Geophysical Research Abstracts
Vol. 12, EGU2010-2641-4, 2010
EGU General Assembly 2010

Anaerobic oxidation of methane in evaporitic settings: An example from the Messinian in Sicily

Simone B. Ziegenbalg (1), Daniel Birgel (1), Catherine Pierre (2), Jean Marie Rouchy (3), and Jörn Peckmann (1)

(1) AG Geobiologie, MARUM, Universität Bremen, Germany (simone.ziegenbalg@uni-bremen.de), (2) CNRS, LOCEAN, Université Pierre et Marie Curie, Paris, France, (3) CNRS, Laboratoire de Géologie, Muséum National d'Histoire Naturelle, Paris, France

Sulphate-dependent anaerobic oxidation of methane (AOM) is known to induce the precipitation of secondary, authigenic carbonates with extreme ^{13}C-depletions at cold seeps (e.g., Thiel et al., 1999, Naehr et al., 2007). AOM has also been documented in marine anoxic sediments (Knittel and Boetius, 2009 and references therein). In modern hypersaline or evaporitic settings, however, AOM appears to be inhibited (Joye et al., 2009).

In Sicily, evaporitic carbonates and secondary carbonates containing native sulphur (the so-called 'Calcare solfifero') occur below a thick succession of gypsum that was deposited during the Messinian salinity crisis. Some of the secondary carbonates are characterized by pseudomorphs after lenticular gypsum and high δ^{18}O values (as high as +9‰ vs. V-PDB), confirming formation under evaporitic conditions. Low δ^{13}C values (as low as -52‰ vs. V-PDB) reveal that the carbonate formed as a consequence of the oxidation of biogenic methane.

The presence of ^{13}C-depleted molecular fossils in these carbonates including pentamethylicosane (PMI; δ^{13}C: -92‰), hydroxyarchaeol (-79‰), as well as archaeal tetraether-derived biphytanes (-97 to -83‰) demonstrates that methanotrophic archaea oxidized methane under evaporitic conditions. ^{13}C-depleted *iso*- and *anteiso*-$C_{15:0}$ and $C_{17:0}$ fatty acids (-78 to -59‰), as well as mono- and dialkylglycerolethers (-84 to -53‰) prove that sulphate reducing bacteria were involved in AOM. This study provides the first evidence that sulphate-dependent AOM was not confined to normal marine environments in the past, having been a dominant process during the onset of the desiccation of the Mediterranean Sea in the Messinian.

References:

Knittel, K., Boetius, A., 2009. Anaerobic oxidation of methane: Progress with an unknown process. Annual Review of Microbiology 63, 311-334.

Joye, S.B., Samarkin, V.A., Orcutt, B.N., MacDonald, I.R., Hinrichs, K.-U., Elvert, M., Teske, A.P., Lloyd, K.G., Lever, M.A., Montoya, J.P., Meile, C.D., 2009. Metabolic variability in seafloor brines revealed by carbon and sulphur dynamics. Nature Geoscience 2, 349-354.

Naehr, T.H., Eichhubl, P., Orphan, V.J., Hovland, M., Paull, C.K., Ussler III, P., Lorenson, T.D., Greene, H.G., 2007. Authigenic carbonate formation at hydrocarbon seeps in continental margin sediments: A comparative study. Deep-Sea Research II 54, 1268-1291.

Thiel, V., Peckmann, J., Seifert, R., Wehrung, P., Reitner, J., Michaelis, W., 1999. Highly isotopically depleted isoprenoids: Molecular markers for ancient methane venting. Geochimica et Cosmochimica Acta 63, 3959-3966.