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Dynamics and Energetics of Earth's Core

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A fundamental goal in deep Earth geophysics is to explain the existence of the geomagnetic field for at least the past 3.5 billion years. The field is thought to be generated by turbulent motion of the liquid iron core and so there must have been sufficient power available to keep this dynamo process operating over most of Earth's history. Power is made available to the dynamo as heat is extracted from the core by the overlying rocky mantle. In the standard picture of core evolution, cooling releases heat and leads to freezing of the alloy from Earth's centre thus forming the solid inner core. As the inner core freezes, latent heat is released and the light elements in the mixture partition preferetially into the liquid phase, mixing the core and providing a very efficient power source. Determining the age of the inner core is therefore critical to understanding the thermal, chemical and dynamical history of the core and geomagnetic field. To achieve this requires coupled models of long-term core-mantle evolution that utilise robust determinations of the structural and dynamical properties of Earth materials.

Models of the core's thermal and magnetic history have undergone something of a revolution in recent years following the first calculations of thermal and electrical conductivity of iron alloys at the enormous pressure and temperatures of the deep Earth. These calculations found the core thermal conductivity to be 2-3 times higher than existing estimates based on extrapolation of lower pressure-temperature data, which drastically reduced estimates of the inner core age from 1-1.5 billion years old to perhaps less than 0.5 billion years old. Moreover, these calculations gave rise to the so-called "new core paradox", which claims that there was insufficient energy to drive the ancient geodynamo prior to inner core nucleation. Subsequent work has identified new potential power sources for the ancient dynamo by arguing that solids (e.g. MgO and/or SiO2) could precipitate from the liquid near the top of the core. However, there is still debate surrounding the conductivity calculations and the efficiency of precipitation, while the power provided to the dynamo by radiogenic elements is still poorly understood.

In this talk I will review the energetics and long-term dynamics of the coupled core-mantle system. I will discuss the role of thermal conductivity and precipitation mechanisms and consider the implications of our changing view of core evolution for models of mantle dynamics.

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