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Interactive Comment

Interactive comment on "Efficiency and adaptability of the benthic methane filter at Quepos Slide cold seeps, offshore Costa Rica" *by* P. Steeb et al.

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General comments This paper describes experiments, using 16 cm long sediment cores, to examine how the microbial community in sediments from a cold seep off Costa Rica respond to changes in seepage flow. In particular, how the rate of anaerobic oxidation of methane changes over time. A synthetic, methane-rich, seepage solution was pumped into the core base and sulphate was allowed to diffuse into the core from the surface, to simulate natural conditions. Samples were withdrawn from the cores at approximately 1 cm depth intervals and at periods during the experiment. The experiment showed clear geochemical changes in the cores over time and demon-

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Interactive Discussion

Discussion Paper

strated that the microbial rates adjusted, with time, to increased or decreased flows. A detailed critique of the experiment is given below. This paper would be enhanced by a section looking at the advantages and disadvantages of the technique and discussing alternative approaches. One problem with the experimental technique was that, even after 258 days, the system had not reached equilibrium, partly due to the long residence time of the pumped fluid. In addition, the method and frequency of sampling may have affected the rates. The least invasive technique to study changes in a flow-through system would be to measure just the inflow and outflow. The authors could discuss whether using short (syringe) cores, with sediment taken from the SMTZ and from above and below this zone, in a flow system might be more effective. Equilibrium should be reached more quickly and it would be simple to study how the microbial community at different depths responded. A disadvantage of this is that it would not allow for the migration of bacteria in the seep fluid from deeper to shallower layers.

Specific Comments SLOT experiments Subsampling the MUC core samples with the SLOT core tubes, if done by just pushing the latter into the former, as described in Steeb et al. (2014), given the core tube thickness, would cause sediment compression. There is no mention of the degree of compression caused, i.e. how much lower the sediment surface was in the SLOT tube compared with the MUC tube. The way to overcome this is to either use a piston, that is withdrawn at the same rate as the core tube is advanced, or by using a controlled vacuum applied to the top of the core to keep sediment levels equal as the tube is pushed deeper. Sediment would be further consolidated by the downwards pumping of water through the core during the 40 day "preparation phase". The pumping rate used during this phase is not stated. Thus the density of the sediment in the experimental cores may not reflect that of the sediment in situ. Both SLOT cores had a lower porosity than the MUC core (Figs. 8 & 9), suggesting sediment compression. The volume of pore water removed during the sampling periods appears to be excessive and may have had an effect on the experiment. Assuming that the core i.d is 6 cm (Steeb et al 2014), the core length is 16 cm and porosity is 0.85, then each core contains approximately 385 ml of pore water. With

16 sediment sampling points per core (Fig. 3) and1.5-2ml/sample, then 24-32 ml of pore water is removed every sampling period, i.e 8 % of the pore water volume in the core. This would have to be replaced either by sediment compaction or by advection from the surface and I do not see how it can be stated “sulfate was transported into the sediment core solely via diffusion” . Thus, for the low-flow experiment, advection from the surface to replace the pore water sampled, would be almost equivalent to the flow from the core base over the period to the 49 day sampling interval. This would have the effect of displacing the SMTZ downwards. In the high flow experiment the effect of removing pore water by sampling is reduced since the advective flow due to the pumped “seep water” would be much greater than the downward advection due to pore water removal. The bromine profiles in the low flow experiment are not adequately explained. It would help to visualize what happened by altering the scale of the bromide concentrations in Fig. 3. Why was Br elevated in the overlying water after 105 days but this disappeared subsequently? Could there be channels that opened and closed over time? The authors note that the “methane concentrations were lower than those potentially encountered under in situ conditions because the cores were not pressurized”. Certainly some of the concentrations measured in core SO206-31 would lead to over-saturation at atmospheric pressure and bubble formation when the core was recovered. We are not told whether this occurred and gas channels could have formed in the SLOT cores, leading to channelled advection of the pumped “seep water”. It would also be interesting to know what effect the insertion of the line of rhizomes has on flow dynamics in the cores. AOM rates cannot be accurately calculated in the LFC core by using differences in the methane inflow and outflow concentrations at 258 days. Firstly, equilibrium has not been reached at this time, only 186 ml of “seep water‘’ had been delivered to the core at this time. Secondly no rates of methanogenesis within the core were measured and since the outflow contained 0.9 μM at this stage, in an anoxic core full of sulphate, it implies possible methane generation within the core or channelling. Without information on how much methane-free water was pumped through the core during the initial 40-day period it is not possible to assess how much

methane might have been left in the core. It would have been helpful had the authors measured methane directly at each sampling period, since this can be done on sample volumes as small as 50μl, either by direct injection of pore water (as sometimes used for pore water bicarbonate) or by using small headspace vials.

Hydrological residence time No units were given for this and I was unable to follow the calculation, "the average time of the seepage medium to flow through the sediment column and was calculated by dividing the pore water volume by the flow rate". For the low flow system, with an approximate pore volume of 390 ml and a flow of 0..5 μl min-1, the HRT should be 541 days. How was the figure of 1080 derived?

Text queries and corrections Abstract "Most of the dissolved methane reaching the seafloor at cold seeps is oxidized within the benthic microbial methane filter by anaerobic oxidation of methane (AOM)." Surely the methane reaching the seafloor has already passed the benthic AOM, since this is below the seafloor.

Introduction "methane gas may be transported upwards in solution by molecular diffusion or by ascending fluids mobilized by - - - (ii) formation of gas hydrates within the gas hydrates stability zone". How does hydrate formation aid upward transport of methane?

Methods The detector used for determining methane is not mentioned and it is not made clear how the concentrations are calculated, are they per litre of sediment or pore water? One would assume the latter but there is no mention of porosity measurements in the methods, other than for the SLOT cores. The use of mM, rather than mmol l-1, would have clarified this. The incubation temperature for the SLOT cores is not given ad we do not know how this differed from the in situ temperature (or how constant temperatures are in Slide sediments). Section 2.7 "At the end of the experiment, 1.5mL porewater from each depth was sampled for determinations of sulfide (0.5 mL), sulfate and bromide (1.0 mL) as well as totalalkalinity (0.5 mL)," These individual volumes add to 2.0 ml, not 1.5.

Results In section 3.2.3 it is stated that the experiment was terminated “after 350 day runtime” although runtime in Figures 3, 4 and elsewhere is calculated from the end of the 40 day initial period.

Interactive comment on Biogeosciences Discuss., 11, 16033, 2014.