Activity and abundance of denitrifying bacteria in the subsurface biosphere of diffuse hydrothermal vents of the Juan de Fuca Ridge

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Little is known about fixed nitrogen (N) transformation and elimination at diffuse hydrothermal vents where anoxic fluids are mixed with oxygenated crustal seawater prior to discharge. Oceanic N sinks that remove bio-available N ultimately affect chemosynthetic primary productivity in these ecosystems. Using N-15 paired isotope techniques, we determined potential rates of fixed N loss pathways (denitrification, anammox) and dissimilatory nitrate reduction to ammonium (DNRA) in sulfidic hydrothermal vent fluids discharging from the subsurface at several sites at Axial Volcano and the Endeavour Segment on the Juan de Fuca Ridge. We also measured physico-chemical parameters (i.e., temperature, pH, nutrients, H2S and N2O concentrations) as well as the biodiversity and abundance of chemolithoautotrophic nitrate-reducing, sulfur-oxidizing gamma-proteobacteria (SUP05 cluster) using sequence analysis of amplified small subunit ribosomal RNA (16S rRNA) genes in combination with taxon-specific quantitative polymerase chain reaction (qPCR) assays. Denitrification was the dominant N loss pathway in the subsurface biosphere of the Juan de Fuca Ridge, with rates of up to similar to 1000 nmol N l(-1) day(-1). In comparison, anammox rates were always < 5 nmol N l(-1) day(-1) and below the detection limit at most of the sites. DNRA rates were up to similar to 150 nmol N l(-1) day(-1). These results suggest that bacterial denitrification out-competes anammox in sulfidic hydrothermal vent waters. Taxon-specific qPCR revealed that gamma-proteobacteria of the SUP05 cluster sometimes dominated the microbial community (SUP05/total bacteria up to 38 %). Significant correlations were found between fixed N loss (i.e., denitrification, anammox) rates and in situ nitrate and dissolved inorganic nitrogen (DIN) deficits in the fluids, indicating that DIN availability may ultimately regulate N loss in the subsurface. Based on our rate measurements, and on published data on hydrothermal fluid fluxes and residence times, we estimated that up to similar to 10 Tg N yr(-1) could globally be removed in the subsurface biosphere of hydrothermal vents systems, thus, representing a small fraction of the total marine N loss (similar to 275 to > 400 Tg N yr(-1)).
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