X-rays use diamonds as a window to the center of the Earth

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Diamonds from Brazil have provided the answers to a question that Earth scientists have been trying to understand for many years: how is oceanic crust that has been subducted deep into the Earth recycled back into volcanic rocks?

A team of researchers, led by the University of Bristol, working alongside colleagues at the STFC Daresbury Laboratory, have gained a deeper insight into how the Earth recycles itself in the deep earth tectonic cycle way beyond the depths that can be accessed by drilling. The full paper on this research has been published (31 July) in the scientific journal, *Nature.*

The Earth's oceanic crust is constantly renewed in a cycle which has been occurring for billions of years. This crust is constantly being renewed from below by magma from the Earth's mantle that has been forced up at mid-ocean ridges. This crust is eventually returned to the mantle, sinking down at subduction zones that extend deep beneath the continents. Seismic imaging suggests that the oceanic crust can be subducted to depths of almost 3000km below the Earth's surface where it can remain for billions of years, during which time the crust material develops its own unique 'flavour' in comparison with the surrounding magmas. Exactly how this happens is a question that has baffled Earth scientists for years.

The Earth's oceanic crust lies under seawater for millions of years, and over time reacts with the seawater to form carbonate minerals, such as

limestone, When subducted, these carbonate minerals have the effect of lowering the melting point of the crust material compared to that of the surrounding magma. It is thought that this melt is loaded with elements that carry the crustal 'flavour'.

This team of researchers have now proven this theory by looking at diamonds from the Juina area of Brazil. As the carbonate-rich magma rises through the mantle, diamonds crystallise, trapping minute quantities of minerals in the process. They form at great depths and pressures and therefore can provide clues as to what is happening at the Earth's deep interior, down to several hundred kilometres - way beyond the depths that can be physically accessed by drilling. Diamonds from the Juina area are particularly renowned for these mineral inclusions.

At the Synchrotron Radiation Source (SRS) at the STFC Daresbury Laboratory, the team used an intense beam of x-rays to look at the conditions of formation for the mineral perovskite which occurs in these diamonds but does not occur naturally near the Earth's surface. With a focused synchrotron X-ray beam less than half the width of a human hair, they used X-ray diffraction techniques to establish the conditions at which perovskite is stable, concluding that these mineral inclusions were formed up to 700km into the Earth in the mantle transition zone.

These results, backed up by further experiments carried out at the University of Edinburgh, the University of Bayreuth in Germany, and the Advanced Light Source in the USA, enabled the research team to show that the diamonds and their perovskite inclusions had indeed crystallised from very small-degree melts in the Earth's mantle. Upon heating, oceanic crust forms carbonatite melts, super-concentrated in trace elements with the 'flavour' of the Earth's oceanic crust. Furthermore, such melts may be widespread throughout the mantle and may have been 'flavouring' the mantle rocks for a very long time.

Dr Alistair Lennie, a research scientist at STFC Daresbury Laboratory, said: "Using X-rays to find solutions to Earth science questions is an area that has been highly active on the SRS at Daresbury Laboratory for some time. We are very excited that the SRS has contributed to answering such long standing questions about the Earth in this way."

Dr. Michael Walter, Department of Earth Sciences, University of Bristol, said: "The resources available at Daresbury's SRS for high-pressure research have been crucial in helping us determine the origin of these diamonds and their inclusions."

Source: Science and Technology Facilities Council