Temporal variations in the electromagnetic field arising from seismic waves in full- and half-space media

*Ken'ichi Yamazaki[1]

1. Disaster Prevention Research Institute, Kyoto University

Seismic waves accompany electromagnetic (EM) variations because Earth’ s crust involves a variety of EM properties such as finite electrical conductivity and ion contents. If we can catch the EM variations just after the earthquake rupture, we will know the occurrence of earthquake before the arrival of seismic waves at observation point. However, quantitative aspects of EM variations arising from seismic waves have not sufficiently understood.

Together with observational works, theoretical works have been made to simulate EM variations arising from seismic waves. The generation mechanisms of EM variations include electrokinetic effect (Pride, 1994), motional induction (Gao et al., 2014), piezo-electric effect (Ogawa and Utada, 2000), piezo-magnetic effect (Yamazaki, 2016), etc. It is widely accepted that the electrokinetic effect is the dominant mechanism. Theoretical calculation of EM variations assuming the electrokinetic effect roughly explains the observed EM variations accompanying with earthquake ground motions (e.g. Gao et al. 2016). However, there is some disagreement between observed and predicted EM variations.

In the present study, I focus on the motional induction mechanism that possibly explain some parts of EM variations accompanying with seismic waves. A theoretical work on EM variations arising from the motional induction has been presented by Gao et al. (2014), but their work assumed uniform full-space medium. In contrast, the present work assumes stratified media which correctly incorporate the effect of the ground surface. I apply a calculating method developed both in seismology (e.g. Kennett, 2013) and in EM studies (Haartsen and Pride, 1997), and derive a set of expressions describing the spatial-temporal variations of the EM field after the onset of rupture.

The derived formula is analyzed to discuss the significance or insignificance of the ground surface in considering seismo-EM variations. If we can ignore the existence of the ground surface, we will be able to make theoretical prediction of seismo-EM variations by using the full-space solution (e.g. Gao et al. 2014). In contrast, if we cannot ignore the ground surface, we must explicitly consider it to make a theoretical prediction.

Keywords: electromagnetic field, motional induction, seismic wave

