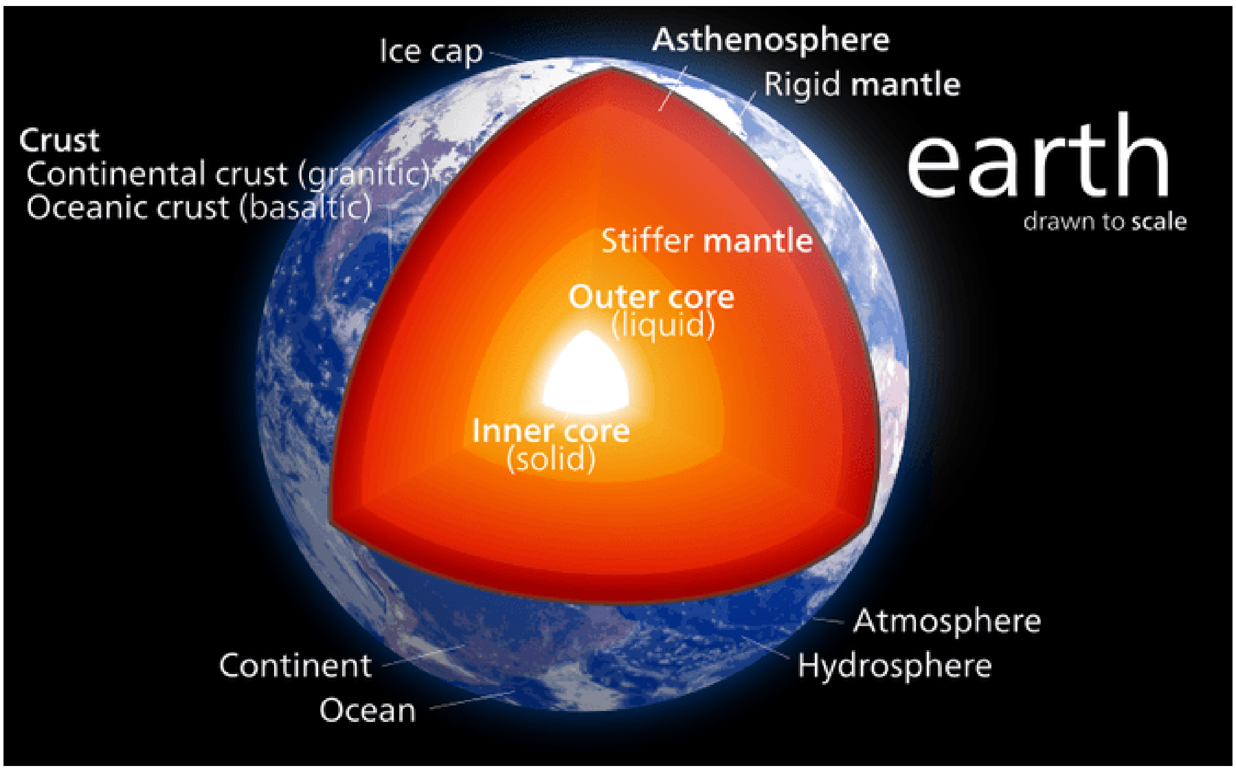
How we discovered that the Earth's inner core is older than previously thought

October 9 2015, by Andrew John Biggin



Dating the Earth's enigmatic inner core: a Pluto-sized ball of iron that is super hot and frozen at the same time. Credit: Kelvinsong/wikimedia, CC BY-SA

According to recent estimates, the Earth's solid inner core started forming between half a billion and one billion years ago. However, our new measurements of ancient rocks as they cool from magma have indicated that it may actually have started forming more than half a billion years earlier.

