**Biogeosciences
Discussions**

Interactive
Comment

Interactive comment on "Constraints on mechanisms and rates of anaerobic oxidation of methane by microbial consortia: process-based modeling of ANME-2 archaea and sulfate reducing bacteria interactions" *by* B. Orcutt and C. Meile

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The authors aim to obtain insight into the controls on AOM via modelling of structured aggregates of methane oxidizing bacteria and sulfate reducing bacteria. The model incorporates transport, kinetic and thermodynamic limitations on the reactions, the latter based on new models advanced primarily by Jin and Bethke. The results indicate that thermodynamic constrains need to be considered in order to comprehend the functioning of these microbial consortia. In particular, thermodynamic constraints strongly influence the optimum reactive intermediate (acetate versus formate of H2) passed

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between the anaerobic methanotrophs and the sulfate reducers.

I do believe that this type of modelling is informative, and therefore, valuable, and a revised paper should be published. But with all modelling exercises the model is only as good as the assumptions that it built upon. By this I do not mean that there are unreasonable or fatal assumptions here, only that I do no necessarily agree with all aspects of the treatment or the justifications provided. For example:

1) The modelled consortia are fixed in size and composition and, consequently, not dynamic. The sensitivity study in this paper varies a number of environmental and microbial parameters, but the microbial domain cannot respond to these changes, as it would in nature. This reader accepts that this limitation might be required to keep the project within reasonable limits of effort, but this does affect the outcomes and it is nowhere discussed.

2) The consortia are assumed to be isolated from other aggregates, without any real analysis of this assumption.

3) The saturations constant for anaerobic methanotrophy, KmCH4, and for the consumption of the exchanged organic substrate (intermediate), KmEX, are set to values that are similar to ambient substrate concentrations, i.e., relatively small values. There is little justification supplied for this approach, e.g., Dale et al. (2006) is a modelling study, and readers have no way to gauge the accuracy of personal communications from T. Treude or A. Boetius. (No personal aspersion intended!) The effect is that the reactions are largely or partially independent of the substrate concentration throughout significant portions of the aggregates. If only to this reader, that strikes me as unlikely.

4) Geochemists and biogeochemists studying Organic Matter (OM) decay in sediments have largely found that OM decomposition is first-order in the substrate concentration, implying resource limitation. (See, for example, the classic work of Westrich and Berner, 1984, Limnol. Oceanogr. 29, 236-249.) The sulfate reducers in the Westrich and Berner study are largely the same as envisioned in this study. Granted that ac-

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etate, formate and H2 are not solid OM, they nevertheless feed an ecology that is derived from an OM-limited ecology, i.e., methanogens. Why would one assume that the AOM system is not also resource limited? In other words, why are equations (6) and (7) not first-order with respect to their respective substrates? I would love to see this issue addressed a bit more in the paper.

5) Finally, the thermodynamic potential factor is a source of some minor perplexity. Firstly, I realize that this is not the creation of the present authors, and secondly, I am fully aware that there must be some thermodynamic constraint(s) on the reactions. However, I wonder about the correct activity values in equation (10). The present authors enter the activities in the porewaters, as best as I can tell, but are these the appropriate activities? The reactions are intracellular, not in the porewaters. Cells can and do contain 'pumps'; to remove products that interfere with reactions. This allows reactions to occur, even when conditions appear thermodynamically unfavorable, as long as the energetics of the pump do not begin to overwhelm the capacity to supply it with energy. I would believe that the thermodynamic factors, as formulated here, cause the oxidation reactions to be underestimated?

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