What controls Sulfur isotope fractionation in modern estuarine sediments?

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Sulfur isotopes are a promising tool for tracing sulfate reduction in sedimentary rocks, and for providing constraints on one of the oldest metabolic process on Earth. However, the relationship between isotopic fractionation and parameters such as sulfate reduction rate, temperature and availability of organic matter remains unclear, with conflicting results from pure culture and natural population studies [1,2,3]. Here, we use flow through reactors that contain undisturbed slices of sediment to measure sulfate reduction rate under quasi-steady state conditions. Flow through experiments were run to investigate the control of temperature, sediment depth, organic matter content, sulfate concentration and the effects of inhibitors on sulfate reduction rate and sulfur isotope fractionation. Samples were collected at a brackish location of a temperate estuarine sediment (Western Schelde, The Netherlands).

Our results indicate an inverse relation between sulfate reduction rate (SRR) and sulphur isotope enrichment factor under optimum temperatures (20 and 30ºC). This trend disappears at low rates (<10 nmol $cm^{-3}h^{-1}$) and for non-optimum temperatures (10 and 50ºC). Large fractionations (>20‰) were observed only at low SRR (<10 nmol cm^{-3} h^{-1}). Sediment depth as well as organic matter content did not significantly affect isotope fractionation.

This study demonstrates that the degree of isotope fractionation can be used to infer SRR in natural populations as well as in pure cultures providing that the bacterial population is thriving under optimal conditions.

References

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History of seafloor hydrothermal activity in the SW Pacific Bare Zone using fish teeth strontium isotope dating of metalliferous sediments

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A 2 million km^2 region virtually devoid of sediment has been identified in the remote SW Pacific Basin (February/March 2005 drill site survey cruise - Rea *et al.*, 2006). This region, informally termed the "South Pacific Bare Zone" comprises ocean floor dating back to the Late Cretaceous. Seismic profiling, piston cores and gravity cores reveal the full extent of barren crust – an area nearly the size of the Mediterranean Sea. Within the Bare Zone, a small ($1km^2$) abyssal valley with 24 m of sediment was identified and sampled with a large diameter piston core, leading to recovery of 8.35 meters of metalliferous sediment at 5082 m water depth. Fish-teeth Sr-isotope stratigraphy reveals a continuous record of sedimentation 31Ma to present, with an average linear sedimentation rate at this site of 0.27 mm/kyr. However, the fish teeth age-depth profile and INAA geochemistry show an exponentially decreasing hydrothermal flux, with sedimentation rates approaching <0.05 mm/kyr between 17 Ma and the present. The origin of the main pulse of hydrothermal activity is uncertain, but may be related to a series of late Eocene/early Oligocene ridge jumps and propagating rifts that accompanied large-scale plate tectonic reorganization of South Pacific seafloor. The fish teeth Sr isotope age-depth profile and pelagic clay geochemistry also reveals that the terrigenous component at this site registers a very low eolian flux, increasing in proportion to the hydrothermal component upcore. Primary dust sources were likely Australia and New Zealand, consistent with Nd-Sr-Pb isotopes of detrital extracts. The unusual conditions of Cenozoic non-deposition that characterize this area of the South Pacific make this the first record of its kind, providing unique insight into hydrothermal activity and eolian sedimentation since the early Oligocene. The utility of the fish teeth Sr isotope method for dating marine hydrothermal cores should be explored further.

References

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