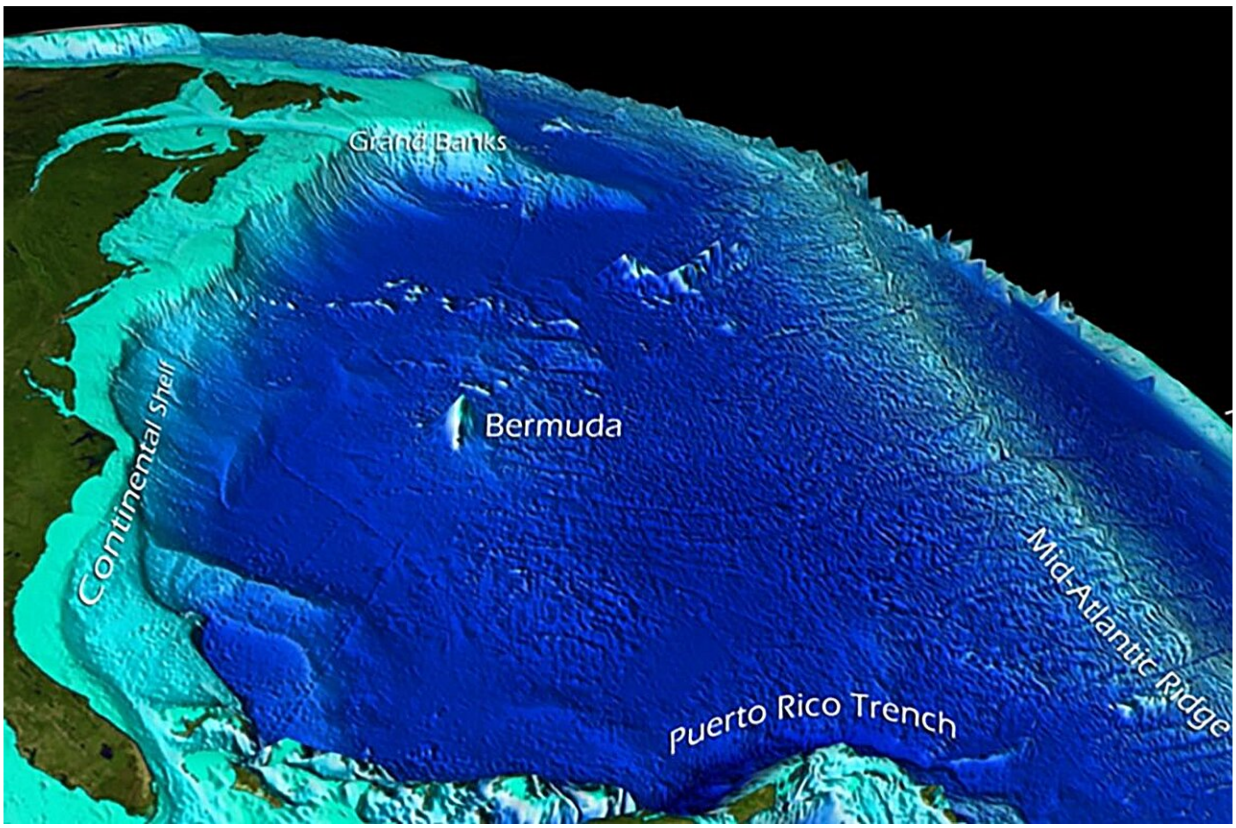
# Shape and depth of ocean floor profoundly influence how carbon is stored there, study shows

June 3 2024, by Benjamin Paul




Graphic depicting satellite captured, bathymetric data of the western Atlantic Ocean basin and its ocean floor features. Credit: NOAA's National Environmental Satellite and Information Service

The movement of carbon between the atmosphere, oceans and continents—the carbon cycle—is a fundamental process that regulates Earth's climate. Some factors, like volcanic eruptions or human activity, emit carbon dioxide into the atmosphere. Others, such as forests and oceans, absorb that $CO_2$. In a well-regulated system, the right amount of $CO_2$ is emitted and absorbed to maintain a healthy climate. Carbon sequestration is one tactic in the current battle against climate change.

A new study finds that the shape and depth of the ocean floor explain up to 50% of the changes in depth at which carbon has been sequestered in the ocean over the past 80 million years. Previously, these changes have been attributed to other causes. Scientists have long known that the ocean, the largest absorber of carbon on Earth, directly controls the amount of atmospheric carbon dioxide. But, until now, exactly how changes in seafloor topography over Earth's history affect the ocean's ability to sequester carbon was not well understood.

