Biominerals in a Changing Ocean

OVERVIEW

Biominerals are the hard parts that make up the skeletons and shells of sea creatures, such as corals and mollusks, that form and inhabit healthy ocean ecosystems. Rapidly changing ocean chemistry and sea surface temperatures, driven by an anthropogenic rise in carbon dioxide, are adversely impacting these organisms—down to the bone. By taking a mineralogical perspective, we can better understand how skeletons and shells form, how they are affected by stress, how they have evolved over time, and ultimately, what steps engineers and policy makers may take to save them.

IMPORTANCE

As the unprecedented rapid rise of anthropogenic CO2 levels in Earth's atmosphere leads to global climate change, the ocean is experiencing profound changes—from rising sea surface temperatures, to ocean acidification and shifting ocean chemistry, to more frequent hurricanes. These rapidly changing variables inherently cause stress in ocean-dwelling organisms. Many organisms that drive major ocean ecosystems, such as the stony corals that make up coral reefs, form their hard parts out of minerals. These skeletons, shells, frustules, and tests are called biominerals—minerals produced by organisms that are capable of manipulating their internal chemistry and creating organic templates to precipitate these minerals. Apart from the immediate ecological and economic need for biominerals to form the architectures of healthy coral reefs, robust mollusk shells for aquaculture, and the tiny mineral parts of critical primary producers in the ocean, biominerals are also important to paleoclimate studies that use historic layers in biomineral skeletons and shells to track past climate variability and predict what may happen in the future. Still, relatively little foundational knowledge exists about how biominerals form and how they will be impacted under predicted climate change environments—especially from a mineralogical and chemical perspective.

POTENTIAL RESEARCH THEMES

A Climate Fellow working at NMNH in the Department of Mineral Sciences may consider working on the following biomineral themes in order to understand: 1) how biomineralizing organisms form critical biominerals; 2) how stress (temperature, chemistry, etc.) influences biomineralizing mechanisms; and 3) what past climate conditions recorded by biominerals can tell us about future climate.

Current curators at NMNH are actively working on these general themes (in coral skeletons and mollusk shells and would be eager to assist the Climate Fellow to develop projects that can be accomplished using the array of collections and instrumentation at NMNH.

PROGRAMS AND ASSETS

Answering climate-related questions in environmental biomineralogy requires scientists from many backgrounds. The Climate Change Fellow working in the Department of Mineral Sciences at NMNH and will be encouraged to address these mineral-related questions in conjunction with experts across the museum who specialize in invertebrate zoology, paleobiology, and more. The Smithsonian is an ideal place to conduct interdisciplinary biomineral studies for several reasons:

1. The Department of Mineral Sciences is equipped with state of the art mineralogical and chemical instruments to characterize biominerals and their geological mineral analogs. In particular, the Department of Mineral Sciences has access to X-ray diffraction, Raman spectroscopy, Scanning electron microscopy, optical microscopy, X-ray CT scanning, and more.

2. Working with historical invertebrate and paleontological collections at the NMNH provides a wealth of information unique to NMNH.

3. The Smithsonian encompasses several units in addition to NMNH, such as the Smithsonian Environmental Research Center and Fort Pierce Marine Station, which may become important collaborators for their culturing facilities and expertise in related marine organism projects that could naturally complement the Fellow's work to address these questions.

4. Advisors at NMNH have active, climate-related collaborations with colleagues at universities and oceanographic institutions who may provide additional expertise and resources to the Fellow.

ADVISORS

The following Smithsonian staff scientists commit to respond to queries from prospective climate fellows, facilitate access to NMNH collections and instrumentation, and provide guidance throughout the fellowships: Gabriela Farfan, Ioan Lascu, and Andrea Quattrini. Fellows will also have the opportunity to seek additional expertise and collaboration from the broader Smithsonian Environmental Research Center, Smithsonian Marine Station at Fort Pierce, and other Smithsonian communities.