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Nitrate N and O isotope anomalies in diffuse hydrothermal vent fluids

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Hydrothermal vent systems at mid-ocean ridges are sites with rapid rates of biomass production, sustained by chemolithoautotrophic bacteria at the base of the vent community food chains. The exact metabolic pathways, in particular those that involve nitrogen (N), and the rates at which the metabolic reactions take place are poorly constrained. Thus far, data on the N isotopic composition of dissolved inorganic N in vent systems, which could provide coherent information on the sources of N during chemolithoautotrophic biosynthesis, as well as on the fate of hydrothermal ammonium and nitrate from ambient seawater during biogeochemical reactions, do not exist.

We will present nitrate isotope ($^{15}N/^{14}N$ and $^{18}O/^{16}O$) data from various sites at the Axial Volcano and Endeavour segments on the Juan de Fuca ridge. Their integration with nitrate concentration data suggests non-conservative behavior of nitrate along temperature gradients. Elevated N and O isotope ratios are associated with decreased nitrate concentrations and indicate a nitrate consuming process, most likely denitrification, which fractionates both N and O isotopes in the low temperature fluids. The ratio of ^{18}O versus ^{15}N enrichment in residual nitrate of $\sim$11, however, is not consistent with previous reports on nitrate N versus O isotope fractionation during denitrification in marine environments. Rather than anomalous N and O isotope fractionation during denitrification in hydrothermal vent fluids, this implies the presence of additional microbially mediated N transformations that affect the nitrate pool in hydrothermal vent systems. We argue that the nitrate isotope anomaly is due to the gross production of nitrate through the microbial oxidation of ammonium. We will discuss several potential processes and mechanisms that can act to raise the $^{18}O/^{16}O$ of nitrate relative to its $^{15}N/^{14}N$ and, thus, to produce the observed nitrate isotope anomalies.