Upper constraint on the mantle conductance estimated from the geomagnetic jerks

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It is well-known that the occurrence time of each geomagnetic jerk delays a few years in the southern hemisphere, especially in the African region, comparing with the northern hemisphere (e.g., Alexandrescu et al [1996], Nagao et al. [2002, 2003]). Two possible physical mechanisms are considered for this interesting phenomenon; one is the distribution of the magnetic field at the core-mantle boundary (CMB), and another one is the effect of the mantle conductivity on the magnetic field diffusion. Although which mechanism is significant is still controversial, it is valuable to estimate the upper constraint of the mantle conductance assuming that a jerk occurs at the same time at the whole CMB.

Backus [1983] derived theoretically several characteristic time constants of a jerk related to the mantle conductivity, in which significant ones are the delay time and smoothing time. We have been developing a tool using the Kalman filter algorithm, which enables us to determine automatically the amplitude, occurrence time, smoothing time of a jerk, and estimation error in each determined parameter. We applied this tool to the eastward component of geomagnetic monthly means obtained at worldwide geomagnetic observatories, and showed for each jerk that the distribution of amplitude has a spherical harmonic component of ${S_2}^2$ and that the occurrence time in the African region delayed comparing with the other regions. According to the Backus' theorem, time lag in the jerk occurrence time is generated even with a 1-D mantle conductivity model, however the mantle conductance is required to be greater than 10^9S at the whole mantle in order to explain the time lag larger than 1 year. This conductance is much larger than the upper constraint estimated from several decades variation in the length-of-day (LOD) with the electromagnetic core-mantle coupling. Therefore, a lateral heterogeneity is to be taken into account in order to satisfy both the time lag in the jerk occurrence time and the LOD variation.

We carried out a numerical experiment using the MIDM (Koyama et al. [2002]) of how a magnetic field diffuses in a conductive mantle, and found that it is possible to explain the time lag of a few years in the jerk occurrence time assuming that a magnetic field input from the CMB has a spherical component of ${S_2}^2$ and a period of 3 years, and that a mantle conductance is an order of 10^9S in the African region and 10^7S in the other regions. We will report in the presentation a result with a more realistic time-variant magnetic field model input from the CMB.