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A constraint to thermal conductivity of Earth's core and CMB heat flow by assessment on a stable region of Earth's core

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It is still controversial for an emergence of a stable region at the top of Earth's core in theoretical modeling because both thermal conductivity of Earth's core and heat flow across the core-mantle boundary (CMB) have not been clearly constrained from mineral physics and geophysical observations, ranging 20 to 220 W/m/K for the thermal conductivity (denoted as) and 5 to 20 TW for the present-day CMB heat flow (denoted as Q^P_{CMB}). In this study, in order to resolve these uncertainties, we try to constrain the values of thermal conductivity of Earth's core and the present-day CMB heat flow by requiring continuous generation of geomagnetic field in addition to existence of a stable region at the top of present Earth's core using a one-dimensional thermal and compositional evolution model.

Numerical experiments for various values of and Q^P_{CMB} show that the solutions satisfying both long-term magnetic field generation and emergence of a stable region is possible only when is larger than 40 W/m/K and Q^P_{CMB} is less than 18.5 TW. The specific required value of depends on Q^P_{CMB}. If the expected CMB heat flow would be as large value as 17.5 TW, which is suggested by the recent studies on the core evolution theory (e.g., Labrosse, 2015), should be a high value such as about 212 W/m/K to satisfy our requirements. The thickness of an expected stable region would be about 30 km in this case. In contrast, when Q^P_{CMB} is as small as that derived from numerical mantle convection models (e.g., 10 TW; Nakagawa and Tackley, 2010), the required value of decreases to 110 W/m/K. In this case, a stable region extends about 75 km thickness below CMB.

If the requirements assumed in this study is confirmed by certain geophysical observations and/or Q^P_{CMB} can be restricted more precisely with some methods, our assessment scheme would be useful for evaluations of the radial convective structure of Earth's core and for further constraint of the value of thermal conductivity of Earth's core.