

Journey from the centre of the Earth?

Most volcanoes occur near the edges of the tectonic plates that make up the Earth's surface. But some sit in the middle – the volcanoes of Hawaii are the best example – fuelled by unusually hot mantle below. Lavas from these volcanoes should tell us about the inside of our planet, but it is difficult to establish exactly where they come from. Some researchers argue the hot plumes in the mantle that drive these volcanoes contain material recycled from the Earth's crust in a process called subduction (see box). Others think the mantle plumes come from much deeper, perhaps even incorporating small amounts of the Earth's core from a staggering 2,900 km below the crust.

Recently, researchers found telltale signatures in lava from Hawaii suggesting it came from deep within the planet. The Earth's outer core may have unusually high levels of the metals platinum and rhenium compared to another metal, osmium. Isotopes of platinum and rhenium undergo radioactive decay, creating forms of osmium with different molecular weights to the

Anders Scherstén, Tim Elliott and Chris Hawkesworth explain how an extinct isotope can tell us about our planet's inner workings.



The central iron core of our planet has a solid inner and a liquid outer layer. A silicate mantle surrounds the core, and on top of that is the Earth's solid crust. The mantle gets heat both from the core, and by the decay of radioactive isotopes. Hot material is buoyant, and this sets up a slow convective circulation that dissipates the heat. As mantle material moves upwards and outwards it melts, and some forces through the Earth's crust, forming active volcanoes. New oceanic crust is made this way, along ridges in the middle of the oceans. But since the Earth is not expanding, this constant growth is balanced. Elsewhere, the plates in the Earth's crust are pushed together, driving one down into the mantle. This subduction takes place beneath arcs of volcanoes, such as those in the Western Pacific, Western North America and the Caribbean.

meteorites and newly-formed Earth would have been the same, the tungsten isotope on Earth must have become slightly concentrated in the mantle, almost certainly because of core formation. In turn, this means that any material from the core that eventually reaches the surface as lava should have lower levels of the tungsten isotope than mantle material. Crucially, since all hafnium 182 decayed over four billion years ago, there will have been no changes in the

most abundant form (isotopes). So researchers finding high levels of these osmium isotopes in the lava inferred at least some of it must come from the core.

But there's a problem. Since platinum and rhenium still exist in the silicate portion of the Earth (i.e. all but the metallic core), and continue to decay into isotopes of osmium, the ratios of isotopes will change over geological time in the silicate Earth too. So our team turned to a more robust test, using an isotope whose 'parent' isotope hasn't existed on Earth for more than four billion years.

The isotope hafnium 182 was present at the birth of our solar system. It survived for only around 50 million years before it had all decayed to form an isotope of tungsten. We know the proportions of this tungsten isotope in the Earth's mantle, but intriguingly, there are about two parts per 10,000 more in the Earth's mantle than in meteorites made up of the same material from which the Earth formed. It might not sound much, but it's significant. If you accept that the overall proportions in the

ratio of the tungsten isotope to its more usual form since then.

Our team reanalysed the Hawaiian rocks. None had tungsten isotope ratios suggesting they came from the core. But we know metals like osmium are scarce in the Earth's mantle, so why do the unusual osmium ratios occur? We now think they support the idea that the Earth's crust is recycled when it's forced downwards where plates collide. Sediments on ocean floors are often rich in metals, such as manganese, which can even form nodules or crusts on the seafloor. These crusts could have similar osmium ratios to those seen in the Hawaiian lavas because they too have relatively high ratios of platinum to osmium, and so with time develop distinctive osmium isotopes.

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