Ocean and Climate Change Institute
Final Report

Culture-Based Calibration of the Benthic Foraminiferal Mg/Ca Thermometer

Daniel McCorkle, GG
Joan Bernhard, GG

What were the primary questions you were trying to address with this research? (Or, if more appropriate, was there a hypothesis or theory that you were trying to prove or disprove?)

We have used support from the OCCI to construct what is, to our knowledge, the first system for culturing deep-sea benthic foraminifera at multiple temperatures. By growing foraminifera under controlled chemical conditions at several temperatures, we will be able to produce laboratory-based calibration data documenting the response of benthic foraminiferal shell chemistry (the magnesium:calcium ratios and oxygen isotopic composition of foraminiferal calcium carbonate) to water temperature. We are now more than four months into our first culturing experiment with this new system. PIs McCorkle and Bernhard are carrying out this experiment in collaboration with postdoctoral investigator (and Fulbright Scholar) Dr. Helena Filipsson of the University of Goteborg, Sweden, and MIT-EAPS graduate student Ms. Sara Lincoln.

What have you discovered or learned that you didn't know before you started this work?

Our first experiment is still under way.

What is the significance of your findings for others working in this field of inquiry and for the broader scientific community?

The shell chemistry of benthic foraminifera can provide valuable records of deep-sea temperatures in the past. However, the chemical "thermometers" used to make these paleotemperature estimates (e.g., foraminiferal Mg/Ca and $\delta^{18}O$ values) respond to other environmental factors, such as deep-water carbonate chemistry (carbonate ion concentration and/or pH), as well as to temperature. Unfortunately, water temperature and these chemical factors tend to co-vary in the ocean, making it hard to produce an unequivocal temperature calibration using field data alone. Calibrations based on laboratory culture experiments will provide a way to separate the influences of water temperature and water chemistry on shell composition, yielding independent temperature calibrations of foraminiferal Mg/Ca and $\delta^{18}O$ values.

What is the significance of this research for society?

Reconstructions of natural, climate-linked variations in ocean temperature, chemistry, and circulation are key parts of the community effort to understand natural climate variability, and to predict anthropogenic climate change. Calibration and testing of paleoenvironmental "proxies", including deep-water temperature and chemistry records based on benthic foraminiferal shell chemistry, are an essential part of producing reliable paleoclimate reconstructions.

What were the most unusual or unexpected results and opportunities in this investigation?

What were the greatest challenges and difficulties?

When and where was this investigation conducted? (For instance, did you conduct new field research, or was this a new analysis of existing data?)

What were the key tools or instruments you used to conduct this research?

This award funded the set-up of a unique multiple-temperature culturing system in a small laboratory in the McLean building. The system is not technologically complex – three refrigerators, 20 small acrylic culture chambers, a pump, and lots(!) of plastic tubing and valves. The culture chambers were inoculated with benthic foraminifera collected from intermediate-depth sites off South Carolina and the Bahamas, and from shallower sites on the west coast of Sweden.

Is this research part of a larger project or program?

The OCCI-funded culturing system gives us the unique capability to carry out multiple-temperature culturing experiments using a single reservoir of seawater, with a single chemical composition. Our multi-T system complements a system developed by colleagues at the University of South Carolina, which allows benthic foraminifera to be cultured with seawater of several chemical compositions, all at a single temperature. Both groups (USC and WHOI) received NSF-OCE awards in early 2007 for separate sets of experiments that will, together, enable us to distinguish the influences of seawater temperature and seawater carbonate chemistry (pH and carbonate ion concentration) on benthic foraminiferal shell chemistry. The WHOI-based proposal, for the multiple-temperature single-chemistry experiments, could not have been submitted and would not have been funded without the existence of our OCCI-funded multiple temperature culturing system.

What are your next steps?

Continued multi-T culturing experiments, including deeper-water species, coupled with feeding and physical substrate experiments which we hope will help us successfully culture some of the benthic foraminiferal species most widely used in paleoceanographic studies.

Have you published findings or web pages related to this research? Please provide a citation, reprint, and web link (when available).

Our first experiment is still under way.

Please suggest or provide photographs, illustrations, tables/charts, and web links that can help illustrate your research.

This project was recently featured in a short article for Oceanus On Line – "Cell-Sized Thermometers" – which includes both text and figures.

http://www.whoi.edu/oceanus/viewArticle.do?id=25726&sectionid=1000