

The Deep Carbon Cycle: Scientific Discoveries of the Deep Carbon Observatory

Craig M. Schiffries¹, Andrea Johnson Mangum¹, Jennifer Mays¹, Michelle Hoon-Starr¹, Robert M. Hazen¹

¹Geophysical Laboratory, Carnegie Institution for Science, Washington, DC, 20015, USA, cschiffries@ciw.edu

The Deep Carbon Observatory (DCO) is a ten-year research program to investigate the quantities, movements, forms, and origins of carbon in Earth. More than 90% of Earth's carbon may reside in the planet's deep interior, and DCO's overarching mission is to understand Earth's *entire* carbon cycle—beyond the atmosphere, oceans, and shallow crustal environments, which have drawn most previous research attention—to include the deep carbon cycle from crust to core. DCO scientists have published more than 1,300 peer-reviewed papers, including more than 100 papers in *Nature*, *Science*, and *Proceedings of the National Academy of Sciences*, documenting novel results of broad interest beyond traditional scientific disciplines. Here we provide an overview of DCO and examples of its major scientific achievements.

DCO researchers pursue diverse avenues of carbon research, such as studying diamonds and their inclusions; exploring the roles of volcanoes and subduction zones in recycling crustal carbon; analyzing hydrocarbon isotopologues to discriminate the abiotic versus biotic origin of methane gas and organic species; and investigating the nature and extent of the deep microbial biosphere.

To pursue its multidisciplinary study of the deep carbon cycle, DCO connects more than 1,000 scientists worldwide, organized into four Science Communities: Extreme Physics and Chemistry, Reservoirs and Fluxes, Deep Energy, and Deep Life. DCO also emphasizes four crosscutting activities that bridge community boundaries: data science, instrumentation, field studies, and modeling and visualization.

No less important than its scientific advances, DCO has built an enduring legacy in its diverse, dynamic, and collaborative community of interdisciplinary scientists. DCO's community building and management innovations are keys to the program's scientific success. These fundamental advances in the study of deep carbon demonstrate that DCO is an effective model for tackling large-scale, interdisciplinary science questions.