Calcite biomineralization in coccoliths: evidence from atomic force microscopy (AFM)

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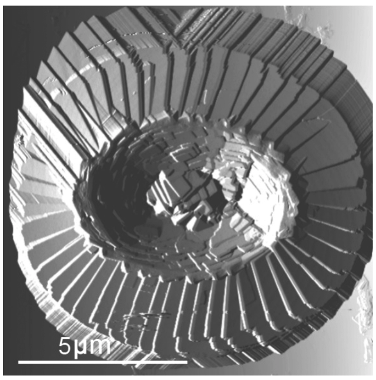
Coccoliths are calcite scales produced by unicellular algae to form cell-wall coverings. They represent a very high level of biological control on the biomineral phase, with crystallographic orientation and morphology tightly regulated. We used high resolution SEM as well as AFM in air and a fluid cell, to reveal detailed morphology and calcite crystallographic orientation of coccolith elements. Crystalline features, such as growth fronts, as well as organic structures, such as bodyscales of the algae, could be resolved by AFM. The influence of organic material associated with the crystals was assesed by investigating their behaviour during dissolution before and after chemical treatment to remove organic coccolith coatings.

Organisms biomineralize both crystalline and amorphous materials. When making use of a crystalline material, such as the calcite of coccoliths, the inorganically stable crystal shape must be modified to fit the requirements of the organism. However, evidence from the two species, *Coccolithus pelagicus* and *Oolithotus fragilis,* suggests that the crystal faces and directions common in inorganic mineralization are adapted to construct the complex coccolith structures. The two species attain specialized architectures of contrasting properties by rotation of the atomic lattice with respect to the overall coccolith structure.

Figure 1: AFM image of *Coccolithus pelagicus.*



Glacial-Interglacial Tropical Sea Surface Temperature Changes Deduced from the Alkenone Paleothermometer

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Alkenone paleotemperature measurements, along with several other new geochemical techniques, offer us the opportunity of reassessing the question of tropical sea surface temperature (SST) stability during the Ice Age climate cycles of the Pleistocene. Because the alkenone unsaturation index (“$U^{k'}_{37}$) can be determined both very precisely and rapidly, it gives paleoceanographers a new window into both the amplitude and timing of glacial SST cooling. Data presented here will include tropical SST determinations through the last full Glacial-Interglacial cycle in each of the major ocean basins. Of special interest is a new record produced in our lab from ODP Site 828, off Vanuatu, the location of coral Sr/Ca paleotemperature estimates (Beck et al, 1997). Available data suggest that:

1. Tropical SST’s cooled by 1-3ºC at the Last Glacial Maximum (LGM).
2. The cooling deduced from the alkenone method is much closer to the CLIMAP ocean reconstruction than to more recent suggestions of a nearly uniform 5ºC ocean cooling at the LGM.
3. Tropical SST’s generally, but not uniformly, warmed ahead of deglaciation ($\delta^{18}O$).
4. SST’s at the previous peak interglacial (marine oxygen isotope stage 5e) were 1-2ºC warmer than late Holocene temperatures.

How do we tell how reliable these estimates are? I argue that regional arrays of paleotemperature data are the best guide to the absolute accuracy of reconstructions. These allow us to test how reproducible our estimates are, and to assess results against physical constraints (for example, a grid of proxy SST data should reveal a cold tongue along the eastern equatorial Pacific, even if its magnitude and gradients are changed from the present day). Alkenone SST estimates appear to perform well from these criteria. I also argue that we should abandon “template” thinking- the idea that one tropical SST pattern is found everywhere. Instead, new insights will come from identifying regional fingerprints of glacial-interglacial SST change from alkenone and other high-quality temperature proxies.

References

Beck, J.W., J. Recy, F. Taylor, R.L.Edwards, and G. Cabioch, 1997, Abrupt changes in early Holocene tropical sea surface temperature derived from coral records, *Nature* 385: 705-707.