Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SEM36-P01 Room:Poster Time:April 30 18:15-19:30

Long-term variation of geomagnetic transfer function in Japan

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Time variation of geomagnetic transfer function in Japan was studied for long period of since 1985. Most of the long-term variation is common at most observatories, and some of then are due to the solar activity. However, different behavior of the variation was found at some observatories, which may be caused by time variation of the local conductivity structure in the earth.

Keywords: geomagnetism, transfer function, long-term variation, induced current, locality

SEM36-P02 Room:Poster Time:April 30 18:15-19:30

Numerical simulations for the electrical prospecting of the rock samples

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For the purposes of oil explorations and surveys of active faults, electrical and electromagnetic methods are powerful tools to reveal the underground properties, since the resistivity images have high sensitivity to the existences of the fluid. Obtained resistivity images are interpreted in relation to the porosity of rock and its connectivity with several mixing lows. In order to verify the applicability of such interpretations, we plan to carry out high-density electrical soundings for hand size rock samples whose other geological characteristics are well known.

As the first step of laboratory experiments, we made numerical simulations to estimate the optimal electrode arrangement and the scale of detectable anomalies. In this presentation, we will report the results of numerical simulations and the future plans of laboratory experiments.

Keywords: rock experiments, electrical conductivity, numerical simulations

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Volcano-Loop observation at Kusatsu-Shirane volcano

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We have made successful measurement of time domain electromagnetic signals using transmitting and receiving loops at the same location. This system is being planned to work for monitoring the volcano vent.

The test measurement was conducted in the Kusatsu-Shirane volcano where detailed resistivity structure is known by audio-magnetotelluric method. The stepwise waveform was used and off-time response was measured using a transmitting and receiving loop both with 33m radius. The induced voltage was measured from the 0.1ms to 30ms. The observed voltages as a function of time in logarithm were inverted using Occam's algorithm and the model resistivity and resolution of the model were investigated. We also compared the result with those obtained by magnetotelluric method and found that the upper surface layers which have 1d structure are consistent with volcano loop results. We plant to use the system for repeated measurements or continuous monitoring the volcano in the future.

Keywords: Electromagnetic induction, time domain, loop, volcano, monitoring

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Electrical conductivity structure beneath the Gomura Fault (Kyotango, Kyoto)

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Fault zone architecture and related permeability structures form primary controls on fluid flow in upper-crustal, brittle fault zone. As the electrical resistivity of rocks is sensitive to distributions of fluids, the magnetotelluric (MT) method can be a powerful tool in investigating the fault zone architecture.

The Yamada Fault is located in Kyoto, Japan. The Yamada Fault zone consists of the main part of the Yamada Fault zone and the Gomura Fault zone. The Gomura Fault zone extends over 34 km and can be grouped into the Gomura Fault, the Chuzenji Fault and so on. The Gomura Fault appeared as a result of 1927 Tango earthquake.

In oreder to delineate subsurface structure of the fault, we made an audio-frequency magnetotelluric survey at 12 stations along the transect (4 km) across the surface trace of the Gomura Fault. The MT response function was obtained at each station, using remote reference processing. After dimensionality analysis by Phase Tensor method (Caldwell et al., 2004; Bibby et al., 2005), two-dimensional inversions for TE and TM modes were carried out, using the code of Ogawa and Uchida (1996).

The model is characterized by two resistive zones and four conductive zones. The most significant conductive zone is recognized beneath the surface trace of Gomura Fault with a width of more than 650 m and located in a depth range of 0.45-1 km. It is noteworthy that the conductive zone beneath the Gomura Fault is comparable in width to the damage zone determined by geological survey.

Keywords: The Gomura Fault, electrical resistivity structure, Magnetotelluric(MT), Damage zone

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A Summary report on the investigations of an electrical resitivity structure beneath Chugoku and Shikoku regions, south

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The purpose of this study is to estimate crossing and longitudinal electrical resistivity structure sections in the southwest Japan arc in order to clarify the relation between the deep crustal low resistivity region and seismic activities. Therefore, based on the investigation research of the electrical resistivity structures in Japan arc and the southwest Japan arc, in Sanin region, it is important to clarify the relation between earthquake occurrences out of the strain concentration zone, volcanoes not having eruption records for a long time and crustal fluid, and to find the structural heterogeneity in the inland earthquake occurrence area, the inland seismic gap (beneath the third class and quaternary volcano) and deep low frequency earthquakes. In Shikoku region, it is also important to find the relation between the occurrence pattern and structural locality of crustal earthquakes and deep low frequency earthquakes and the fluid supposed to be supplied from ocean plate subduction.

