Biogeosciences Discuss., 5, S1625–S1629, 2008
www.biogeosciences-discuss.net/5/S1625/2008/

Biogeosciences
Discussions

Interactive comment on "Short-term changes in anaerobic oxidation of methane in response to varying methane and sulfate fluxes" *by* G. Wegener and A. Boetius

Anonymous Referee #1

Received and published: 2 September 2008

Wegener and Boetius present an experimental approach to test the response of methanotrophic communities at cold seeps to short-term variations in methane and sulfate fluxes. Overall, I agree that such type of experiments are required to obtain a more quantitative understanding of biogeochemical processes in extreme environments, however, I have substantial concerns about the chosen experimental setup (including its documentation) with respect to the addressed main questions (page 3072) and the interpretation of results. I recommend that the authors give a more extensive description of their experiments together with an extended presentation of their results. The ms. lacks precision in both descriptive and interpretative issues, hence major revision is suggested.

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General remarks and recommendations:

Improve description of experimental setup: What is the source of methane in the reservoir? The authors should analyse the composition with respect CO and higher hydrocarbons instead of speculating about an additional electron donor for sulfate reduction (p. 3076, l. 20-22). Can sulphate reduction of sediment substrates really be excluded? There are no starting conditions reported for the experiments (Fig. 2). At which temperature were the experiments conducted? A table summarizing general parameters of all experiments (flow rate, temp, reservoir concentrations, sampling period, etc.) should be provided.

Methane concentrations used in the experimental setup roughly correspond to methane solubility at atmospheric pressure. Although it is quite clear that operating the system at higher pressures would drastically increase the operational costs, it would be good to mention that methane concentrations cold seeps in submarine environments are much higher and hence comparability is limited. I suppose that all sediments used in this study where sampled from water depths $>$100 m.

I doubt that the system setup is useful to answer the (highly demanded) question of the efficiency of ANME communities in consuming methane at high fluid flow rates. First of all, I wonder why the flow rate was chosen to be so high. Although the authors give a few references the chosen rate is clearly above the average flow rate usually observed in cold seep environments (p. 3074, l. 18-19). Secondly, in natural seep environments methane and sulfate are coming from different reservoirs and only react in a narrow sediment layer close to the sediment surface. If methane passes this horizon (because of high flow rates) it usually reaches the seawater. Knowing methane fluxes below and above the AOM zone then allow the calculation of a methane oxidation rate (as well as their efficiency). In case of the experiment fluid flow rate determines the reaction time depending on the length of the sediment column. I find it very difficult to transfer this situation to the natural environment. How can the contact time between reservoir water (methane enriched artificial seawater) and sediment be related to the residence time

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of methane in an AOM zone (of x-cm thickness) at given upward directed flow velocity. This seems to me to be the only way to make the results of this study being comparable to results obtained from field observations. Although flow rates may be very high (as commented above) the choice of the experimental setup seems to be not appropriate to derive quantitative aspects on AOM efficiency directly related to fluid flow.

In order to determine rate constants for quantitative use of the experiments it would be good to see how the systems reacts as a function of temperature. Did the authors think about modifying their experiments in this respect or is there any preliminary data available?

Page 3076, line 23 ff: I think that the results of the short column experiments should be documented the same way as in fig. 2 in order to enable comparability of the results. In addition, it would be helpful to find compilations of results (rates, concentrations) in tables rather than being listed in the text. In addition, why not showing comparative data from the field (Page 3077, line 2)

Pages 3079-3080: I have doubts that the experiments are suitable to derive half saturation constants. There is much scatter in the data and the range is quite low. At least a more thorough discussion and comparison to other experimental studies would be appropriate.

Specific remarks:

Page 3071, line 13-14: Unfortunately, the biochemical...; this is what frequently can be read in manuscripts related to this topic. I would be very much interested to read a brief overview on what is known / needs to be found out on biochemical pathways and regulating factors of AOM instead of a simple statement for the purpose of supporting research on AOM consortia.

Page 3071, line 26: Flow rates of 0.1-2.5 m/yr span over an order of magnitude. I wonder if this difference shouldn't have an effect on methane oxidation efficiency. Is it

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constantly 50%?

Page 3077, line 6: Pwhat is a "substantial amount"?

Page 3077, line 20-23: I can't detect a total mass balance here. Please be more precise.

Page 3077, line 25-27: It would be nice to see the reproducibility of the experiments. Why only showing one data set? Why not all, the average, etc.. Which column length has been used here?

Page 3079, line 13: What is meant by an adjustment time and what is meant by more than 8 days? How many days exactly? Is it different for both replicates? Again, which column length has been used? Be more precise! Please provide a table with all experiments and setting details (as mentioned above).

Page 3079, line 24-25: The offset is clearly more than 20-30% in most cases. The explanation is not sufficient.

Page 3079, line 26-27: What is meant with a methane saturation effect here and the related Km value? Please provide more extensive information.

Figure 2: Why are H2S concentration high from the beginning? Write hydrogen sulfide or H2S instead of sulfide (axis label).

Figure 3: Report H2S in mM; ml/l is confusing.

Minor editorial comments

Page 3070, line 1: A major role in regulation of global...

Page 3071, line 9: Due to...

Page 3072, line 11: ...not possible to obtain...

Page 3075, line 22: delete according

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