the Sq noises can affect the MT responses to some extent, it is difficult to deny the presence of the asthenospheric conductor. However, it was also shown that the conductor may have different quantitative features in terms of the peak depth and conductivity. It will be further argued whether it is appropriate to subtract Sq, i.e., the solar daily variations on quiet days, or SD (the solar daily variations on disturbed days).

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Preprocessing of Network MT electric field data contaminated by leak currents to obtain the accuracy MT response

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We report a preprocessing method of Network-MT electric field data affected leak currents for obtaining the accuracy MT response. In general, it is difficult to obtain the accuracy MT response using Network-MT electric field data contaminated by leak currents produced by DC railways. We have obtained more accurate MT responses using multivariable analyses (PCA and FA) utilizing characteristics of Network-MT method as the preprocessing method.

Keywords: MT response, Network-MT data, leak currents, multivariable analysis

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Preliminary report on a 2D resistivity structure in the middle-western part of Tottori Prefecture, southwest Japan

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The purpose of this study is to estimate an electrical resistivity structure beneath the Middle-western Tottori prefecture in the eastern part of Sanin regions, southwestern Japan in order to clarify the relationship between deep crustal conductors and the seismicity in these regions. In this presentation, a preliminary report on a investigations of this study and a two-dimensional resistivity structure beneath these regions, based on the result of the wide band MT observations carried out from fall to winter of 2009, is given.

Our research group has shown that there is a clear relationship between resistivity and seismicity in the Sanin and Shikoku regions. We investigated deep crust resistivity structures in the measurement lines that traverse a linear seismic activity area along with the coastal part of Japan Sea, including Yoshioka and Shikano seismic fault of Tottori earthquake in 1943, M7.2 and the epicenters of the remarkable earthquakes in the eastern part of San-in region, for example, Western Tottori earthquake in 2000, M7.3, and so on. As the result, in the eastern part of San-in region, it was found that a conductive area exists in the deep crust part under the seismic region, which is a resistive area, along with the seismic activity area stretching nearly in the east and west direction. These studies suggest that high conductivity is possibly caused by the existence of deep crustal fluids, which probably play an important role in the inland earthquake occurrence mechanism of these regions.

Wide-band MT observations were carried out from fall to winter of 2009 along a N-S line in the middle-western Tottori, where the Middle-western Tottori earthquake (Mj5.3) occurred in 2002. This area is also a western extension part of the seismic activity zone of Tottori earthquake in 1943, and Central Tottori earthquake in 1983, and is located in the eastern side of a seismic gap of the quaternary volcano Mt. Daisen.

An investigation was carried out from the beginning of November to the end of it in 2009. A total of 5 Phoenix measurement devices were used to observe three geomagnetic field and two electric field components. The numbers of observation points were eight in total. Unfortunately, a remarkable geomagnetic disturbance could not be recorded during the observation. A Preliminary 1-D model shows that there is a resistivity boundary in the crust beneath this area. However, the clear relationship between resistivity and seismicity in other Sanin regions may not have been found here as mentioned above. In this presentation, a preliminary report of 2-D resistivity modeling performed will be shown.

We would like to express sincere gratitude for the Nittetsu Mining Consultants Co. Ltd. kindly let us use their continuous geomagnetic records as remote references. This study was supported by the Ministry of Education, Culture, Sports, Science and Technology of Japan, under its Observation and Research Program for Prediction of Earthquakes and Volcanic Eruptions. Last of all, we would like to express our thanks to S. Tamai, S. Higashi, Y. Yamamoto, S. Ota and T. Kumada, geospheric structure and dynamics of Tottori University for their help during data acquisition.

Keywords: resistivity, MT, Tottori Prefecture, San-in region

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Resistivity Structure Analysis beneath the Eastern Marmara Sea by 2D OBEM Modeling.

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In this study, we perform Magnetotelluric method (MT hereafter) in the Sea of Marmara which is an inland sea located at north western Turkey as different from previous marine electromagnetic studies performed in open oceans. Turkey is seismically very active country that has hosted large destructive earthquakes throughout the history. Westward migration of big events along the North Anatolian Fault Zone (NAFZ), one of the main fault zones in the region of interest, and occurrence of the last two demonstrative earthquakes (Mw7.4 Izmit and Mw7.2 Duzce, 1999) at the eastern edge of the Sea of Marmara indicate that the next big event is most likely expected to occur at the Sea of Marmara. Previous MT studies clearly show the relation between the seismicity and resistivity variation near fault zones. Such as, generally the big earthquakes occur at asperity zones where high wave velocities and high resistivities are observed and locations of the fault zones widely overlap the resistivity transition zones. In order to reveal the extension of the NAFZ and crustal structure within the Sea of Marmara, Ocean Bottom Electromagnetic (OBEM) data at 16 sites were collected during three campaigns between 2008 and 2009. Site locations were arranged in accordance with 3D and 2D modeling. Chave and Thompson code (1987) was applied in order to obtain transfer functions from continuous electric and magnetic fields (three components). Strike analysis for east two profiles show almost 90 and 70 degree strikes for the long (P1) and short (P2) profiles respectively. These strikes are consistent with possible trace of the NAF around the Cinarcik Basin. Comparison of 3D and 2D forward modeling results demonstrates significant effect of the bathymetry on the data set. However, these effects are almost same in TM case and similar in TE that provides us to trust 2D modeling at least for TM mode. We performed 2D inversion modeling using Ogawa and Uchida (1996) code modified by us to account for the bathymetry effects on the measurements. According to 2D inversion results, there is a high conductivity anomaly located at a depth of upper mantle and bounded with resistive zones at the north and south beneath the eastern Marmara Sea. In this presentation, we show the OBEM data analysis and relation of the results with the structure beneath the Sea of Marmara.

