Fatty acids and stable carbon isotopes of a sulfate-reducing bacterium: implications for carbon cycling in organic-rich marine sediments

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Tools for Identifying Carbon Cycling Pathways

Sulfate-reducing bacteria (SRB) have characteristic lipid biomarkers, which help identify carbon cycling pathways under sulfate-reducing conditions. This is especially important in marine sediments because of their high degree of sulfate reduction. Little research has been done to determine carbon isotope fractionations associated with lipid biomarkers of known SRB.

Method

We examined the fatty acid compositions and their carbon isotope ratios of *Desulfovibrio desulfuricans* G20 using lactate, pyruvate, or formate as the electron donor and sulfate as the electron acceptor. No CO_2 or HCO_3^- was added during experimentation, and a starved control was also incubated.

Results

G20 grew well with lactate and pyruvate but only marginally, if at all, with formate. Diagnostic fatty acids of iso- and anteiso-15:0 and 17:0 were higher in formate and lactate cultures (5-17%) than in pyruvate cultures (2.5-5.0%). Carbon isotope fractionation of these and other fatty acids against total biomass was similar under lactate (-10.7 to -15.1‰) and pyruvate (-9.9 to -15.7‰) conditions, which may be due to the fact that no carbon splitting occurs during lactate degradation to pyruvate (DeNiro and Epstein, 1977). The fractionation was much smaller (0.1 to -8.21‰) under formate conditions. The mechanism for this lower fractionation is not yet clear.

Conclusion

Carbon isotopes of lipid biomarkers may provide insight into metabolic pathways and carbon cycling by SRB in environments where bacteria can grow on different organic substrates.

Reference

DeNiro, M.J. and Epstein, S. (1977). *Science*. **197.** 261-263.

Heavy Isotope Deficiencies in Corals: Kinetic and McCrea Models

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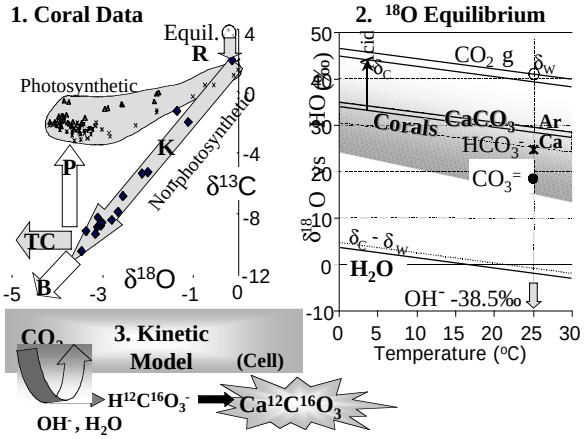
Skeletal isotopic data from non-photosynthetic corals falls along $\delta^{13}C - \delta^{18}O$ diagonals, trending downward from points slightly depleted in ^{13}C compared to seawater isotopic equilibrium (Fig. 1). Photosynthetic corals have somewhat higher $\delta^{13}C$. Most coral ^{18}O data falls between equilibrium aragonite (Ar) and equilibrium HCO_3^-, and all lies well above the equilibrium $\delta^{18}O$ of $CO_3^=$ (Fig. 2).



The "Kinetic" model (fig. 3) suggests that CO_2 reacts with isotopically light H_2O and especially OH^- to create a product DIC that is depleted in both ^{18}O and ^{13}C. This DIC precipitates before re-establishing ^{18}O equilibrium with H_2O. A partial simulation using a bubble apparatus (arrow B in figure 1) produced isotopically light $CaCO_3$ collinear with data from non-photosynthetic corals, but the actual pH for coral calcification remains unknown. This isotopic model implied CO_2 based calcification and gave rise to a detailed physiological model of biological calcification.

More recently it was found that foram skeletal $\delta^{13}C$ and $\delta^{18}O$ decrease as ambient pH increases, and that the trabecular calcification centers of corals may have especially low _^{18}O values (TC arrow in figure 1). This rekindled interest in "McCrea" models, which suggest that DIC within the calcifying space equilibrates with H_2O. That could give precipitating $CaCO_3$ an ^{18}O content between equilibrium HCO_3^- and $CO_3^=$ in figure 2, depending on pH and various assumptions. McCrea models must contend with uncatalyzed ^{18}O equilibration times for $CO_3^=$ of several hours to days at high pH, and strained interpretations of skeletal ^{13}C.

The kinetic interpretation still appears stronger, and offers plausible explanations for the foram and TC data. Improved modelling sheds light not just on the isotopes, but also on skeletal mineralogy, chemistry, and calcification physiology.