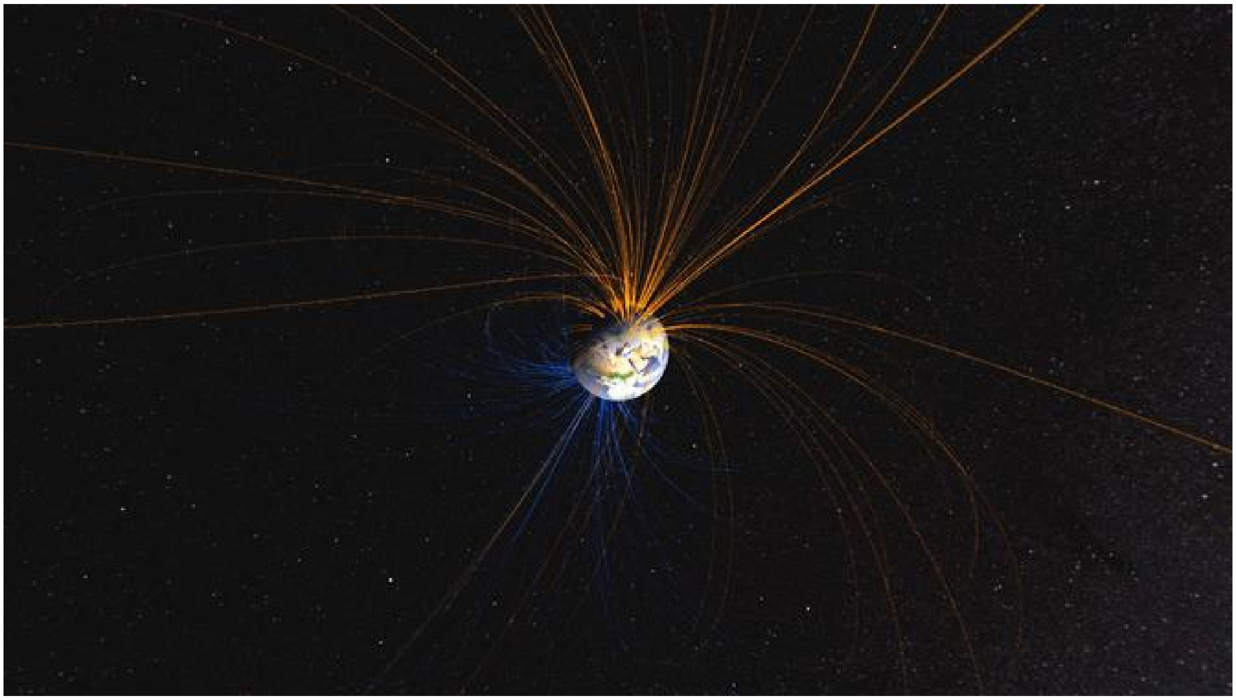
While this is still relatively late in the Earth's four-and-a-half billion year history, the implication is that the Earth's deep interior may not have been as hot in the deep past as some have argued. That means the core is transferring heat to the surface more slowly than previously thought, and is less likely to play a big role in shaping the Earth's surface through tectonic movements and volcanoes.

Just after the Earth formed from collisions in a huge cloud of material that also formed the Sun, it was molten. This was because of the heat generated by the formation process and the fact that it constantly collided with other bodies. But after a while, as the bombardment slowed, the outer layer cooled to form a solid crust.

The Earth's inner core is, today, a Pluto-sized ball of solid iron at the centre of our planet surrounded by an outer core of molten iron alloyed to some, as yet unknown, lighter element. Despite the Earth being hottest at its centre (about 6,000°C), liquid iron freezes into a solid because of the very high pressures there. As the Earth continues to cool down, the inner core grows at a rate of about 1mm per year by this freezing process.

Knowing the point in time at which the Earth's centre cooled down sufficiently to first freeze iron gives us a fundamental reference point for the entire thermal history of the planet.

The magnetic field of the Earth is generated by the movement of electrically conducting molten iron in the outer core. This movement is generated by light elements released at the inner core boundary as it grows. Therefore, the time when iron was first frozen also represents a point in time when the outer core received a strong additional source of power.



