

Seasonal controls of methane gas solubility and transport on anaerobic oxidation of methane in shallow water marine sediments

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Sediments with free methane gas are a common occurrence in shallow water marine environments which receive high organic matter flux to the sediment surface. Methanogenesis of buried organic matter occurs below the zone of sulfate reduction and results in the formation of dissolved methane. Subsequently, free methane gas forms when dissolved methane exceeds the solubility concentration. Upward migration of dissolved and gaseous methane sustains the microbially-mediated anaerobic oxidation of methane (AOM) coupled to sulfate reduction in the sulfate-methane transition zone (SMTZ). Since pressure and temperature govern methane solubility, temporal variations in these parameters affect the location and volume of gaseous methane, and thus, biogeochemical reaction rates. In this study, a reactive-transport model is applied to investigate the transient (diurnal and seasonal) dynamics of methane cycling in a marine sediment environment triggered by the individual and combined effects of temperature and pressure fluctuations. The model, which explicitly accounts for the total sediment volume occupied by gas, is calibrated with data from Eckernförde Bay, Germany, where intense AOM occurs above the gas-containing sediment. Results reveal that seasonal temperature fluctuations control the depth of gas formation and dissolution, and that typical diurnal-scale pressure variations due to tides and atmospheric conditions lead only to centimeter-scale vertical shifts in the depth of the gas horizon. Our transient simulations ultimately suggest that methane is efficiently oxidized within the sulfate-methane subsurface barrier, and can only escape to the water column when large and abrupt decreases in sea level reduce rapidly the gas solubility, allowing increased transport rates of gaseous methane through the sediment.

Hydrogeochemical controls on Arsenic enrichment in waters and sediments of the Humboldt River, North-central Nevada

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The Humboldt River (HR) with an area of approximately 43,700 km² is the only source of water for municipal uses, irrigation and mining activities in northern Nevada. The river drains through several geothermal hot springs, and hydrothermal alteration zones and epithermal deposits, including silver, copper, and arsenic-rich gold. As a result, the waters and sediments from the HR system are highly enriched in many elements besides arsenic (As). The concentrations of As in the waters range from 11.9 ppb to 65.8 µg/L (average 31.0 µg/L), whereas the concentrations in stream sediments range from 0.6 to 1785 mg/kg. The water in the HR system is alkaline (pH ranges from 8.4 to 9.3), oxic (average 12 mg/L of dissolved O₂, and +139.9 mV of ORP), and saline with an average of 1035 µS/cm of specific electrical conductivity and highly enriched in B (average 717.2 µg/L), Li (average 141.4 µg/L), and S (average 65000µg/L).

Correlation between As and S in the waters indicates that oxidation of As-rich sulphides may play a role in As enrichment. Lack of correlation between As and dissolved iron in the waters may indicate removal of iron into solid phases. High concentrations of As are commonly associated with high concentrations of B and Li in this system indicating geothermal source of these elements. Ongoing sequential extraction analyses and factor analyses of the stream sediments will shed significant insights on the source, partitioning and release mechanism of dissolved As in the area.