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Preferential utilization of organic substrates in marine sediment at elevated temperatures – A case study from Guaymas Basin, IODP Exp. 385

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In marine sediment microbial abundance and activity normally decreases with depth, mainly caused by a decrease in organic matter reactivity due to preferential degradation of easily degradable organic matter.

Upon deeper burial the sediment eventually reaches temperatures where thermochemical cracking of macromolecular sedimentary organic matter leads to the formation of bioavailable short-chain organic molecules (catagenesis). IODP Expedition 385 recovered sediment drill cores from several sites at Guaymas Basin, a marginal ocean basin off Mexico with sediment containing abundant organic matter of both marine and terrestrial origin. Active sea floor spreading and hydrothermal activity leads to steep geothermal gradients of up to 1000°C km^{-1}. Due to this peculiar geological setting, the bioavailability of organic substrates is expected to (1) not follow the expected decrease as in non-hydrothermal sediments and (b) be much higher due to thermal cracking of sedimentary organic matter already at shallow burial depths.

We quantified sulfate reduction rates (SRR) via highly sensitive radiotracer incubations and found that close to the sediment surface SRR decrease with depth similar to other deep ocean settings. However, absolute rates differ considerably, with highest rates associated with the steepest geothermal gradient. Also, the often-observed drop in microbial abundance and sulfate reducing activity by several orders of magnitude at the transition from a mesophilic to a thermophilic microbial community around 50°C is hardly visible in Guaymas Basin sediments. We do observe subtle but significant differences associated with differences in geothermal gradients, which we interpret as variations in substrate availability.

Anabolic and catabolic substrate utilization differs between sites and with depth. Using a combination of SRR radiotracer measurements and NanoSIMS analyses of incubations with stable isotope (^{2}H, ^{13}C,^{15}N) labeled substrates we see strong differences in preferences for certain compounds. Nitrogen (as NH_4Cl) was massively taken up in near seafloor samples, especially when the samples were incubated with methane as a carbon source. Among the carbon sources, hexadecane showed higher uptake rates than benzene and methane. However, the incorporation ratios do not reflect to the dissimilatory SRR.