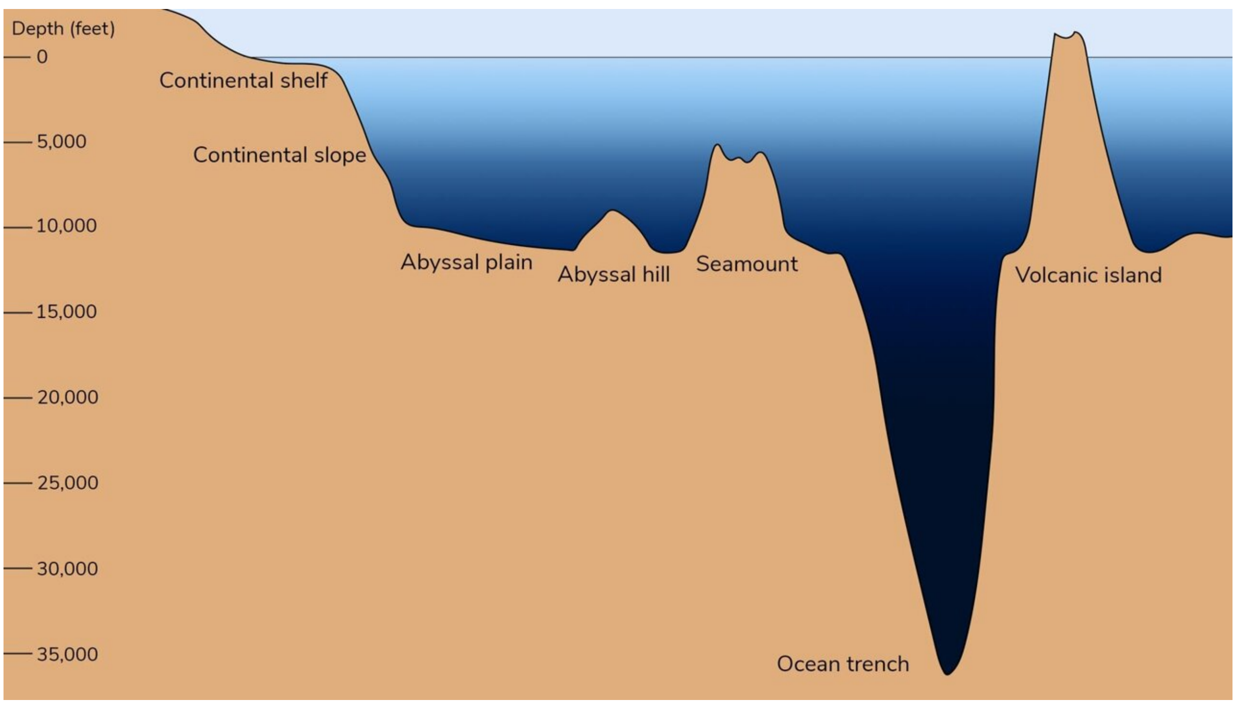
The work is published in the journal *Proceedings of the National Academy of Sciences*.

"We were able to show, for the first time, that the shape and depth of the ocean floor play major roles in the long-term carbon cycle," said Matthew Bogumil, the paper's lead author and a UCLA doctoral student of Earth, planetary and space sciences.

The long-term carbon cycle has a lot of moving parts, all functioning on different time scales. One of those parts is seafloor bathymetry—the mean depth and shape of the ocean floor. This is, in turn, controlled by the relative positions of the continent and the oceans, sea level, as well as the flow within Earth's mantle. Carbon cycle models calibrated with paleoclimate datasets form the basis for scientists' understanding of the global marine carbon cycle and how it responds to natural perturbations.

"Typically, carbon cycle models over Earth's history consider seafloor bathymetry as either a fixed or a secondary factor," said Tushar Mittal, the paper's co-author and a professor of geosciences at Pennsylvania State University.

The new research reconstructed bathymetry over the last 80 million years and plugged the data into a computer model that measures marine carbon sequestration. The results showed that ocean alkalinity, calcite saturation state and the carbonate compensation depth depended strongly on changes to shallow parts of the ocean floor (about 600 meters or less) and on how deeper marine regions (greater than 1,000 meters) are distributed. These three measures are critical to understanding how carbon is stored in the ocean floor.




Graphic showing several ocean floor features on a scale from 0–35,000 feet below sea level. Credit: NOAA Office of Education

The researchers also found that for the current geologic era, the Cenozoic, bathymetry alone accounted for 33%–50% of the observed variation in carbon sequestration and concluded that by ignoring bathymetric changes, researchers mistakenly attribute changes in carbon sequestration to other less certain factors, such as atmospheric $CO_2$, water column temperature, and silicates and carbonates washed into the ocean by rivers.

"Understanding important processes in the long-term carbon cycle can better inform scientists working on marine-based carbon dioxide removal technologies to combat climate change today," Bogumil said. "By studying what nature has done in the past, we can learn more about the possible outcomes and practicality of marine sequestration to mitigate climate change."

This new understanding that the shape and depth of ocean floors is perhaps the greatest influencer of carbon sequestration can also aid the search for habitable planets in our universe.

"When looking at faraway planets, we currently have a limited set of tools to give us a hint about their potential for habitability," said co-author Carolina Lithgow-Bertelloni, a UCLA professor and department chair of Earth, planetary and space sciences. "Now that we understand the important role bathymetry plays in the carbon cycle, we can directly connect the planet's interior evolution to its surface environment when making inferences from JWST observations and understanding planetary habitability in general."

The breakthrough represents only the beginning of the researchers' work.

"Now that we know how important bathymetry is in general, we plan to use new simulations and models to better understand how differently shaped ocean floors will specifically affect the carbon cycle and how this has changed over Earth's history, especially the early Earth, when most of the land was underwater," Bogumil said.

**More information:** Matthew Bogumil et al, The effects of bathymetry on the long-term carbon cycle and CCD, *Proceedings of the National Academy of Sciences* (2024). DOI: 10.1073/pnas.2400232121

Provided by University of California, Los Angeles