New theory suggests magnesium could be the key to understanding Earth's magnetic field

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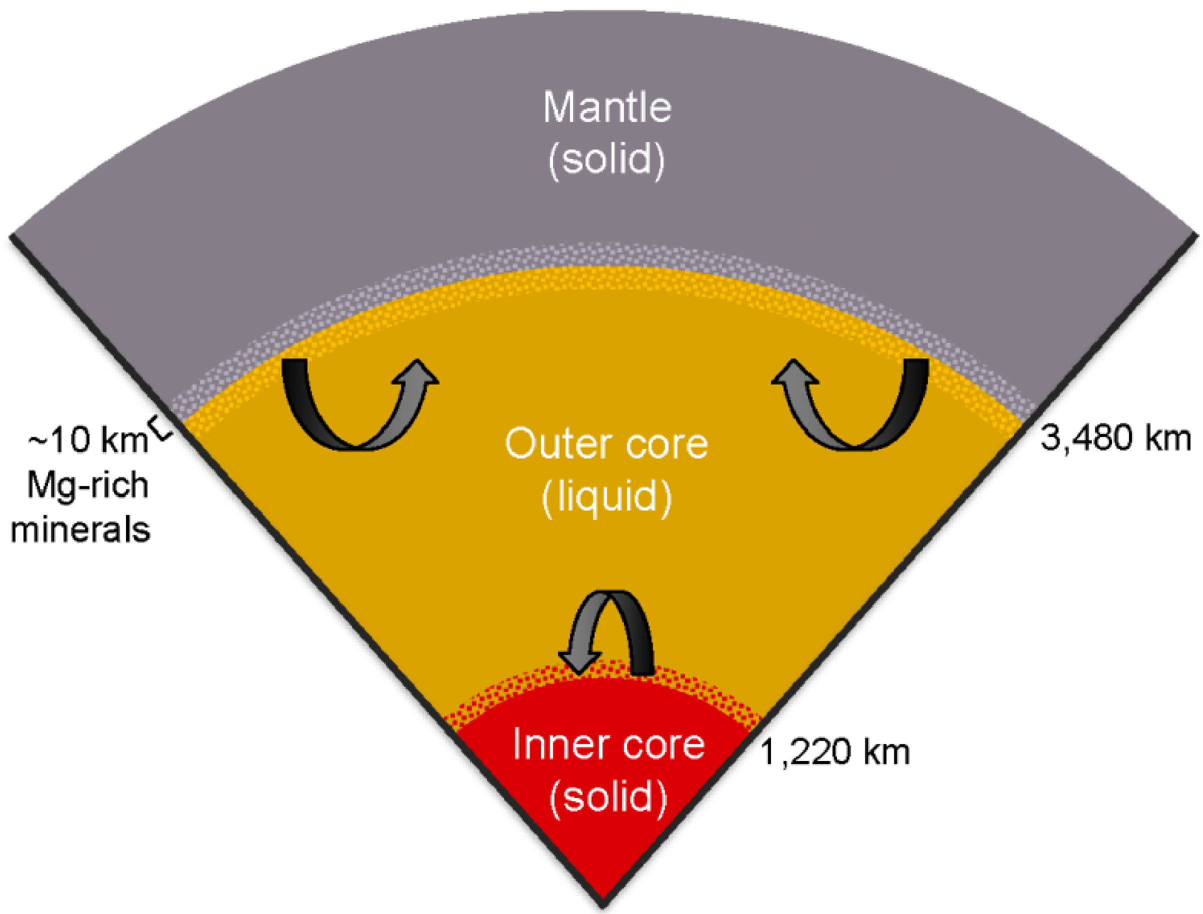

Two types of chemical convection in Earth's core. Precipitating a thin layer of magnesium-rich minerals at the top of the core provides as much energy for the magnetic field as forcing silicon and oxygen out of the entire inner core. Credit: Joseph O'Rourke

(Phys.org)—A pair of planetary scientists has come up with a new theory to help explain the mechanism behind the generation of the Earth's magnetic field. In their paper published in the journal *Nature*, Joseph O'Rourke and David Stevenson, both with the California Institute of Technology, suggest that magnesium that made its way to the core of the planet during its early history could be the key to understanding how the magnetic field was generated in the past and what drives it in the present. Bruce Buffett with the University of California offers a *News & Views* piece on the work done by the team in the same journal issue.

For many years, scientists have believed that the Earth's magnetic field is likely generated by energy that is released as the core cools and material solidifies, and radioactive decay—causing churning, the essence of the geodynamo. But, there is a problem with that idea, scientists also believe that the core did not cool enough to form an inner core, until approximately one billion years ago—that begs the questions of what caused the magnetic field to come about before there was sufficient cooling? The research pair with this new effort suggest it has to do with magnesium—they propose that it was introduced to the core during the time when the Earth was being formed, by collisions with other protoplanets, approximately 3.4 to 4.2 billion years ago.

They further suggest that magnesium could make up as much as 1 percent of the material in the core, and because magnesium is only soluble in iron at very high temperatures, they believe that it is slowly precipitating out to the boundary between the core and the mantle. That process, the team notes, would leave the iron behind denser, which would cause the release of energy, which they suggest could explain the power source behind the dynamo. Their theory would explain how it is that the magnetic field has been present for so long—it would also suggest that it continues to play at least a part in how the field is generated today—with magnesium possibly driving iron convection from the top part of the core while the release of light elements from the inner

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core would drive convection from the bottom side.

The team used computer models in developing their theory which means experiments will have to be conducted to help bolster their ideas.

More information: Joseph G. O'Rourke et al. Powering Earth's dynamo with magnesium precipitation from the core, *Nature* (2016). DOI: 10.1038/nature16495

Abstract
Earth's global magnetic field arises from vigorous convection within the liquid outer core. Palaeomagnetic evidence reveals that the geodynamo has operated for at least 3.4 billion years, which places constraints on Earth's formation and evolution. Available power sources in standard models include compositional convection (driven by the solidifying inner core's expulsion of light elements), thermal convection (from slow cooling), and perhaps heat from the decay of radioactive isotopes. However, recent first-principles calculations and diamond-anvil cell experiments indicate that the thermal conductivity of iron is two or three times larger than typically assumed in these models. This presents a problem: a large increase in the conductive heat flux along the adiabat (due to the higher conductivity of iron) implies that the inner core is young (less than one billion years old), but thermal convection and radiogenic heating alone may not have been able to sustain the geodynamo during earlier epochs. Here we show that the precipitation of magnesium-bearing minerals from the core could have served as an alternative power source. Equilibration at high temperatures in the aftermath of giant impacts allows a small amount of magnesium (one or two weight per cent) to partition into the core while still producing the observed abundances of siderophile elements in the mantle and avoiding an excess of silicon and oxygen in the core. The transport of magnesium as oxide or silicate from the cooling core to underneath the mantle is an order of magnitude more efficient per unit mass as a source of buoyancy

than inner-core growth. We therefore conclude that Earth's dynamo would survive throughout geologic time (from at least 3.4 billion years ago to the present) even if core radiogenic heating were minimal and core cooling were slow.