Our research group has shown that there is a clear relationship between resistivity and seismicity in the Sanin and Shikoku regions. We investigated deep crustal resistivity structures in the measurement lines that traverse a linear seismic activity area along with the coastal part of Japan Sea. 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

However, Ozaki et al.(2011) showed that the crust has generally a high resistivity in the earthquake occurrence region in the middle-west part of Tottori pref. (2002, Mj5.3). This observation fact conflicts with the model advocated by the group including the author that has studied electrical resistivity in Sanin region. That is, there is a possibility that the deep low resistivity area beneath the Sanin region does not exist in series. Assuming that inland earthquakes occur because of local stress concentration caused by heterogeneity beneath a seismic activity band (Iio, 2009), the heterogeneity should be clarified by a spatial and structure analysis, and a more detailed surfacial structure data should be completed hereafter.

On the other hand, in the Shikoku region, the same investigation was carried out mainly in the outer zone, the south side of MTL and the result suggested that a remarkable conductive area should exist in the upper crust of the outer zone, and that the conductive area in the central and western part should have a clear relation with the non-seismic area.

These studies suggest that high conductivity(low resitivity) 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. As one of the possible interpretations of water supply system, it is thought that the fluids in the deep crust are supplied from the subducting Philippine Sea plate by means of the dehydration processes. However, the existence of the plate is not thoroughly identified in the geological inner zone of the southwestern Japan Arc. Therefore, in order to grasp a whole tectonic setting, from the fore to the back arc side in the southwestern Arc, quantitative discussions based on the wideband MT survey covering whole these regions should be required. Consequently, for making the island arc crossing structure section in the southwest Japan arc, an additional structure investigation in the unmeasured area, the area of Setouchi as the main area is required to clear the northern edge of Philippine Sea plate.

In this presentation, the summary report on joint structure analysis result in Chugoku and Shikoku regions and key features of spatial resistivity distributions in these regions, using the recent data acquired in the Seouchi area incorporated in the existing data, will be shown.

Keywords: electrical resistivity, Chugoku and Shikoku regions, heterogeniety

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Electrical resistivity features of the back-arc areas in the NE Japan subduction zone

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Electrical resistivity in the crust and upper mantle depends on the pore-fluid distribution, salinity, and connectivity of fluid-filled rock pores. Thus imaging of resistivity distribution based on magnetotelluric surveys gives us fundamental information about fluid distribution of subduction zones. Marine magnetotelluric survey is important to understand dynamics of the NE Japan subduction zone because dehydration of subducting Pacific plate occurs under the Japan Sea. In this study, we discuss resistivity distribution around back-arc areas in the NE Japan subduction zone based on the marine MT data.

We collected natural EM signals with ocean bottom electro-magnetometers (OBEMs) in the eastern Japan sea area between April and August 2013 by MR13-02A and NT13-18 JAMSTEC scientific cruises. In addition, 3 land MT stations were settled in islands in the Japan Sea (Tobishima, Awashima and Sado islands) between April and October 2013. These recorded time-series data were converted to a frequency-domain impedance tensor based on the BIRRP program [1]. The remote reference technique [2] was applied in the data processing using horizontal magnetic field data from Kakioka Station in the period range between 10 and 20000 seconds. As results, high-quality MT responses and geomagnetic tippers in both the trench and back-arc areas.

We calculated phase tensors [3] based on MT impedances by this and previous studies [4] to discuss re-sistivity distribution beneath the back-arc area. The phase tensor ellipse indicates high Φ_{max} (>65 degrees) and Φ_{min} (>50 degrees) in the long periods (>8000 seconds). Large β of phase tensor and large amplitude of geomagnetic transfer function are also shown. These features cannot be explained with bathymetry and sediment effects based on the 3-D forward modeling [5]. Thus strong three-dimensionality and deep conductor possibly distributed beneath the Japan sea. In order to discuss detailed resistivity structure, 3-D inversion approaches are required by using a newly developed 3-D MT inversion code for marine data to treat complicated ocean bottom and land topography [6].

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Keywords: back arc, NE Japan subduction zone, magnetotelluric, OBEM, phase tensor

SEM36-P07 Room:Poster Time:April 30 18:15-19:30

Conductivity structure beneath the fault segment gap in the Yamasaki fault zone, southwest Japan (2)

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Abstract

The Yamasaki fault zone (YFZ) of southwest Japan is a typical strike-slip fault system consisting of the Nagisen fault, the main strand of YFZ, and the Kusadani fault. The main strand of YFZ extends for over 79km and is divided into northwestern (NW) and southeastern (SE) groups based on their latest seismic activity. The NW group consists of the Ohara, Hijima, Yasutomi and Kuresaka-touge faults, and the SE group consists of the Biwako and Miki faults. The maximum magnitudes of the earthquakes generated by the NW and SE groups are estimated to be 7.7 and 7.3, respectively. Simultaneous activation of both fault groups is also pointed out to be as large as M = ˜8.0 (The Headquarters for Earthquake Research Promotion, 2013).

