Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.6445

Coccolithophore response to seawater Mg/Ca ratio

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Coccolithophores are calcifying unicellular phytoplankton sensitive to environmental change. Although Mg is essential for photosynthesis, Mg also has the potential to inhibit mineral growth in inorganic calcite, and raises the saturation state needed for precipitation of calcite. Whether an increasing Mg content of the ocean relative to Ca, as has occurred over the last 60 Myrs, may also interfere with calcite biomineralisers, particularly coccolithophores which calcify intracellularly and have reduced in size over this same timescale, is unknown.

In this study, we cultured 6 strains which represent 4 coccolithophore species including over-calcified *Emiliania huxleyi* (RCC1216), regular-calcified *E. huxleyi* (RCC911 and OA1), *Gephyrocapsa oceanica* (RCC1314), *Coccolithus braarudii* (RCC1198) and *C. pelagicus* (RCC3776) under a range of Mg/Ca ratios (Mg/Ca: 0.5, 1, 5, 10, 15, 20). We evaluated their cell adaption and calcification sensitivities under different magnesium concentrations by measuring the growth rate(μ), Photosystem II efficiency (Fv/Fm) and coccolith morphology. We have found that only in OA1 and RCC911 strains, there was a hint that the lowest Mg/Ca ratio could limit growth, perhaps due to the scarcity of Mg required for photosynthesis. In terms of calcification, both over-calcified *E. huxleyi* RCC1216 and *G. oceanica* RCC1314 have the strongest adaptation abilities for the changing magnesium concentration as no significant change was observed for growth rate, Fv/Fm and morphology across the Mg/Ca range except under extremely high magnesium concentration, where both of the strains lost calcification. The two strains of regular-calcified *E. huxleyi* OA1 and RCC911 appear to exert the strongest control over the chemistry at the site of calcification, as they are still able to maintain coccosphere structure under extreme magnesium concentration. Even though the coccolith morphology were changing with the Mg/Ca ratio where more malformed and incomplete coccoliths were observed with the increasing of magnesium. *Coccolithus spp.* strains RCC1198 and RCC3776 are more vulnerable compared to other species as they grew very slowly at a Mg/Ca ratio of 15 and growth was completely inhibited at the highest Mg concentration.

Further exploration is needed to understand the magnesium transportation mechanism in coccolithophores especially the relationship between magnesium and calcium transportation.