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Evaluation of ULF electromagnetic phenomena during the 2002 and the 2007 slow slip events in Boso Peninsula, Japan

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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. Recently electromagnetic phenomena have been considered as a promising candidate for short-term earthquake prediction. And especially 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 investigate the electromagnetic phenomena associated with crustal activities, a sensitive geomagnetic network has been established in Japan. At each station, three magnetic components and two horizontal electric components are observed. In this study, we have analyzed geomagnetic data observed during the 2002 and the 2007 slow slip events in Boso Peninsula, Japan.

According to previous studies, the geomagnetic signals at the frequency around 0.01Hz might be sensitive to underground activities. So in this research, we have applied wavelet transform analysis to the 1Hz sampling data observed at three magnetic observatories in Boso Peninsula (Kiyosumi, Uchiura, and Fudago). 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 Peninsula with global background, it is found that there are several local energy enhancements which only appear in Boso area. Especially during the 2002 and the 2007 slow slip events, 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. To verify these phenomena and clarify possible mechanism, direction finding and numerical simulation have been applied and detailed results will be presented in our presentation.

Keywords: ULF seismo-magnetic phenomena, Slow slip events, Wavelet transform, Principal component analysis (PCA)