Pressure regulation of microbial methane cycling in deep-sea sediments

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The factors that regulate microbial processes in deep sea sediments are poorly constrained. When working with deep-sea sediments, cores are typically retreived and microbial process rates and geochemistry are determined in incubations conducted at surface pressure (1 atm). Such estimations of microbial carbon cycling are subsequently applied to estimate global budgets and fluxes of carbon from cold seeps, and more specifically to elucidate pathways and interactions between the methane and sulfur cycles. These data are used to constrain our current level of understanding of elemental cycling within deep-sea sediments.

We developed a pressure-incubation system that allowed us to quantify rates of microbial processes in deep sea sediments at *in situ* pressure and temperature and over a range of substrate concentrations. Using this system, we conducted a series of laboratory experiments using methane-rich cold seep sediments (Gulf of Mexico) with the goal of elucidating the factors regulating methane cycling and carbon flow in the microbial community. Radiotracer techniques were used to quantify rates of specific microbial processes, including sulfate reduction and anaerobic methane oxidation. Pressure exerted strong and unanticipated effects on rates of microbial metabolism and interactions between different microbially-mediated processes.

Preservation vs. alteration of zircon Pb, O isotope and trace elements following 80 Ma of lower crustal metamorphism, Kapuskasing Uplift

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Ion microprobe (SHRIMP and CAMECA 1280) analyses (U-Pb, O isotopes, trace elements) of detrital zircon cores and metamorphic rims in an Archean lower crustal metasediment have been used to test the fidelity of primary micron-scale zoning after prolonged metamorphism. Zircon cores generally retain primary composition and range from 2.85±0.02 to 2.67±0.02 Ga (all values $^{207}Pb/^{206}Pb$ ages), have $\delta^{18}O$ values of 5.1 to 7.1‰ (±0.3 to 0.5 ‰, 2 sd), and U (9-249 ppm), Yb (33-359), Y (81-839), Th/U (0.18-2.03) and U/Yb (0.2-1.7) values similar to magmatic arc sources [1, 2, 3]. Metamorphic rims also retain zoning, recording nearly continuous overgrowth events from 2.66±0.01 to 2.58±0.01 Ga during granulite facies (≥700°C) regional metamorphism, significantly higher $\delta^{18}O$ values (8.4 to 10.4 ‰), and significantly higher U (271-1833 ppm) and U/Yb (1.7-52.5)) values, and lower Th/U (0.01-0. 13), Yb (12-155) and Y (75-369), similar to continental reservoirs [1, 2, 3]. Large differences in Li concentration are preserved between magmatic cores (10-51 ppm) and metamorphic rims (76-252) despite prolonged (~80 Ma) high-T regional metamorphism. A small number of cores (4 of 63 grains analyzed), recognizable by dimmed and blurred cathodo-luminescence (CL) response, are interpreted to have undergone high temperature alteration that caused Pb-loss at 2.64 Ga, elevated $\delta^{18}O$ values similar to host paragneiss, and a five-fold increase in Th and U concentrations. However, the values of Yb, Y, Y/Yb, Th/U and U/Ce in these ‘anomalous’ cores are similar to those of normal magmatic cores but quite distinct from those of metamorphic rims. Our work aids zircon research by identifying potential microstructural and trace element signatures accompanying rare isotopic and trace element alteration in high grade metamorphic zircons.

[1] Grimes *et al.* (2007) *Geology*, **35**, 643–646. [2] Valley *et al.* (2005) Contr. Min. Pet. **150**, 561–580. [3] Moser *et al.* (2008) *Geology*, **36**, 239–242.