Dynamics of convection and dynamo action in a numerical dynamo model with strongly heterogeneous CMB heat flow.

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As has presumably been thought, the geomagnetic field is influenced by the thermal and/or compositional inhomogeneity in the lowermost mantle through the core-mantle boundary (CMB). Using three-dimensional numerical models, we have shown that the fundamental structures of the core convection and the generated magnetic field are affected by the amplitude and spatial distribution of the imposed CMB heat flow (Takahashi et al., 2008). Takahashi et al. (2008) shows that when the CMB heat flow heterogeneity is comparable with the mean, dynamo action significantly strengthens the magnetic field. It is in contrast with the previous studies, in which dynamo fails with strong CMB heterogeneity. Owing to the low value of the Ekman number, E, dynamo action sustains the strong magnetic field in models of Takahashi et al. (2008).

We have conducted an analysis of convection and dynamo action in a numerical dynamo model with strong lateral heterogeneity in CMB heat flow. Numerical values of the dimensionless parameters are as follows: the Ekman number, E, is 10^{-5}, the Rayleigh number, Ra, 10^7, the Prandtl number, Pr, 1, and the magnetic Prandtl number, Pm, 1. The amplitude of boundary heterogeneity in terms of the ratio of the peak-to-peak value to the mean is 2. It is found that strong downwelling flows from the CMB are sporadically induced in the specific longitudes with heat flow higher than the mean. Core flows converge in the longitudes below the CMB due to the thermal wind, and then, undulations in the isotherm develop beneath the CMB. Consequently the strong downwellings are observed possibly due to the Rayleigh-Taylor instability.

Reference: Takahashi, F., Tsunakawa, H., Matsushima, M., Mochizuki, N., and Honkura, Y., Effects of thermally heterogeneous structure in the lowermost mantle on the geomagnetic field strength, 2008, submitted.