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Lateral heterogeneity of the electrical conductivity in the lowermost mantle inferred from geomagnetic jerks

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Geomagnetic jerks are abrupt changes in the linear trend of the geomagnetic secular variation, and are the surface observable shortest-period components of the geomagnetic field variation of core origin. Hence, the jerks have been studied by many authors to infer dynamics of the core and the electrical conductivity of the lower mantle in the last few decades. Geomagnetic jerks are traditionally studied using time series of the magnetic field recorded in geomagnetic observatories. The uneven distribution of the observatory network precludes the investigation of global distribution of the geomagnetic jerks, and internal origin of the jerks have been questioned by a number of authors. Recently, as a result of continuous satellite measurements since 1999, the magnetic fields and their variations can now be described with high resolution in space and time, and the internal origin of most of the known jerks and their global nature are now firmly established. Since jerks are generated in the core, they will pass through the electrically conducting mantle, before arriving at the surface. Consequently, the geomagnetic field observed at the surface will correspond to a filtered version of the original field generated in the core. Even an 1D electrical conductivity distribution in the mantle exerts screening effects such as delaying and smoothing of signals on the surface observed geomagnetic field. Moreover, a laterally heterogeneous electrical conductivity structure causes more dramatic changes in time and space on the magnetic fields come through the heterogeneous layer. Recent discovery of the postperovskite phase change at the lowermost mantle, and the measurements of the electrical conductivity in the high P and high T condition expected at the bottom of the mantle, predict very high and heterogeneous electrical conductivity structure in the lowermost mantle adjacent to the core surface. Observation of the geomagnetic jerks at the Earths surface may reveal this possible electrical conductivity heterogeneity in the lowermost mantle. For that purpose, however, we need to estimate the source field in the core.

In the present study, filtering effects of an electrically heterogeneous layer in the lowermost mantle on the short-period variations of the geomagnetic field of core origin are examined by using a newly formulated induction equations in a 3D heterogeneous mantle (Hamano, 2002). As the source field at the core surface, we use the temporal variations of toroidal and poloidal magnetic fields obtained by the high-resolution MHD dynamo models (Sakuraba and Roberts, 2009), in which high frequency variations of magnetic fields such as torsional oscillations are clearly reproduced. Results of the numerical calculation indicate that the heterogeneous layer in the lowermost mantle cause very complicated spatial variations of the surface geomagnetic field reflecting the pattern of the electrical conductivity heterogeneity in the lowermost mantle.

Keywords: geomagnetic jerks, geomagnetic field, geodynamo, electrical conductivity structure, lowermost mantle