Environmental control on size and genotype of *Emiliania huxleyi*

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Coccolithophores play an important role in the global carbon cycle as primary producers and marine calcifiers. Because of ocean acidification due to increased atmospheric CO_2 we need to constrain how natural coccolithophore populations can acclimatize or adapt to projected changes, and how their natural feedback mechanisms may operate in future. In recent years, numerous experimental studies have highlighted environmental controls on coccolith calcification and malformation, mostly using monoclonal cultures of *Emiliania huxleyi* (*e.g.* Paasche *et al.*, 1996; Paasche, 1998; Riebesell *et al.*, 2000; Sorrosa *et al.*, 2005; Iglesias-Rodriguez *et al.*, 2008). However, extrapolating laboratory-based results to the scales and dynamics of the 'real' ocean remains speculative. The upwelling region offshore Namibia, characterized by small-scale but large gradients in temperature, nutrient availability and CO_2 concentrations, serves as a natural laboratory where we can test hypotheses concerning the environmental controls on coccolith calcification/malformation and ecological responses in natural populations.

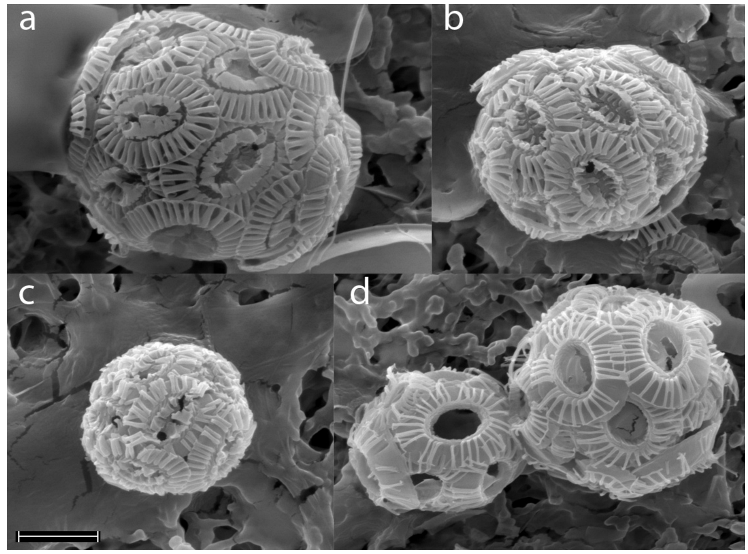

Figure 1: Examples of living *E. huxleyi* sampled offshore Namibia. **a**) Type A heavily calcified, large coccosphere; **b, c**) Type A coccospheres with malformed coccoliths; **d**) Type B/C with delicate distal shield elements and open central areas. Scale-bar = 2μm

Here we present coccolithophore and *in situ* environmental data from water-column samples collected during cruise 48/5 of the RV *Meteor* (October 2000) from transect lines perpendicular to the Namibian coast. Samples cover a wide spectrum, from recently upwelled waters to oceanic surface waters. Closest to shore in recently upwelled waters, large blooms of diatoms dominate the phytoplankton biomass. *E. huxleyi* is the most dominant species in older upwelling waters above the shelf edge and slope. Coccoliths in these waters were often malformed. Two different morphotypes (likely genotypes) of *E. huxleyi* occurred in environmentally distinct zones (Fig. 1). *E. huxleyi* with delicate distal shield elements and open central areas (Type B/C cf. Young *et al.*, 2003) dominated in highly nitrogen-depleted surface waters above the continental slope. At these stations, cell abundances reached 300x10^3 cells/liter. More heavily calcified *E. huxleyi* (Type A cf. Young & Westbroek, 1991) were dominant at stations above the shelf edge and slope, with cell abundances ranging from 2000 to >10^6 cells/liter. Most populations of *E. huxleyi* Type A were malformed, with irregularly arranged distal shield elements that appear detached from a central coccolith rim. A bloom of anomalously large Type A coccospheres with well-developed and heavily calcified coccoliths was observed in relatively cool water where nutrient concentrations were closer to the Redfield N:P ratio. Our observations suggest a scenario where *E. huxleyi* populations thrive under elevated levels of dissolved inorganic carbon (DIC), although nitrate deficiency and/or lower calcite saturation/ocean pH may contribute to extensive coccolith malformation in this upwelling region.

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