Diamonds found with gold in Canada's Far North offer clues to Earth's early history

October 6 2020, by Michael Brown

Researchers Graham Pearson (left) and Jesse Reimink examine conglomerate rocks in Nunavut. Analysis of the 15 kilograms of samples they collected revealed three small diamonds within the rocks—an unexpected find that sheds light on what geological conditions were like on Earth three billion years ago. Credit: University of Alberta

The presence of diamonds in an outcrop atop an unrealized gold deposit in Canada's Far North mirrors the association found above the world's richest gold mine, according to University of Alberta research that fills in blanks about the thermal conditions of Earth's crust three billion years ago.

"The diamonds we have found so far are small and not economic, but they occur in ancient sediments that are an exact analog of the world's biggest gold deposit—the Witwatersrand Goldfields of South Africa, which has produced more than 40 percent of the gold ever mined on Earth," said Graham Pearson, researcher in the Faculty of Science and Canada Excellence Research Chair Laureate in Arctic Resources.

"Diamonds and gold are very strange bedfellows. They hardly ever appear in the same rock, so this new find may help to sweeten the attractiveness of the original gold discovery if we can find more diamonds."

Pearson explained that ex-N.W.T. Geological Survey scientist Val Jackson alerted his group to an unusual outcropping on the Arctic coast that has close similarities to the Witwatersrand gold deposits.

Pearson said this outcrop of rocks, known as conglomerates, are basically the erosion product of old mountain chains that get deposited in braided river channels.

"They're high-energy deposits that are good at carrying gold, and they're good at carrying diamonds," he said. "Our feeling was if the analogies are that close, then maybe there are diamonds in the Nunavut conglomerate also."

Pearson said finding new diamond deposits in Canada's North is critical in Canada continuing to host a $2.5-billion-per-year diamond mining industry.

So, on a hunch, Pearson used the last of his Canada Excellence Research Chair funding that brought him to the U of A, along with funding from the Metal Earth Project and the National Science Foundation, and—accompanied by post-doctoral diamond researcher Adrien Vizinet and former U of A grad student Jesse Reimink, now a professor at Penn State University—traveled to Nunavut.

Once at the site, the group—with the assistance of Silver Range Resources, whose CEO Mike Power is also a U of A alumnus—bashed off a modest 15 kilograms of the conglomerate and dated these rocks using the state-of-the-art mass spectrometry equipment at the U of A, which established their deposition to be about three billion years ago.

The group promptly delivered their samples to the Saskatchewan Research Council, the world leader in quantifying how many diamonds are in a rock.

Pearson remembers the precise moment about a year later, when the council's Cristiana Mircea, who visits Edmonton to teach Diamond Exploration Research Training School (DERTS) students about diamond indicator mineral identification, matter-of-factly told him the sample produced three diamonds.

"My jaw hit the floor," said Pearson. "Normally people would take hundreds of kilograms, if not tons of samples, to try and find that many diamonds. We managed to find diamonds in 15 kilos of rock that we sampled with a sledgehammer on a surface outcrop."

Though the diamonds found are quite small—less than a millimeter in diameter—he said the geologic implications are immense.

First, Pearson said there must have been kimberlite or rock like kimberlite present to carry diamonds to the Earth's surface in the ancient Earth—a notion many people have doubted.

Kimberlite pipes are the passageways that allow magma to erupt diamonds and other rocks and minerals from the mantle through the crust and onto the Earth's surface.

It also helps us understand under what conditions these peculiar kimberlite rocks can form.

Pearson said an Italian collaborator, Fabrizio Nestola from the University of Padua, managed to find an inclusion—a non-diamond mineral—in one of the diamond samples. From that, Suzette Timmerman, a researcher in the Canadian Centre for Isotopic Microanalysis and a Banting Postdoctoral Fellowship recipient, began building a theory that the diamonds had to be derived from a small, deep but cool lithospheric root, which is the thickest part of the continental plate.

"This is something completely unexpected from what we think conditions were like three billion years ago on Earth," said Pearson.

He explained that stable diamonds exist only in cool parts of the mantle, so it suggests there must have been very deep, perhaps 200-kilometer-thick cold roots beneath parts of the continent very early in Earth's history.

Pearson said despite the U of A's expertise in dating diamonds around the world, there's always an argument about the relationship between the inclusion and the diamond deposit.

"Here, there's no argument because we know when those rocks were eroded onto the Earth's surface," he said.

"It tells us there's an older source, a primary source of diamonds that must have been eroded to form this diamond-plus-gold deposit," he said.

This also means mining diamonds in the area would not necessarily require very deep mines, if more economic outcrops of these rocks can be found.

"We went up there on a float plane, bashed a piece of rock off with a sledgehammer and found three diamonds," he said. "That's actually one of the most astounding parts of this discovery."

He added that the provincial government, through Alberta Innovates, clearly realized universities can help a lot in expanding and diversifying Alberta's economy into the mining sector.

"The government's investment enables us to chase hunches that might otherwise be difficult for industry to go and look at."

Pearson pointed to the Collaborative Research and Training Experience grant from the Natural Sciences and Engineering Research Council of Canada, which almost instantly turned the U of A into the world's leading diamond research institution thanks to the formation of DERTS.

"Alberta has several potential diamond deposits and areas ripe for further exploration," he said. "I believe the University of Alberta can play a key role in helping to find and establish diamond and other mineral mines in Alberta."

Pearson said more research is continuing on similar nearby outcrops being developed by Silver Range Resources in collaboration with the Metal Earth Project, the Nunavut government and Penn State University, to establish the extent of the diamonds and gold in these rocks, and the possible primary sources of these minerals.

The studies, "Mesoarchean Deposition Age for Diamond-Bearing Metasediment of the Northwestern Slave Craton, Nunavut Territory (Canada)" and "Diamond-Bearing Metasediments Point to Thick, Cool Lithospheric Root Established by the Mesoarchean Beneath Parts of the Slave Craton (Canada)," will be presented at the virtual fall meeting of the American Geophysical Union this December.

Provided by University of Alberta