

DEEP CARBON OBSERVATORY

Carbon plays an unparalleled role in our lives, as the element of life, as the basis of most of society's energy, as the backbone of most new materials, and as the central focus in efforts to understand Earth's variable and uncertain climate. Yet in spite of carbon's importance, scientists remain largely ignorant of the physical, chemical, and biological behavior of many of Earth's carbon-bearing systems. The Deep Carbon Observatory is a global research program to transform our understanding of carbon in Earth. At its heart, DCO is a community of scientists, from biologists to physicists, geoscientists to chemists, and many others whose work crosses these disciplinary lines, forging a new, integrative field of deep carbon science. To complement this groundbreaking research, the DCO's infrastructure includes public engagement and education, online and offline community support, innovative data management, and novel instrumentation.

DEEP LIFE

What mechanisms govern microbial evolution and dispersal in the deep biosphere?
 What ecological rules explain deep microbial community structure?
 How does deep life respond to physical and chemical extremes?
 What can genomes can tell us about the limits and possible origins of life?
 How does life shape carbon transformations in the subsurface and what governs the rates of these reactions?
 How does life influence transitions between abiotic and biotic realms?
 How does deep life and its influence on the carbon cycle interact with the surface world?

RESERVOIRS AND FLUXES

How much carbon is contained in Earth?
 How much carbon is emitted from active volcanoes and active tectonic areas?
 How is carbon recycled between the atmosphere and Earth's crust, mantle, and core?
 What are the chemical forms of carbon in deep Earth, and how are they distributed?
 What is the nature of the whole Earth carbon cycle and how has it changed over Earth's history?

DEEP ENERGY

How are organic molecules such as methane formed in deep Earth?
 Are these organic molecules formed independently from life (abiotically)?
 What characteristics of deep Earth control the movements of organic molecules?
 Did mineral-mediated chemical reactions play a role in life's origins?
 How do organic molecules influence the global carbon cycle?

EXTREME PHYSICS AND CHEMISTRY

How do the physical and chemical properties of carbon change in Earth's deep interior?
 What is the nature and extent of carbon in Earth's core?
 How do extreme temperatures and pressures affect carbon's interactions with other elements?
 Are there as yet undiscovered high-pressure carbon minerals in Earth's deep interior?
 Can we simulate the conditions of deep Earth and other planets in the lab?

KEY RESEARCH AND INSTRUMENTATION INITIATIVES

- The Census of Deep Life (CoDL)
- The Nature of Rock-Hosted Life
- Deep Carbon Degassing (DECADE)
- Diamonds and Mantle Geochemistry of Carbon (DMGC)
- Integrated Carbon Algorithm-Software-Hardware Computational Facility (iCASH)
- The Panorama High-Resolution Mass Spectrometer
- Volcano Mass Spectrometer and SO₂ Camera Monitoring System

The DCO, established in July 2009, is a 10-year initiative to intensify global attention and scientific effort in the burgeoning field of deep carbon science. DCO's overarching purpose is to understand the complete carbon cycle—beyond the atmosphere, oceans, and shallow environments, which have drawn much research attention until now—to include the entire planet.

The Alfred P. Sloan Foundation pledged \$50 million over the duration of the initiative to fund infrastructure development, scientific workshops, new technology development, and preliminary research and fieldwork. This seed funding will catalyze collaborative scientific efforts around the world, increase public and private sector spending in deep carbon science, and leave a thriving community of international scientists as its legacy.

Ultimately, the DCO will synthesize 10 years of scientific research to generate unique and unprecedented views of Earth, looking at both scientific and human societal issues through a new, sharper lens.