



## **Biogeochemistry of methane and sulfate in Himmerfjärden estuary sediment, Sweden**

Nguyen Manh Thang (1), Volker Brüchert (2), Michael Formolo (1,3), Gunter Wegener (1), Maja Reiholdsson (4), Ginters Livija (2), Bo Barker Joergensen (5,1), and Timothy Ferdelman (1)

(1) Max-Planck-Institute for Marine Microbiology, Bremen, Germany (tferdelm@mpi-bremen.de, +49 (0)421 2028-690), (2) Dept. of Geological Science, Stockholm University, Stockholm, Sweden, (3) University of Tulsa, Tulsa, OK, USA, (4) Dept. of Geology, Lund University, Lund, Sweden, (5) Center for Geomicrobiology, Aarhus University, Aarhus, Denmark

The distribution of methane in shallow marine sediments and its control by biogeochemical processes, as well as the effect of eutrophication, has been the focus of the current BONUS Baltic Gas project. Himmerfjärden estuary, Sweden, provides a natural setting to study how a) low salinity (5-7), b) high organic matter deposition due to an upstream waste water treatment plant, c) annual algal blooms (<http://www2.ecology.su.se/dbHFJ/index.htm>), and d) high overall sedimentation rates (1.3cm a<sup>-1</sup>) (Bianchi et al., 2002) in a shallow water body of the Baltic Sea impact the production and consumption of methane and sulfate. During a recent research expedition to Himmerfjärden in May 2009, three stations representing the variable influx of organic matter and nutrients were selected for sediment sampling. Sediments were sampled using a multicorer and deeper sediments were sampled with a small gravity corer. Sediment samples were collected to determine dissolved methane concentrations. Pore water samples were taken to measure sulfate, sulfide, chloride, iron, and dissolved inorganic carbon. Solid phase sampling included total organic carbon, total sulfur, total nitrogen, acid volatile sulfide (AVS), chromium (II) reducible sulfide (CRS). Additionally, radiotracer experiments for sulfate reduction, bicarbonate - methanogenesis and methane oxidation rates were conducted. Finally, some results were utilized in a reaction-transport fitting model (PROFLILE) to calculate the fluxes of methane and sulfate between the sediments and the water column. The sulfate-methane transition zone is positioned between 10 and 20 cm depth. Overall sulfate reduction rates vary from 0.055 (H2) to 0.31 mmol cm<sup>-2</sup> a<sup>-1</sup> (H5). The rate of anaerobic oxidation of methane at H3 is 0.06 mmol cm<sup>-2</sup> a<sup>-1</sup>. At all three stations, two distinct zones of sulfate reduction of approximately equal magnitude were observed, one zone driven by organoclastic sulfate reduction (3 – 7cm depth) and the other by the anaerobic oxidation of methane (10 – 20 cm depth). The bicarbonate - methanogenesis rates varied between 0.06 and 0.41 μmol cm<sup>-3</sup> a<sup>-1</sup> with the peak rates just below the sulfate – methane transition zones. Interestingly, the CH<sub>4</sub> flux to the sediment surface (0.016 - 0.035 mmol cm<sup>2</sup> a<sup>-1</sup>) was highest at Station H2, where the lowest sulfate and organic carbon fluxes were observed. Furthermore, there are high organic sulfur concentrations in the sediment throughout the fjord (138 – 251 μmol g<sup>-1</sup>). The impact of organic bound sulfur on carbon preservation and methanogenesis is still not clear.