Climate stability on the early Earth. How to recover from glaciations?

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The overwhelming geologic evidence suggest that early Earth was a warm planet despite the faintness of the young Sun. The standard explanation for this apparent paradox requires high atmospheric CO_2 levels in the Proterozoic-Archean so that the increased atmospheric greenhouse effect would compensate for the solar energy shortage. Accumulation of CO_2 in the atmosphere was also proposed as the mechanism of recovery from the most severe glaciations in the earth history (Snowball glaciations).

I found that under the decreased solar luminosity even at moderate CO_2 levels, the polar surface tempertures could drop below the CO_2 condensation temperatures. If CO_2 were condensing at the surface it could not have stabilized climate against any climate perturbations by means of the carbonate-silicate cycle or could not have accumulated in the atmosphere during Snowball events and defreezed the planet. My climate simulations suggest that some additional warming was required throught Archean and Proterozoic to prevent CO_2 from condensing.

Calcite growth orientation and trace metal uptake: Implications for biomineral proxies

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Coccolith trace metal palaeoenvironmental proxies are used to reconstruct past marine conditions. Fundamental controls on trace metal incorporation into these biominerals are poorly understood. Coccoliths produced by the dominant coccolithophorid species, *Emiliania huxleyi*, consist of radially oriented calcite crystals that exhibit elevated Sr/Ca ratios [1]. This radial crystal alignment has been suggested to develop by the propagation of obtuse kink sites on the $\{10\bar{1}4\}$ surface of calcite, promoting growth along the c-axis. This is proposed to occur via the poisoning of acute kink sites with coccolith associated polysaccharide (CAP) [2]. Cations, such as Sr, with atomic radii larger than Ca become preferentially incorporated into obtuse kink sites during calcite growth [3]. We hypothesise that di-carboxylic acid additives (e.g., malonate) which mimic the behaviour of CAP by blocking the acute surface kink sites cause the enrichment of larger elements, such as Sr, in calcite.

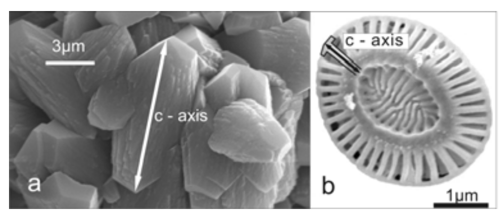

Figure 1: SEM images: **a)** calcite crystals elongate along c-axis, grown with 10^{-2} M malonate **b)** *E. huxleyi* coccolith, after [2].

Results indicate that elongation along the c-axis (Fig. 1a) and strontium partition coefficient (D_{Sr}) increase with malonate concentration. For example, a system with 10^{-1} M malonate produces a D_{Sr} comparable to that predicted for *E. huxleyi* coccolith calcite [4]. We suggest that Sr enriched *E. huxleyi* coccolith calcite is produced, at least in part, by the interaction of carboxyl-bearing CAP with the growing coccolith calcite.

[1] Rickaby *et al.* (2007) *Earth & Plan. Sci. Lett.* **253**, 83-95. [2] Henriksen *et al.* (2004) *Am. Min.* **89**, 1586-1596. [3] Paquette & Reader (1995) *GCA* **59**, 735-749. [4] Langer *et al.* (2006) *Limn. & Ocean.* **51**, 310-320.