ULF Electromagnetic phenomena induced by underground activities in Izu and Boso Peninsula, Japan during 2000 – 2010

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Abstract

Recently electromagnetic phenomena have been considered as a promising candidate for short-term earthquake prediction. In this study, we have investigated ULF (Ultra Low Frequency) electromagnetic phenomena possibly associated with underground activities in Izu and Boso Peninsula, Japan during 2000 – 2010. Daily average energy of geomagnetic signals at the frequency around 100Hz has been examined, and geomagnetic diurnal variation at each station has been investigated. It is found that there are highly confirmed anomalous electromagnetic signals during the 2002 and the 2007 slow slip events in Boso Peninsula. And geomagnetic diurnal variations observed at Boso Peninsula also exhibit unusual behaviors before the 2005 M6.1 and M6.0 earthquakes.

1. Introduction

The detection of electromagnetic perturbations prior to fault ruptures or volcanic eruptions has often been proposed as a simple and effective method for monitoring the crustal activities. And electromagnetic phenomena have been considered as a promising candidate for short-term earthquake prediction. So far, a lot of evidence of seismo-electromagnetic precursory signatures in a wide frequency range from DC to VHF has been reported [1-2]. Meanwhile, abundant indoor/outdoor experiments and numerical simulations [3-4] have confirmed the existence of seismo-electromagnetic phenomenon. Because of skin depth, passive ground-based observation of ULF (ultra low frequency) geomagnetic signatures is considered to be the most promising method for seismo-magnetic phenomena study. In this study, we have analyzed geomagnetic data observed during the past decade in Izu and Boso Peninsula, Japan. And the possible relation between geomagnetic anomalies and local underground activities has been discussed.

2. Data acquisition and analysis

The Tokai area of Japan is a seismically actively region and of complex tectonic structure. In order to clarify seismo-electromagnetic phenomena and monitor underground activity by electromagnetic method, a sensitive geomagnetic network has been installed in Japan [5] and plenty of data associated with moderate-large earthquakes have been accumulated. In this paper, we analysis the geomagnetic data observed at three magnetic observatories in Boso Peninsula (Kiyosumi, Uchiura, and Fudago) and Izu Peninsula (Seikoshi, Mochikoshi, and Kamo), respectively.

2.1 Investigation of ULF geomagnetic signals of the period around 100s

According to previous studies, the geomagnetic signals at the frequency around 0.01Hz might be sensitive to seismic activities. So in this research, we have applied wavelet transform analysis to the 1Hz sampling data observed at each station. The signature at the 0.01Hz frequency band has been revealed and daily average energy has been computed.

In general, ULF geomagnetic signals observed on the ground mainly contain three parts: global signals originated from Ionosphere, artificial noises, and signals induced by underground activities. In order to minimum artificial noise, we only use the midnight time data (LT 0:00~3:00). 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 in Boso and Izu Peninsula with

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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 2002 and the 2007 slow slip events in Boso Peninsula, significant anomalous behaviors have been detected in both Y and Z components. Time series of magnetic signals associated with this two slip events are quite similar.

2.2 Investigation of ULF geomagnetic diurnal variation

In this section, we have investigated the geomagnetic diurnal variation observed at each station in both Boso and Izu Peninsula from 2000 to 2010. In general, the geomagnetic diurnal variation which is mainly composed of four harmonics (24h, 12h, 8h, and 6h), depends on two causes: the main one is perturbations in the ionosphere, and the other one is underground resistivity. Usually for a region that is not large, diurnal variation in magnetic stations should be stable and quite similar to each other. However, the situation could be changed if there were some strong local underground activities such as earthquakes and volcanoes which may cause electromagnetic emissions and/or underground resistivity changes. In this study, we have applied PCA method to the diurnal variation hoping to extract information about local underground resistivity and electromagnetic anomalies. It is found that the contribution of the second principal components, which may relate with the local underground conductivity structure and/or the local electromagnetic disturbance, has some significant anomalous behaviors during the past ten years. Especially before the 2005 M6.1 and M6.0 earthquakes, very clear anomalies have appeared.

3. Conclusion

In this paper, we have analyzed geomagnetic data observed d in Izu and Boso Peninsula, Japan during the past decade. Energy of ULF geomagnetic signals at the frequency around 0.01Hz and geomagnetic diurnal variation at each station have been investigated. After comparing the results at the stations in Boso and Izu Peninsula with global background, it is found that there are several local energy enhancements which only appear in Boso or Izu area. Especially during the 2002 and the 2007 slow slip events in Boso Peninsula, significant anomalous behaviors have been detected. And geomagnetic diurnal variations observed at Boso Peninsula also exhibit unusual behaviors before the 2005 M6.1 and M6.0 earthquakes. Statistical investigation has also been carried out.

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