Carbon isotopes and calcifiers

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The evolution of the carbon isotopic composition of the ocean as recorded by bulk marine carbonate reflects the relative balance between the burial of carbon in its reduced form as organic carbon, and the burial of carbon in its oxidised form as carbonate from volcanically sourced CO2. Given the dramatic changes in the biosphere from the origination of photosynthesis and the advent of biomineralisation, what is remarkable about the record of marine $\delta^{13}C$ is that despite shorter term perturbations and some fluctuations, over the majority of Earth history, the $\delta^{13}C$ of marine carbonates has averaged around +2 ‰. This baseline has been sustained even during the Cenozoic when the $\delta^{13}C$ of organic matter for the first time, trends to significantly heavier values.

The carbon isotopic composition of most biominerals deviates away from equilibrium due to the physiology of the organism, a deviation known as the vital effect. The carbon isotopic composition of calcite precipitated by single celled photosynthesising cells such as coccolithophores can be thought of as a microscopic ocean. Carbon enters the cell and is then partitioned between fixation into organic matter by photosynthesis and calcification. The $\delta^{13}C$ vital effect of coccolith carbonate has been shown to depend on this PIC/POC ratio and on the degree of utilisation of the internal carbon pool (McClelland et al., 2017). By contrast the C isotopic composition of planktonic foraminifera, single celled heterotrophs, takes in seawater DIC for calcification via endocytosis but the calcite is additionally imprinted by is isotopically light respiratory carbon dioxide.

Here we will explore what these two contrasting vital effects in different calcifying groups may reveal about the evolution of the carbon cycle during the Cenozoic and whether parallels can be drawn between cellular and ocean scale processes that lead to natural balance in C isotopes.

McClelland H. L. O., J. Bruggeman, M. Hermoso & R. E. M. Rickaby, The origin of carbon isotope vital effects in coccolith calcite, Nat Comms, DOI: 10.1038/ncomms14511, 2017

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