Organics and life in the serpentinite subsurface

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Microorganisms inhabit vast regions of the subsurface of the ocean and mediate global biogeochemical processes. In sedimentary environments, relationships have been identified between biogeochemical regimes and cellular abundances, allowing the global biomass living in sediments to be estimated [1]. A similar mechanistic understanding of the relationship between microbial activity and the physical and geochemical characteristics of the rocky subsurface has not yet been obtained.

Oceanic subsurface regimes where seawater circulates through ultramafic and serpentinite rocks may be particularly important, high-activity ‘population centers’ since they are associated with high concentrations of hydrogen and reduced carbon compounds. Recent International Ocean Discovery Program Expedition 357 drilled a series of boreholes into the Atlantis Massif (30°N, Mid-Atlantic Ridge) with the goals of investigating carbon cycling and the presence of life in a zone of active serpentinization.

The abundances and distributions of organic carbon compounds in recovered samples have been analyzed to investigate subsurface water-rock reactions and microbial activity. Formate and acetate in the liner fluids of cores from the Central, Northern, and Western portion of the Massif reach concentrations that are as high as, and in some cases substantially higher than, those previously observed in hydrothermal fluids from the nearby Lost City field. The highest concentrations are associated with serpentinized harzburgite and metadolerite lithologies. In contrast, concentrations remain low in the basalt-dominated Eastern portion of the Massif. Amino acid distributions in the water column follow a similar geographical distribution, with the lowest concentrations in the Eastern portion of the Massif, potentially reflecting enhanced microbial activity in the Centeral, Northern, and Western regions.

These patterns highlight the heterogeneity of the serpentinite subsurface and can be used to build a better understanding of the controls on abundances of reduced organic compounds within it. The physiochemical charactersistics of the rocky subsurface constrain what types of metabolic pathways are favorable for microorganisms and, ultimately, could be linked to patterns of microbial activity.

[1] Kallmeyer et al., Proc Natl Acad Sci 109:16213-16216