The search for Earth's missing carbon

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Deep beneath the surface of the Earth, a vast and unseen community of strange, microscopic lifeforms quietly subsists on the heat rising from our planet's interior.

In its total mass, this life might rival all that walks, crawls, stands, swims and soars above it, but scientists don't know for sure. Life has already been found in the deepest layer of Earth's crust, nearly one mile down, but scientists expect to find life thriving even deeper. Studying mysteries like this one is a task for the Deep Carbon Observatory, a new project that will search out not just life but everything carbon-related that lies beneath our feet.

“Twenty years ago, the idea that there was a deep underground biosphere would have been laughed at,” said Robert Hazen, a research scientist at the Carnegie Institution of Washington's Geophysical Laboratory in Washington, D.C., and leader of the Deep Carbon Observatory. “But we now know there is, because anywhere you drill you find life.” He spoke about the project on February 20 during the American Association for the Advancement of Science meeting in Washington, D.C.

Now in the first year of its planned decade-long existence, the Deep Carbon Observatory aims to reshape our fundamental understanding of carbon's role in the biology, chemistry, and physics of Earth's interior. Unlike typical astronomical observatories, which consist of a single instrument at a fixed location, the Deep Carbon Observatory will be a distributed operation, requiring a wide variety of instruments installed at locations around the world.

“We really don't know to a factor of 20-30 how much carbon there is in our planet,” Hazen said.

Carbon is among the most important chemical elements to humans. It forms the basis of life as we know it, is the central ingredient in many energy sources and plays a key part in our climate. In a planetary-scale machine called the carbon cycle, the element circulates among the oceans and atmosphere, into and out of the Earth's crust, and through living creatures that take it up, chemically process it, and redeposit it back into the planet. But even this immense cycle is thought to contain only a small part of total amount of carbon in our planet, with the rest locked deep beneath the surface.

“When you step back and ask fundamental questions about carbon in the Earth,” said Russell Hemley, also of the Geophysical Laboratory and co-leader of the program, “you realize there is a great deal that we do not know about this important element.”

Scientists believe that the subterranean microbes, some of them isolated from Earth's surface since before the dawn of humanity, crucially influence the engines that drive our planet's interior. The microbes process carbon relatively quickly, making them an important step in the carbon cycle. But the team behind the Deep Carbon Observatory says the project could also answer questions about many other issues.

The observatory is being funded by the Alfred P. Sloan Foundation, which has previously supported similarly large and ambitious science projects. The Sloan Digital Sky Survey, for example, has investigated the mysterious, universe-filling dark matter and dark energy, which are thought to be responsible for invisible effects of gravity and the cause of the increasing rate of expansion of the universe, respectively. The Census of Marine Life recently completed a survey of the abundance, diversity, and distribution of ocean life. Together, these programs cost hundreds of millions of dollars.

Still in its infancy, the Deep Carbon Observatory has yet to make any big discoveries. Efforts so far have mostly focused on galvanizing interest and participation by governments, industry, and geoscientists across the globe.

Some of the instruments envisioned for the observatory don't even exist yet. One device the scientific team hopes to develop is a small detector that can be placed on an active volcano to measure the amount of carbon it releases. Other instruments will extract data from existing resources, like the world's deepest drillshafts and mines.

“We want to see if we can get microbiologists on site at every deep drilling site in the world so we can collect samples before they can be contaminated,” Hazen said. “We're learning fascinating things about a biosphere that lives in very different conditions than we're familiar with.”

The goal of the project is to answer basic science questions, but industry already has its eyes on the research. In the past year, two of the world's largest natural gas reserves have been discovered off the coasts of Israel and Brazil. Hazen says his team has plans to study these methane reservoirs to see if the gas has its origins in biological processes underground, or high-pressure chemical reactions occurring at great depths. Last summer, scientists from the Shell Oil Company, which is a participant in the project, hosted a Deep Carbon Observatory workshop aimed at identify research directions.

“Science is not cataloging all the things we know, it's exploring the things we don't,” said Hazen. He suggested that discoveries by the Deep Carbon Observatory could lead to Nobel Prizes in chemistry and physics ten years from now. “We want to find the carbon equivalent of dark energy,” Hazen said.

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