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Radioactivity in the core or 'isolated reservoirs' in the lowermost mantle: How did the Earth's magnetic field survive?

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A mainly dipolar, reversing, magnetic field has existed on Earth since at least 3.5 Gyr ago (e.g., McElhinny and Senanayake, 1980). The internal field is believed to be generated through the dynamo mechanism as the result of convection in the liquid core. The magnetic history of the Earth places constraints on the heat flow across the core-mantle boundary (CMB). If the heat flux across the CMB is high, vigorous convection takes place in the core and maintains the geodynamo process. If the heat flux is too low, convection in the core is insufficient to maintain a magnetic field. Knowledge of core heat flow over geological time is crucial in resolving the missing heat source paradox. A continuous dynamo action and a magnetic field that was not much weaker in the past imply sufficiently high initial core temperatures as to cause pervasive lower mantle melting (e.g., Buffett, 2002; Nimmo et al., 2004). We use a finite-difference 2D axisymmetrical numerical model for the mantle, coupled to parameterized core energy and entropy models to study the thermal evolution and magnetic field history of the core. We study several scenarios for magnetic field evolution, including the effects of core radioactivity or of an enriched reservoir in heat-producing elements at the base of the mantle. We present the most succesful scenarios for providing continuity in the magnetic field for at least 3.5 Gyr and final CMB temperatures in the range of recent mineral physics estimates, without starting with core temperatures that exceed the mantle solidus.