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Bacterial Sulfate Reduction and Sulfur Isotope Discrimination in the Hypersaline and Hypersulfidic Water Column of the Urania Basin (Mediterranean Sea)

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In 1993 and 1994, three deep basins filled with highly concentrated brines were discovered south-west of Crete in a plateau that lies between the crest of the Mediterranean Ridge and the Matapan Trench (MEDRIFF 1995). The basins were named after the research vessels: L´ Atalante, Discovery and Urania. We report here on biogeochemical and stable isotope investigations that were carried out in 1997 during Meteor cruise M40/2 in the north-western branch of the Urania basin which is 3570 m deep. A sharp pycnocline at 3490 m is separating a 80-m deep brine with a salinity of 162‰ from the sea water above. The salt concentrations in the brine are believed to originate from dissolution of Messinian evaporites that lie beneath the seafloor or to be relicts of fossil (5 Ma) evaporated seawater (MEDRIFF 1995; Wallmann et al., 1997; Vengosh et al. 1999). Due to the density difference of the two water bodies, organic material sinking through the water column accumulates at the seawater- brine interface. Within a 20 m-thick chemocline above the hypersaline deep water bacterial numbers and microbial activity strongly increase. Bacterial sulfate reduction rates (SRR) determined in this intermediate layer (14 nmol SO_4^{2-} $cm^{-3}d^{-1}$) are among the highest measured in a marine water column, so far. The highest SRR coincide with the a maximum in bacterial cell numbers. The 80-m deep brine contains up to 11 mM hydrogen sulfide and is, therefore, the most sulfidic body of water reported for the marine environment, so far. The high biomass concentration and secondary productivity in the intermediate layer further increases the concentration of particulate organic carbon, which is 15-fold enriched in the brine compared to the sea-water above. The hypersaline and hypersulfidic conditions in the deep basin do not inhibit organic matter remineralisation by sulfate-reducing bacteria, organic carbon undergoes further decomposition on its way through the brine and is, therefore, not accumulated in the sediment. Bacterial anaerobic oxidation of methane is suggested to further contribute to sulfate reduction. SRR in the sediment have been measured for the first time based on in-situ incubations with the autonomous lander LUISE at the depth of 3570 m and show similar results to on-board ship incubations of parallel cores. A maximum was observed at 3-6 cmbsf with SRR comparable to the water column. The sulfur isotopic composition of sulfate is constant throughout the water column above the chemocline and in the deep brine with +20.5 and +25 permil vs. V-CDT, respectively. With about -16 permil vs. V-CDT, coexisting hydrogen sulfide in the hypersulfidic water column is significantly enriched in the lighter sulfur isotope. This indicates sulfur isotope fractionation during microbial sulfate reduction of about 40 permil. Isotope discrimination is smaller than previous reports for the Black Sea or other deep anoxic brines from the Mediterranean. This is probably due to a growth inhibition of disproportionating bacteria by H_2S, higher cellular SRR because of enhanced temperatures, or a specific population of sulfate reducers in the Urania basin. A combined mass and isotope balance indicates a sulfate source with a composition of about +22 permil vs. V-CDT. Particulate material from below the chemocline was sampled with in-situ pumps. Significant amounts of elemental sulfur were identified by SEM-EDX which was isotopically heavier than co-existing H_2S. This indicates isotope exchange reactions via polysulfides towards equilibrium. Isotope data in anoxic surface sediments compared well to the brine results.

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