Anaerobic oxidation of methane in sulfate-rich lake sediments

GUANGYI SU*, HELGE NIEMANN, JAKOB ZOPFI AND MORITZ F. LEHMANN

Department of Environmental Sciences, University of Basel, Bernoullistrasse 30, CH-4056 Basel, Switzerland (*correspondence: guangyi.su@unibas.ch)

Sulfate reduction coupled to anaerobic oxidation of methane (AOM) has been recognized as an important sink in marine environments. This microbial process is mediated by anaerobic methanotrophic archaea (ANME) probably in syntrophy with sulfate-reducing bacteria (SRB). However, in most lacustrine environments (e.g., anoxic lake sediments), sulfate-dependent AOM is likely limited by relatively low sulfate concentrations, while other alternative electron acceptors (e.g., nitrate/nitrite and metal oxides) may be involved.

We investigated methane oxidation in the anoxic sediments of a sulfate-rich lake in Switzerland: Lake Cadagno. We show depth distribution data of dissolved CH_4 and other porewater constituents, as well as methane oxidation rate profiles. Our data provide clear geochemical evidence for AOM in the sediments and maximum AOM rates determined by three different radioisotope based approaches (15.87±2.13, 15.17±8.83 and 14.67±2.55 nmol/cm^3/d, respectively) were consistently observed at ~17 cm below the sediment-water interface. The highest rate occurred at the zone where sulfate became exhausted, which could suggest sulfate-linked AOM. However, different from most diffusive marine settings, a well-defined sulfate-methane transition zone that corresponds to peak AOM rates was not developed. Relatively high porewater CH_4 concentrations were observed throughout the sediment core. In the anoxic surface sediments, where both sulfate and CH_4 were abundant, AOM was undetectable, which suggests that the benthic microbial methane filter does not operate at maximum efficiency. The involvement of electron acceptors other than sulfate remains uncertain. Yet, porewater profiles indicate the reduction of iron and manganese at and below the AOM zone, raising the question as to whether AOM may be partly iron-/Mn-dependent. Ongoing high-resolution phylogenetic analyses of the benthic microbial community will help us to further identify the organisms responsible for AOM in Lake Cadagno sediments, and may ultimately shed light on the controls on AOM limitation (or inhibition) above and below the AOM zone.