Keywords: Sea of Marmara, North Anatolian Fault Zone (NAFZ), Ocean Bottom Electromagnetic (OBEM), Magnetotelluric, Resistivity

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Preliminary result of OBEM survey around the Japan Trench

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Japan Trench system is an interesting scientific research field to understanding subduction processes including interplate earthquakes and volcanic activities. We conducted natural source electro-magnetic surveys around Japan Trench using newly developed small ocean bottom electro-magnetometers (OBEMs) (Kasaya et al., 2009). The small OBEM consists of a 17-inch glass sphere involving data logger and battery, sensor unit (fluxgate magnetometer, tilt meter and thermo meter) in a small metallic pressure housing, and electrode arm unit with arm-folding system. The electrode arms are folded during surfacing, which enable easy recovery operation. 24bit and 16 bit AD converters are included for the electric field and the other measurements, respectively. Sampling rate can be settled between 0.125 and 240 seconds. The rate can be switched during observation, which enable to obtain wide-band MT/GDS responses.

We deployed the 6 small OBEMs and 5 conventional OBEMs across Japan Trench from 900m to 6000m deep during 2009-2010. In addition, 4 or 5 small OBEMs will be deployed in 2011. High quality data were obtained in some stations although geomagnetic disturbance had been weak. Preliminary analyses imply strong bathymetric and coastal effects in the MT/GDS responses. These effects will be deeply discussed in the presentation for 2-D/3-D resistivity modeling.

Keywords: magnetotelluric, subduction zone, OBEM, Japan Trench

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Three-Dimensional Crustal Resistivity Structure beneath Kanchanaburi province, Western Part of Thailand

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Kanchanaburi province located in the western part of Thailand (about 150 km from Bangkok) consists of two major fault zones: the NW-trending Three Pagodas Fault (TPF) and Sri Sawat Fault (SSF) zones. Both have produced large earthquakes in the past according to the paleoseismic studies. Two big earthquakes (5.3 and 5.9) in 1983 on the SSF zone were detected after a year of completion of the big hydroelectric power dam. During the December 2009 to February 2010, thirty nine stations were deployed covering most of the area of Kanchanaburi province and its fault zones. Phase tensor analysis reveals that the data is mostly 3-D. Three-dimensional inversion is therefore conducted with WSINV3DMT with data from 160 Hz to 200 s. Shallow part of the 3-D resistivity structures is consistent with geology of Kanchaburi. The L-shape conductor producing the phase greater than 90 degree can be observed in the north-western part at mid-depth. Both fault zones can be clearly seen from the 3-D resistivity model. The TPF zone appears to be vertical fault extending deep to the Moho. The SSF zone appears to be a thrust-fault dipping at about 60 degree and end at about 15 km depth. This indicates that the two big earthquakes on SSF were shallow earthquakes and reservoir induced.

Keywords: Magnetotelluric, 3D modeling, Crustal Resistivity Structure, Kanchanaburi

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3D magnetic structure of Sakurajima-volcano and Aira caldera.

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In 2007, we carried out the aeromagnetic survey on Sakurajima volcano and Aira caldera to clarify the subsurface magnetic structure. This survey was conduced as a part of the Joint Observations of Sakurajima Volcano in 2007. On this campaign, various surveys, such as geodetic, geothermal, geochemical and geomagnetic surveys were done under the cooperation of the researchers at the university and institute of Japan. On our survey, we made helicopter-bone aeromagnetic mesurment with sampling time of 0.1 sec and observation area was NS22.5 x EW 16.5km area which include Sakurajima volcano and most part of Aira caldera. Total ?ight distance was about 2000km. From the obtained data, we tried to investigate the subsurface magnetic structure beneath Sakurajima volcano and Aira caldera by 3-D inversion. On this calculation, we used the iterative inversion scheme with minimum support stabilizing developed by Portniaguine and Zhdanov (2002). In our presentation, we will show the results of our 3D inversion.

Keywords: aero magnetic survey, 3D magnetic structure