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Published online 15 May 2008 | Nature | doi:10.1038/news.2008.822

News

Are there nuclear reactors at Earth's core?

Fission reactors may have been burning for billions of years.

Philip Ball

Could this be home to buried nuclear infernos?

NASA

Nuclear reactors could be burning deep beneath the ground, two scientists have claimed. They say that uranium could become sufficiently concentrated at the base of Earth's mantle to ignite self-sustained nuclear fission, as in a human-made reactor.

This is not the first time that natural 'georeactors' deep inside Earth have been proposed, and the idea has previously been greeted with scepticism by geoscientists. But physicist Rob de Meijer of the University of the Western Cape in Cape Town, South Africa, and geochemist Wim van Westrenen of the Free University of Amsterdam in the Netherlands, believe that their new proposal[1] is more plausible.

Radioactive decay of unstable isotopes of heavy elements such as uranium happens all the time beneath Earth's surface. The energy released contributes significantly to the heat of Earth's mantle, which is also warmed by the planet's molten iron core. This combined heating creates convection currents in the sluggish mantle rock that ultimately power the drift of tectonic plates at the surface, giving rise to mountain ranges and earthquakes.

But the intense 'burning' of radioactive fuel in nuclear reactors relies on a chain reaction in which nuclear decay of some atoms releases subatomic particles that stimulate the decay of others. This is possible only if the decaying atoms are much more concentrated than they generally are in rocks and minerals. "In the normal mantle, there is no way you could get a high enough concentration", says van Westrenen.

Spontaneous ignition

Yet it is clear that natural nuclear reactors can occur. Crustal rocks at Oklo in Gabon, Africa, bear unambiguous evidence of spontaneous ignition of uranium fission in mineral deposits 1.7 billion years ago.

That is thought to be a very unusual case. But some researchers have previously suggested, although it's not a widely held view, that gravity could cause a concentration of radioactive ultra-heavy elements such as uranium. These elements might sink down into Earth's core, where they are enriched enough to ignite georeactors.

Such proposals don't, however, seem to fit with what is known about how elements are distributed between the mantle and the core. De Meijer and van Westrenen now have a different idea, which draws on recent discoveries about the distribution of an isotope of the rare element neodymium in rocks[2,3].

Those observations suggested that there is a 'reservoir' of material deep inside Earth, which formed soon after the birth of the planet, about 4.5 billion years ago, and has not mixed with the rest of the mantle.

The only place where such a reservoir could easily exist is at the very bottom of the mantle, at the boundary with the core, where convection currents don't really reach to cause much stirring.

Live reactor

In a paper to be published in the *South African Journal of Science* [1], the two researchers have estimated how much uranium the reservoir could contain. They note that uranium and its decay product plutonium are more readily incorporated into calcium silicate perovskite, a mineral which makes up 5% of the lower mantle, than into the two other minerals that make up this part of the deep earth. This concentrates the radioactive elements into a small volume.

All the same, the calculations show that an isolated, 4.5-billion-year-old reservoir at the core-mantle boundary would contain 20 times too low a concentration of these elements to ignite a chain reaction. That, however, is not a large deficit. De Meijer and van Westrenen say that melting and other geological processes could quite conceivably concentrate up the fissile material further until it crosses the ignition threshold.

In fact, they say, if there wasn't this initial shortfall then the whole of the core-mantle boundary might conceivably have become a live nuclear reactor.

Bill McDonough, a geochemist at the University of Maryland in College Park, thinks that the idea of concentrating radioactive elements in a calcium perovskite reservoir at the base of the mantle is "eminently more credible" than previous proposals for how georeactors might form. “The authors have thought hard about this,” he says, but cautions that “the hypothesis requires that all conditions be just right for it to work”.

Such a reactor would probably function as a 'breeder' reactor, generating plutonium fuel as it burns the original uranium. This means that such reactors could still be running today. What's more, because the other decay products include helium and xenon, this could help to explain the confusing ratios of these elements in volcanic magma, van Westrenen suggests.

Proving the unseen

Balancing these ratios would require a nuclear reactor roughly 1,000 times more powerful than a typical man-made reactor, although van Westrenen points out that this power output is entirely possible, and would represent only a small proportion of the heat that escapes from Earth's surface.

How can the existence of these reactors some 3,000 kilometres beneath our feet be proved? De Meijer and Westrenen say that the reactions will generate very light subatomic particles called antineutrinos, which can mostly pass right through Earth and so could be detected by instruments at the surface. Such particles produced by nuclear decay in the mantle have already been seen by a neutrino detector in Japan[4].

Neutrino detectors that can sense the direction from which such particles came are now being planned. De Meijer and van Westrenen are both members of a Dutch collaboration called Stichting EARTH, which is aiming to develop such detectors for three-dimensional tomographic mapping of antineutrino sources in the earth. A georeactor would show up in such a survey as a particularly intense, localized source at the core-mantle boundary.

References

1. de Meijer, R. J. & van Westrenen, W. *S. Afr. J. Sci.* (in the press).
2. Boyet, M. & Carlson, R. W. *Science* 309, 576–581 (2005).
3. Carlson, R. W. , Boyet, M. , Horan, M. *Science* 316, 1175–1178 (2007).
4. Araki, T. *et al. Nature* 436, 499–503 (2005).

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