

## Science Network Focuses on Deep Carbon in the Earth

With carbon playing a critical role related to energy, climate, resources, and life on the planet; with vast stores of it underground; and with many basic questions unanswered about the element, the 10-year international Deep Carbon Observatory (DCO) program, which began in 2009, has ambitious goals to fill in some of those knowledge gaps. To help assess current knowledge and questions about carbon, DCO held a scientific meeting in early March at the U.S. National Academy of Sciences in Washington, D. C., and released a nearly 700-page open access book, *Carbon in Earth*, which outlines many key issues related to carbon.

“There is nothing more fundamental than understanding carbon, and yet we remain remarkably ignorant about carbon in our planet,” observatory executive director Robert Hazen said on 4 March at the DCO meeting. Hazen, who is a research scientist at the Carnegie Institution of Washington’s Geophysical Laboratory, said that the program is focusing on carbon from a variety

of perspectives, including from the Earth’s crust to the core, from the nanoscale of individual molecules to the global scale of the carbon cycle, and in deep time.

“We don’t know by a factor of 20 how much carbon our planet holds,” Hazen said. Other key questions include whether there is a significant carbon flux between Earth’s deep interior and the surface, whether deep biochemistry has played a role in the origin of life on Earth, and the nature, distribution, and amount of deep microbial life.

DCO, which is organized into four broad and overlapping communities, now includes a network of about 1000 scientists from 40 countries with backgrounds in geology, biology, chemistry, physics, and other fields. “I cannot think of a single scientific program in history that has been as diverse in terms of the number of different fields,” Hazen told *Eos*.

The meeting included updates from the four communities. The extreme physics and chemistry community is looking at questions

such as what physical and chemical processes govern the behavior of carbon in the deep Earth. The decadal goal for the deep energy community is to quantify environmental conditions and processes controlling the volume, rates of production, and reactivity of organic compounds derived from deep carbon through geologic time.

For the community focusing on deep life, the decadal goal is to explore the evolutionary and functional diversity of the deep biosphere and its interaction with the carbon cycle, with projects including the Census of Deep Life, a global three-dimensional census over time of biological diversity of bacteria, archaea, eukarya, and viruses in deep subsurface environments. The reservoirs and fluxes community’s initiatives include the Deep Earth Carbon Degassing research effort, the Diamonds and the Mantle Geodynamics of Carbon project, and other programs.

In addition to the updates from the four communities, a number of researchers provided presentations on a range of topics, including serpentinization in time and space, seafloor microbial life in venting fluids from a hydrothermal system, volcanic carbon emissions from subduction zones, and a 2012 Integrated Ocean Drilling Program expedition by scientists on board the *R/V Chikyu* to a deep coal bed biosphere off Japan that set a new record for scientific ocean drilling.

One researcher, Steven D’Hondt, professor of oceanography at the University of Rhode Island, Narragansett, reflected on some new findings about the deep biosphere, including microbes that appear to be breathing too slowly for present theory to allow them to reproduce and genetically similar microbes detected in several isolated subsurface locations. Regarding the study of life beneath the seafloor and the subsurface generally, he said that “invariably when we discover something, it violates our sense of the possible, and so it forces us to consider a broader range of explanations.”

The meeting also included some outside perspectives. Former U.S. Geological Survey director Marcia McNutt said DCO should reach out more to the drilling and mining industries and to professional societies and should also focus on the observatory’s legacy beyond 10 years. Hazen said that DCO is involved with those sectors and also has established several legacy programs. Noting the Census of Deep Life and other programs including global monitoring of volcanoes, he told *Eos* that DCO has “lots of ambitions to make sure that what we do here today lives on.”

For more information and to read the new book *Carbon in Earth*, see <http://deepcarbon.net>.

—RANDY SHOWSTACK, Staff Writer