The Earth’s magnetic field. Credit: NASA/Flicr, CC BY-SA

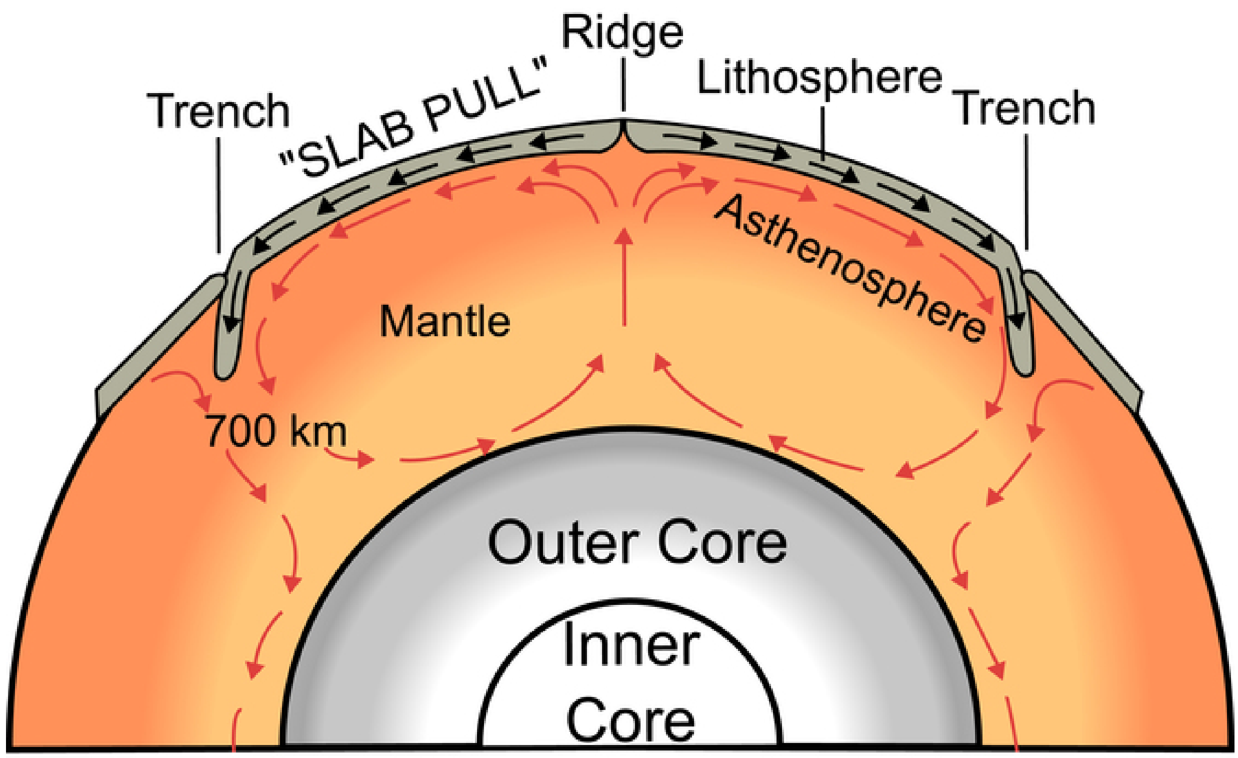
It is the signature of this boost of the magnetic field – the largest long-term increase in its entire history – that we think we have observed in the magnetic records recovered from igneous rocks formed at this time. Magnetic particles in these rocks "lock-in" the properties of the Earth's magnetic field at the time and place that they cool down from magma.

The signal can then be recovered in the laboratory by measuring how the magnetisation of the rock changes as it progressively heated up in a controlled magnetic field. Hunting for this signature is not a new idea but has only just become viable – a combination of having increased amounts of measurement data available and new approaches to analysing them.

The Earth has maintained a magnetic field for most of its history through a "dynamo" process. This is similar in principle to a wind-up radio or a bicycle-powered light bulb in that mechanical energy is converted to electromagnetic energy. Before the inner core first started to solidify, this "geodynamo" is thought to have been powered by another entirely different and inefficient "thermal convection" process.

Once iron started to freeze out of the liquid at the base of the core, the remainder became less dense, providing an additional source of buoyancy and leading to much more efficient "compositional convection". Our results suggest that this efficiency saving happened earlier in the Earth's history than previously thought, meaning that the magnetic field would have been sustained for longer with less energy overall. Since the energy is mostly thermal, this implies that the core as a whole is likely cooler than it would have been if the inner part formed later.

Heat and plate tectonics



Mantle convection - the process that drives plate tectonics. Credit: Surachit/wikimedia, CC BY-SA

A cooler core implies lower heat flow across the core-mantle boundary. This is important for all of Earth sciences because it could be one of the drivers for making tectonic plates move and is also a source of plume volcanism at the Earth's surface. We know that these processes are a result of mantle convection produced, ultimately, by the flow of heat out of the planet at a rate that we can measure rather precisely. What we still do not know is how much of this heat lost at the Earth's surface is from the mantle and how much is from the core.

Heating from the core is thought to produce plumes welling up from just above the core-mantle boundary, which might help drive the flow within the mantle. The suggestion from our findings is that the core contribution to the surface heat flow is lower than implied from other studies and that subduction in the ocean, when one tectonic plate goes under another down into the mantle, are much more important in driving mantle convention than the heat rising from the core.

The debate about the age of the inner core and the resulting thermal evolution of the Earth is not yet over. More palaeomagnetic data are needed to confirm that the sharp increase in magnetic field strength that we have observed is really the largest in the planet's history. Furthermore, modelling needs to verify whether some other event could have created the magnetic strengthening at this time.

Nevertheless, as things stand, theory and observation combine to indicate that the Earth was two-thirds of its present age before it started growing an inner core – meaning earth scientists may have to revise their understanding of the planet's history.

Source: The Conversation

Citation: How we discovered that the Earth's inner core is older than previously thought (2015, October 9) retrieved 19 April 2024 from https://phys.org/news/2015-10-earth-core-older-previously-thought.html