

Anabolic and Catabolic Microbial Activity in Hydrocarbon-rich Sediments of Guaymas Basin

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Abstract

Guaymas Basin, located in the Gulf of California, Mexico, is a young marginal ocean basin with high sedimentation rates of >1 mm/year, active seafloor spreading, and steep geothermal gradients in its sediment. It hosts a unique microbial subseafloor biosphere as these conditions lead to thermal cracking of sedimentary organic matter and the production of bioavailable organic carbon compounds and hydrocarbons already at shallow depths. The abundance and diversity of potential microbial substrates raise the question of which substrates are being used for catabolic and anabolic microbial metabolism. We thus analyzed the microbial uptake of hydrocarbons and inorganic nitrogen using nanoscale secondary ion mass spectrometry (NanoSIMS) analysis after incubation with stable-isotope labeled substrates. Incubations were carried out with samples from two International Ocean Discovery Program (IODP) Exp. 385 drill sites. Site U1545 is characterized by undisturbed sedimentary strata and a temperature gradient of 225°C/km, whereas Site U1546 has experienced a sill intrusion at greater depth, below the cored interval. The intrusion led to temporary heating of the sediment, but a temperature gradient of 221°C/km indicates thermal equilibration with the surrounding sediment since sill emplacement. Incubations were carried out with ¹³C-benzene + ²H-hexadecane + ¹⁵NH₄Cl or ¹³C-methane + ¹⁵NH₄Cl at in-situ temperature (4-62°C) and pressure (25 MPa) for 42 days. Additionally, sulfate reduction rates (SRR) were measured by incubating the samples with four aliphatic hydrocarbons + four aromatic hydrocarbons or methane and radioisotope-labeled ³⁵SO₄²⁻ for 10 days, also at in-situ temperature and pressure. The NanoSIMS analyses reveal that a few samples showed detectable microbial assimilation of hydrocarbons. Nitrogen was significantly assimilated in some samples incubated with methane. The assimilation mostly occurred in samples from near the seafloor (2 and 44 meter below seafloor (mbsf)). Our results indicate that anaerobic microorganisms in Guaymas Basin take up measurable amounts of hydrocarbons and inorganic nitrogen even in the relatively short incubation time of 42 days. The results of the SRR measurements indicate that a mixture of hydrocarbons and methane increases the SRR in samples from near the seafloor (2 mbsf) and around the sulfate-methane transition zone (44 and 55 mbsf) but not in samples from greater depths.

Our results show that anaerobic microorganisms in Guaymas Basin can use hydrocarbons for anabolic and catabolic metabolism in this extreme environment. Given the high abundance of various carbon compounds, nitrogen appears to be a limiting factor for cellular growth.

Keywords

NanoSIMS, Hydrocarbon uptake, Sulfate reduction, Anabolism

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Presented at

Oral presentation (Part 4: Emerging Tools & Areas of Scientific Inquiry, ISEB-ISSM 2023)

Conflicts of interest

The authors have declared that no competing interests exist.