The subsurface structure beneath the fault segment gap between both groups will be the key information for assessing the possibility of such large earthquake.

To infer the structure, we carried out Audio-frequency Magnetotelluric (AMT) survey at 11 sites along a transect between the NW group and the SE group and showed the two-dimensional resistivity model along the transect based on MT impedances. This model is characterized by three conductive zones. They locate beneath the points where the transect crosses the extension lines of the surface trace of the Yasutomi, Kuresaka-touge, and Biwako fault. We thus concluded that the Yasutomi and Kuresaka-touge faults are extended to southeast and the Biwako fault is extended to northwest further than the recognized terminals of their surface trace.

In this presentation, we show the improved resistivity model which is determined by not only MT impedance but tipper vectors.

Keywords: conductivity structure, active fault, Yamasaki fault system, Magnetotellurics

SEM36-P08 Room:Poster Time:April 30 18:15-19:30

Electrical Resistivity Imaging at Western Turkey by Wideband Magnetotelluric Method

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The westward migration of large magnitude earthquakes along the North Anatolian Fault Zone indicates that a major event may take place at and around the Marmara region, following the Izmit (Mw7.4) and Duzce (Mw7.2) earthquakes that took place in 1999 in northwest Turkey. For this reason many studies were conducted around Marmara sea, west of these events. These studies focused mostly on the northern part of this area because of the high damage risk near Istanbul, but the similar potential is also present for the southern Marmara. In order to investigate the upper crustal electrical resistivity structure at this location, wide-band magnetotelluric data were collected at sixteen sites forming two parallel profiles. These profiles were constructed to cross the southern branches the North Anatolian Fault. Following the application of Groom and Bailey decomposition that has been applied to remove the surplus features and to deduce the appropriate geo-electric strike direction which is an important requirement for two-dimensional interpretation, an inversion algorithm developed by Ogawa and Uchida (1996) was utilized to develop electrical resistivity models. These models pointed out a relatively complicated shallow (surface-to-5 km) structure which may be associated with the presence of crustal fluids, but below these depths the electrical resistivity is more uniform with only a deep conductor appearing beneath the northern ends of the two profiles. The known faults in the survey area correlate well with the features characterized in the final geo-electric models. A resistive-conductive boundary between Manyas - Karacabey basin and Bandirma-Karadag uplift on the western and Uluabat uplift and Mudanya uplift on the eastern profiles may be associated with the South Marmara Fault.

Keywords: North Anatolian Fault, Fluids, Electrical resistivitiy, Magnetotellurics, geo-electric models

SEM36-P09 Room:Poster Time:April 30 18:15-19:30

Installation of a Vector Magnetometer for a Ground-based Tsunami Early Warning

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Conductive sea water moving in the geomagnetic main field generates electromagnetic variations by a physical process called the oceanic dynamo effect. This effect at the time of tsunami passages was recently detected on the seafloor in the northwest Pacific (Toh et al., 2011) and on Easter Island (Manoj et al., 2011). The tsunami-induced electromagnetic field is expected to contribute to existing global tsunami warning systems.

We are carrying out a project that aims to observe geomagnetic variations associated with tsunami passages by ground-based real-time observations. This project requires a pair of geomagnetic observation sites for clear detection of tsunami events. The geomagnetic coast effect and the external field due to ionospheric and/or magnetospheric disturbances can be removed by taking real-time differences between a coastal and an inland geomagnetic sites. We installed a vector magnetometer at Umaji located in the middle of Muroto Peninsula, where artificial electromagnetic noises are very small. This location is selected as a counterpart of the existing observation site at Muroto located at the tip of the peninsula, which is operated by Geospatial Information Authority of Japan (GSI).

In this presentation, we will make a progress report on our ground-based tsunami warning system consisting of a pair of vector magnetometers. This system is intended to detect the geomagnetic field variations induced by tsunamis at the time of Nankai/Tonankai earthquakes.

Keywords: Geomagnetism, Tsunami

SEM36-P10 Room:Poster Time:April 30 18:15-19:30

The several Records of tsunami induced magnetic field obtained by the JMA Chichijima observation station(CBI).

