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Assessing the response of coccolithophores and foraminifera to enhanced ocean alkalinity as a CO_2 sequestration technique

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The alkalinity of seawater sets the overall capacity of the ocean to hold carbon dioxide in dissolved forms. Variations in past alkalinity, related to changing weathering or carbonate compensation, may have played an important role in moderating or controlling past variations of atmospheric *p* CO_2. Future manipulation of ocean alkalinity by direct addition of suitable chemicals to seawater, or through enhanced weathering on land, has also been suggested as one possible route to intentionally draw CO_2 from the modern atmosphere and mitigate the impacts of future climate change [1]. Although we know an increasing amount about how biological species and ecosystems respond to changes in pH, we know much less about their response to changes in alkalinity. Calcifying plankton play a crucial role in modulating the surface ocean carbonate system and its buffering of alkalinity perturbations [2]. Here we investigate the growth and calcification response of both coccolithophores and foraminifera to elevated ocean alkalinity and potential CO_2 limitation [3] through a series of carefully designed batch culture laboratory experiments. Alkalinity is raised by two different methods during the experiments: by (i) addition of $NaHCO_3$ and (ii) addition of Na_2CO_3 and $CaCl_2$. The reason for two differing elevated alkalinity treatments is that they allow us to constrain how physiology and calcification respond to two different modes of alkalinity manipulation; both of which provide simple laboratory analogues for probable real-world scenarios.

I will present results from experiments with two species of coccolithophores: *Emiliania huxleyi* and *Coccolithus braarudii*, as well as two species of planktonic foraminifera: *Gloigerinoides ruber* and *Globigerinella siphonifera*. We have found that the main bloom-forming coccolithophore, *Emiliania huxleyi*, may increase its calcification and growth rate in response to enhanced alkalinity up to Total Alkalinity (TA) = 4000μmol/kg. Whereas *Coccolithus braarudii*, a much larger and relatively less abundant coccolithophore, shows only a hint of increased calcification in enhanced alkalinity, with negligible changes in growth rate in enhanced alkalinity up to a threshold of Total Alkalinity (TA) = 3500μmol/kg. However, at TA = 4000μmol/kg, *C. braarudii*'s growth is significantly suppressed/delayed compared to control conditions. In contrast, planktonic foraminifera's gametogenic success rate alters with enhanced alkalinity, and they may live longer in enhanced alkalinity before undergoing gametogenesis, but with no concurrent measurable increase in calcification. These results from two major groups of calcifiers have implications for future experiments on biotic response to ocean alkalinity enhancement (OAE) schemes, as well as

implications for the design implementation of OAE schemes.

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