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Was the Early Earth dynamo reversing its polarity?

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Recent estimates of the present heat flow at the Earth's core-mantle boundary range from Q_{cmb} =5 to 15 TW. This uncertainty range prevents full knowledge on the thermal state of the early Earth, and, in particular, on the nature of its dynamo. If the present heat flow is large, the early Earth dynamo could have been thermal (without an inner core); if it is low, thermal modelling shows that an early thermal dynamo was impossible and the existence of the Earth's magnetic field at a given epoch means that the inner core has already nucleated. Here we present a new constraint on the early Earth dynamo based on the power needed to trigger geomagnetic reversals. We carry out numerical simulations of dynamos driven by thermal cooling, in the absence of an inner core, and show that they follow standard scaling relationships already obtained for numerical dynamos with present-day inner core size. For the obtention of reversals, we use a criterion based on the local Rossby number of the flow. Extrapolation to the Earth shows that an early Earth thermal dynamo without an inner core would have needed 1-2 TW superadiabatic CMB heat flow to reverse. We check the compatibility of this constraint with various Earth thermal cooling models.