Feasibility of Observing Magnetic Signals Arising from Seismic Waves Propagating through the Magnetized Crust

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Several studies have reported that electromagnetic (EM) fields show slight variations following large earthquakes[1]. One of the candidate mechanisms that generate co-seismic variations in the magnetic field is the piezomagnetic effect, which describes changes in magnetization in the Earth's crust under the application of mechanical stresses[2, 3]. In this study, a series of calculations are performed by combining a linear constitutive law of the piezomagnetic effect[4] and a set of analytical formulae describing EM fields radiated from a dipole source[5].

As the simplest case, amplitudes of variations in the piezomagnetic field accompanying with propagations of the Rayleigh wave are evaluated. Calculations are performed for both non-uniformly and uniformly magnetized crust with an intensity of 10 A/m. The amplitudes of the piezomagnetic signals arising from uniformly magnetized crust are up to 0.02 nT, whereas those arising from non-uniformly magnetized crust are as large as 0.1–0.2 nT. This finding indicates that the piezomagnetic field is a plausible mechanism of generating co-seismic changes in the magnetic field with detectable amplitudes, provided that the observation site is located near the magnetization boundaries.

The result of the calculation in the present study also shows that amplitudes of the piezomagnetic field are proportional to squares of wavenumbers of seismic waves. Therefore the possibilities are that body waves, whose wavenumbers are considerably smaller than those of surface waves, also generate variations in the magnetic field with detectable amplitudes, although the detailed estimation is still remained unsolved.

Keywords: piezomagnetic effect; magnetic anomalies; seismic waves; co-seismic variations.

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