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The effects of a conducting layer in D″ on the Earth's thermal and magnetic evolution

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The temperature drop at the core-mantle boundary (CMB) is inferred to be of order 1000 K based on extrapolation of upper mantle temperatures to the lower mantle and based on the recent observations of a D″ post-perovskite phase. This large temperature drop implies high heat flow from the core to the mantle if there is no barrier to convection within D″, with the implication that the temperature of the core would have been sufficiently hot in the geological past to cause widespread melting in the lower mantle. If this scenario is to be avoided, a thin layer that is not participating in mantle convection has been postulated and this idea has received support on geochemical grounds as a reservoir for missing incompatible elements. In this study, we examine the consequences of such a layer for the Earth's thermal and magnetic evolution. Our model couples a numerical model of convection in the mantle with a parameterized model for the thermal and magnetic evolution of the core. We find that the presence of a conducting layer at the base of the mantle leads to a substantial decrease in the cooling rate of the inner core. With a modern-day internal heating rate of 3 TW in this layer, the inner core is essentially the same age as the Earth. However, we find that the dynamo process is not active throughout the entire lifetime of the Earth if the internal heating rate in the conducting layer exceeds 1 TW.