Deep Earth has oceans' worth of water, $10 diamond reveals

University of Alberta researchers find 'meteorite mineral' that formed naturally on our planet

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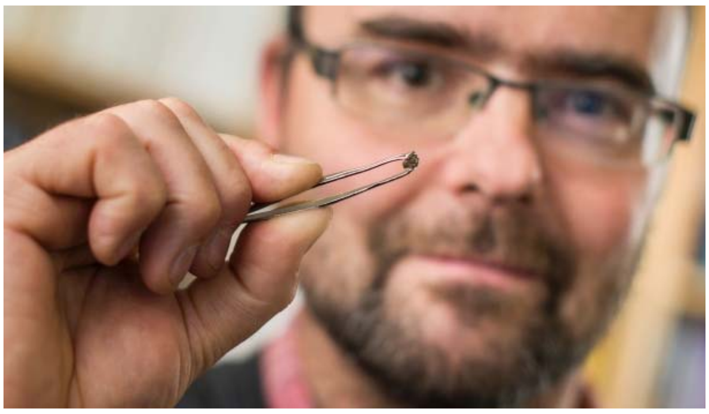

University of Alberta geochemist Graham Pearson holds a diamond containing the first sample of ringwoodite ever found to originate deep in the Earth. (University of Alberta)

A dirty, $10 diamond with a prize inside has helped reveal that there are vast quantities of water stored deep inside the Earth.

The diamond formed in the "transition zone" around 410 to 660 kilometres below our planet's surface. Analysis of a mineral grain trapped inside it suggests that it came from surroundings that were about one per cent water, report researchers led by University of Alberta geochemist Graham Pearson. They published their findings online in the journal Nature today.

If the sample is representative of that part of the deep Earth, the amount of water there could be "about the same as the mass of all the world's oceans combined," wrote Hans Keppler, a geophysicist at the University of Bayreuth in Germany, in an analysis article.

That, in turn, changes our understanding of the way water cycles through our planet, and has implications for the way tectonic plates and volcanoes behave, Pearson notes.

Meteorite mineral from Earth

Previously, geophysicists had debated about whether there could be water in the transition zone. Geophysical measurements from the surface had provided conflicting results.

The new, hard evidence that there is water deep in the Earth comes from a tiny grain of rock — just four-hundredths of a millimetre in diameter — trapped inside the diamond.

That grain was made of ringwoodite — a form of the green mineral peridot that has never before been found on Earth, except in meteorites from space. That's because, like a diamond itself, it can only be made under extremely high pressures like those found so deep inside the Earth that they are inaccessible to humans.

"You can't run a field trip to those areas," Pearson said in a phone interview. "No one's ever even going to drill to those areas."

Typically, the amount of water in peridot is "vanishingly small," Pearson added.

But he and his colleagues probed the ringwoodite in the diamond with different kinds of light and looked for the signature of water. Their analysis showed the sample contained 1.5 per cent water by weight, suggesting that the transition zone where it formed is about one per cent water.

The layers of Earth above and below the transition zone, called the upper and lower mantles respectively, are each known to be "a desert for water," Pearson said.

"What we've found is an oasis of water in the transition zone."

A lot of that water was likely carried down by tectonic plates that were originally at the bottom of the oceans, Pearson said — "water that we would call recycled, that comes from Earth's surface and then is put back down into the Earth."

Although scientists hadn't acknowledged until recently that the planet's water might make these kinds of underground voyages, it makes sense, Pearson added. That's because huge amounts of water from the depths of the Earth are constantly being spewed by volcanoes into the oceans and atmosphere.

"If that weren't replenished, then the interior of the Earth would just become a dry desert," he said. "So it's part of what we call the water cycle."

The water now known to exist deep in Earth may help scientists better understand major geological processes.

"Really it's the essence of how plate tectonics works, because water weakens rocks," Pearson said. "And also, water lowers the melting point of rock, so water dictates where many of the Earth's volcanoes are found."

August birthstone

Ringwoodite is a form of the mineral found on Earth's surface as peridot (the birthstone for the month of August) or olivine. In fact, the grain trapped inside the diamond likely started its life as an ordinary grain of olivine on a plate at the bottom of the ocean, Pearson said.

At some point, the plate was pushed down to the transition zone. There, the high pressure compresses the peridot into a different kind of crystal — one that is mostly denser than regular peridot, but features regularly spaced pores that allow it to suck up surrounding water like a sponge: ringwoodite.

The grain of ringwoodite became trapped in a diamond that has kept it preserved under high pressure. The diamond eventually transported it up to Earth's surface via a type of volcanic rock called kimberlite, which can erupt very quickly from extreme depths.

The diamond, a bumpy, dirty brown stone, just three millimetres wide, eventually ended up in the gravel at the bottom of a shallow river in Mato Grosso, Brazil, where it was scooped up by artisan miners in 2008.

"It actually looks as though it's been to hell and back, which it literally has," said Pearson, who estimates his research team bought the 90-milligram (0.45 carat) diamond for about $10.

Back at the University of Alberta, his graduate student John McNeill examined the rock using an instrument called a Raman microscope in the hopes that it might contain a calcium-rich mineral that would provide information about how old the diamond was.

Lucky find

The instrument belonged to Enrica Nestola, who happened to walk into the lab while McNeill was puzzling over what he was seeing.

That was a stroke of luck.

Nestola "is one of the handful of people in the word who would have known instantly what that was and identified it as ringwoodite," Pearson said. "And if that hadn't happened, then we would have just put this diamond on the pile and kept looking for what we were supposed to be looking for."

Pearson, who is a Canada Excellence Research Chair in Arctic Resources, added that the story illustrates the importance of basic and not just applied research, since scientists often make major discoveries "almost by chance" while looking for something completely different.

"But of course," he said, "you don't make discoveries like that unless you're looking in the first place."