MARINE SEDIMENTS HAVE AN APATITE FOR DIATOMACEOUS POLYPHOSPHATE

Phosphorus is an essential nutrient for life. Levels of atmospheric carbon dioxide, a greenhouse gas, are directly related to the growth and productivity of marine life, which is a function of phosphorus availability. A team of scientists using an APS beamline has identified a process by which marine organisms influence the amount of atmospheric carbon the sea absorbs. A greater understanding of how phosphorus uptake, metabolism, and sequestration occur within marine organisms could provide clues to how carbon uptake and sequestration take place in the ocean and affect the global carbon balance.

Understanding the sources and sinks of phosphorus in systems like the ocean relates directly to understanding the controls on marine productivity.

Calcium phosphate deposited in marine sediments is a major sink for phosphorus in the form of the mineral apatite, but the mechanism by which apatite forms and is buried is unknown. One key step in the formation of marine apatite may involve polyphosphate bodies formed in common marine organisms. Polyphosphate generated by living cells has not been considered important in marine phosphorus cycl-ing. But recent advances in high-resolution spectromicroscopy led to a re-evaluation of this thinking. The re-search team, with members from the Georgia Institute of Technology, the University of South Carolina, Argonne National Laboratory, the Skidaway In-stitute of Oceanography, and the Aus-tralian Synchrotron found that polyphosphate from marine diatoms and mineral apatite derived from these polyphosphates represent a significant sink of phosphate. Marine sediments collected off the coast of British Columbia were analyzed using scanning x-ray microscopy (SXM) at XOR beamline 2-ID-B with a spatial resolution of ~60 nm and were found to have significant levels of polyphosphate and apatite derived from polyphosphate (Fig. 1).

In order to analyze polyphosphate levels in marine samples collected during the spring bloom (when organisms might be expected to accumulate polyphosphate), investigators performed bulk 31P nuclear magnetic resonance spectroscopy. The measurements indicated that polyphosphate constituted 7% of the surface water biomass, but it did not alter the normal carbon/nitrogen/phosphate composition of the samples. Polyphosphate constituted 11%, 7%, and 8% of dissolved matter, sinking particles, and surface sediment, respectively. High-resolution spectromicroscopy supported the hypothesis that the polyphosphate found in these samples originated from diatoms because the size (0.5 μM to 3 μM) of the polyphosphate fragments found in each sample type were comparable to those found in diatoms.

Further x-ray spectromicroscopic analysis revealed information about the next step in the sedimentation process: the transition of polyphosphate into mineral apatite. In sediment samples, the investigators were able to detect polyphosphate, apatite, and also some distinct particles that had spectral properties representing materials that could be considered transitional between the two. This finding suggests that polyphosphate from diatoms provides sites for nucleation of the geologically stable mineral phase—apatite—in marine sediments.

The researchers concluded that polyphosphate from diatoms could represent an important sink of phosphate that is globally important because of the widespread abundance of these planktonic organisms.

Thus, a clearer understanding of the dynamics of phosphate deposition and sequestration by diatoms may broaden our understanding of both modern and ancient climate change.

— *Sandy Field*

See: Julia Diaz[1], Ellery Ingall[1]*, Claudia Benitez-Nelson[2], David Paterson[3†], Martin D. de Jonge[3‡], Ian McNulty[3], and Jay A. Brandes[4], "Marine Polyphosphate: A Key Player in Geologic Phosphorus Sequestration," Science **320**, 652 (2 May 2008). DOI: 10.1126/science.1151751

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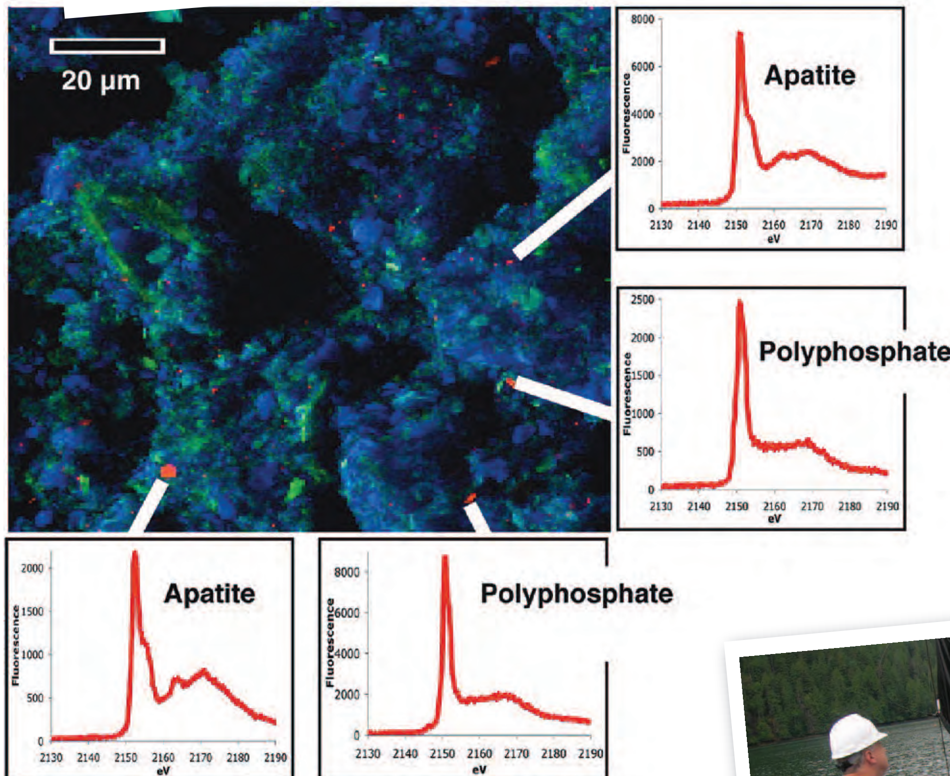
2-ID-B • XOR • Materials science, environmental science, physics • Coherent x-ray scattering (soft x-ray), microfluorescence (soft x-ray) • 5.5-cm undulator • Accepting general users

The RV Barnes, the research vessel that was used to collect samples in Effingham Inlet, British Columbia, houses all of the equipment needed to collect water, plankton, and sediment samples

Processing a sediment core



< Fig. 1. X-ray fluorescence micrograph and fluorescence spectra of phosphorus-rich regions in Effingham Inlet sediment. Sedimentary phosphorus (red) appears as distinct, heterogeneously distributed submicrometer-sized particles against a comparatively uniform background of sedimentary aluminum (blue) and magnesium (green). On the basis of high-resolution x-ray spectroscopic characterization, about half of the 147 phosphorus-rich regions examined were found to be polyphosphate, whereas the other half were classified as apatite. (© 2008 American Association for the Advancement of Science. Reprinted with permission.)

Rinsing particle samples aboard the research vessel

Collecting water samples from aboard the RV Barnes in Effingham Inlet, British Columbia