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Through the geomagnetic field, electrically conducting seawater movement generates electric fields and currents in generally. Furthermore, the current induces secondary magnetic fields. Our Chichijima geomagnetic observation station (CBI) is located on the solitary island in the Pacific Ocean. Addition this, located the tsunami observation station (Futami tide gauge) that is subject to the JMA. We are able to obtain concurrent tsunami and magnetic data because the distance between these observation points is only 1 km. So, this Chichijima Island is suitable in order to research tsunami induced magnetic fields research. We have investigated in CBI data (samples taken every 1 second) and Chichijima Futami tide gauge data (every 15 seconds) from 1995 to 2013, finally obtained 9events tsunami induced phenomena. The many of the signal of these events is small, but three of them has clear record, the 2011 off the Pacific coast of Tohoku Earthquake Tsunami (2001/3/11 M9.0), The 2010 Chile earthquake (2010/2/27 M8.8) and 1996 the Irian Jaya Earthquake Tsunami (1996/2/17 M8.1). The other events are week, but their magnetic signals are detectable enough. it may be worth worldwide renown that so many induced magnetic phenomena have been fund in one observation station Chichijima (CBI). In the low solar activity periods, the induced magnetic signal may be detectable, if the half tsunami amplitude is 20cm or over. Some of these events might have been disturbed and dismissed due to magnetosphere substorm, even though the induced magnetic field was enough to detect. Each of above-mentioned three examples has over 1 m tsunami height, and clear induced magnetic record. Especially, in spite of weak magnetosphere substorm, the record of the 2011 off the Pacific coast of Tohoku Earthquake Tsunami is very clear. So, on 1 m or more-high tsunamis, it is safely said that the induced magnetic fields is detectable definitely. These induced magnetic field records will be one of mediation between the geomagnetic science and the tsunami disaster prevention science.

Keywords: tsunami, Induced magnetic effects, chichijima

SEM36-P11 Room:Poster Time:April 30 18:15-19:30

Geomagnetic total intensity variations associated with vertical crustal movement in the eastern part of Izu Peninsula

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In order to detect geomagnetic changes associated with the earthquake swarm and anomalous crustal activities, continuous observations of the geomagnetic total intensity have been conducted in the eastern part of Izu Peninsula. The continuous data of the geomagnetic total intensity were utilized after an analysis of removing the effect of external magnetic field from those data during 2010 - 2012. An association between the geomagnetic field variation and the vertical crustal movement was examined comparing the day-to-day variation of the geomagnetic total intensity with that of the geodetic height measured by GPS (Global Positioning System). It is found that the day-to-day variation in the geomagnetic total intensity shows each seasonal change on the quiet seismic period during 2010 and on the relatively active seismic period during 2011 and shows no significant change on the quiet seismic period during 2012, though the day-to-day variation in the vertical crustal movement shows seasonal changes during 2010 - 2012. It is inferred that the hydrothermal activity related to the Dec. 2009 earthquake swarm caused by magma injection had been lasting up to less than two years and the hydrothermal movement associated with the vertical crustal movement had caused the seasonal changes in the geomagnetic total intensity during 2010 - 2011. This suggests the observed variations of the geomagnetic total intensity were not directly associated with seismic faulting. The continuous observation of the geomagnetic total intensity is expected to have a monitoring advantage in predicting the course of the earthquake swarm activity in the eastern part of Izu Peninsula.

Keywords: eastern part of Izu Peninsula, geomagnetic total intensity, crustal movement, hydrothermal activity

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Validity of using space approximation in calculating EM variations generated by the piezomagnetic effect

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Variations in the magnetic field generated by the piezomagnetic effect, which is referred to as the piezomagnetic field, has been discussed in a framework of magneto-statics, in which temporal variations are totally ignored. This treatment is valid for quasi-static processes, but possibly invalid for dynamic processes including fault ruptures. The earlier works by the author has demonstrated that, when the temporal variations in the EM field is considered, finite conductivity of the Earth's crust alters the feature of the piezomagnetic field. However, consideration of the temporal variations in the EM field makes estimation of the piezomagnetic field complicated, even in a simple two-layered model which consists of the Earth's ground with finite conductivity and the air as a perfect resister.

The problem will be largely simplified if the situation is approximated by a finite space model with a uniform electrical conductivity.

In the present work, variations in the EM field generated by the piezomagnetic effect are compared for two situations: finite space and semi-finite space models with finite conductivity, assuming the source of the piezomagnetic field is two-dimensional. It is demonstrated that, for some situations, the simpler model provides a good approximation of the expected piezomagnetic field.

Keywords: piezomagnetic effect, electromagnetic field, electrical conductivity, infinite space, semi-infinite space