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## ***Interactive comment on “Miniaturized biosignature analysis reveals implications for the formation of cold seep carbonates at Hydrate Ridge (off Oregon, USA)” by T. Leefmann et al.***

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Title: "Miniaturized biosignature analysis reveals implications for the formation of cold seep carbonates at Hydrate Ridge (off Oregon, USA)"; Authors: T. Leefmann, J. Bauermeister, A. Kronz, V. Liebetrau, J. Reitner, and V. Thiel

General comments:

The paper by Leefmann et al. represents an innovative analytical approach to obtain valuable information on the formation of different carbonate precipitates in cold seep

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carbonate formations. A problem when analysing such seep carbonate formations is that the different carbonate precipitations occur very close to each other in thin layers or small restricted areas. Therefore, a conventional sample of several grams often provides only an average of the different carbonate phases. The specific feature of the presented methods is a so-called miniaturized biomarker technique on mg samples using micro drill cores (< 2mm deep and 2mm in diameter) and thus, allowing the investigation of the different carbonate precipitations. Using this technique the authors were able to provide a deep insight into the question as to how particular microorganisms and biogeochemical processes were involved in the formation of the different carbonate phases. The analytical procedure was supplemented by factor analysis and electron microprobe analysis. I recommend publication of this paper with minor changes in Biogeosciences as the relevant scientific question fits well into the scope of this journal. The paper represents original work and is well written, the overall presentation is well structured and clear. Nevertheless, in my opinion the manuscript would benefit if it is revised in some aspects as outlined in the specific comments and technical corrections. Especially, the discussion chapter should be a bit more extended.

#### Specific comments:

Title - The title represents the content of the paper. Abstract - The abstract reflect a concise summary of the paper's content. However, suggestion on the dominance of ANME-2 archaea in the whitish aragonite and ANME-1 in the grey micrite might be added. The last sentence in the abstract "The formation of these precipitates....." appears to be related here to the grey micrite, different to the conclusions where almost the same sentence was dedicated to the whitish aragonite (page 4451 line 25ff). This has to be checked and revised. Introduction - The introduction is clearly written and provides an accurate introduction into the addressed scientific question of the paper. Nevertheless, a brief paragraph on the formation (biotic and abiotic) of carbonate phases in such seep areas might be added. Material and Methods - Overall a brief but adequate method chapter is presented. However, you might provide more

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details on the way you obtain your sample material as it appears to be crucial for this paper. Concomitantly, you might add a paragraph on the advantages and disadvantages of the presented micro sampling technique. Results - The results are clearly outlined and well structured. Nevertheless, it might be helpful for the readers, if the biomarkers in table 1 are assorted concerning their potential sources (archaeal-, SRB- and allochthonous biomarkers). It is not clear in which figure you show that "Ca was somewhat more abundant in the lucent aragonite than in the whitish aragonite and grey micrite" (page 4449 line 12). Discussion - The interpretations in the discussion chapter are conclusive and supported by the results presented. However, the discussion should be more detailed and expanded concerning the formation of the different carbonate phases. Although, there is a brief discussion on the formation of the whitish aragonite and grey micrite, final interpretation are not presented before the conclusions and an interpretation or at least a suggestion on the formation of the lucent carbonates is totally missing in the discussion chapter. How do you think the lucent carbonates are formed if you state that microbes are not involved? Where is the bicarbonate for the formation coming from? Were these void spaces, later filled by carbonate precipitation possibly caused by AOM-bicarbonate diffusing in? Or are there differences in the carbon isotopic composition of the lucent aragonite compared to the other phases indicating a different source for the lucent aragonites? Please provide a final discussion about the implication your findings have on the formation of chemoheterotrophs to round off your paper. Conclusions - The conclusions provide a concise summary of the findings presented in this paper. However, there are some information presented for the first time, which should be mentioned already in the results and discussion chapter, e.g. "20% of the total carbonate rock volume" and the final interpretation on the formation of the different carbonate phases which should already be elaborated in detail in the discussion chapter.

Technical corrections:

To Introductions:

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- On page 4445 line 4 you might exchange "at other times" by "in other cases".
- Add full UPAC name for crocetane and put crocetane into brackets behind. Add "(PMI)" after its UPAC name (page 4445 line 11).
- Page 4445 line 24/25: "SE"! Do not use abbreviations when mentioned for the first time. Add abbreviation then in brackets after the full written term before further use.
- Page 4445 line 27: Here "of aragonites" might be missing after "...cryptocrystalline variety".

#### To Material and Methods:

- Again, although you might think it is common knowledge, you should generally not start with abbreviation without given the full term before (e.g. TV, TVG, MC-ICP-MS etc.). Carefully revise the whole manuscript for this.
- Page 4446 line 14: "5 subsamples from this core" however a "core" was not mentioned before, only a "carbonate block" in lines 10 and 11. A drilled core is not mentioned before line 17. Please revise this.
- Down to the word Teichert et al. (2005) seems not to use the term "micrite". The interpretation might be right but then you should better say "based on Teichert et al." instead of "according to" on page 4446 line 20.
- Page 4447 line 9: Flow rate is volume of fluid per unit of time. Please check your unit.

#### To Results:

- Page 4448 line 22: You might write "were on average one order of magnitude lower", because in some cases it is two orders of magnitude lower.
- Page 4448 line 24: Crocetane is not lower than in 5 from 8 samples of the whitish aragonite (table 1). Following Blumenberg et al. (2005) ANME-1 does not contain crocetane. What does this mean for your interpretation? Micrites are often breakdown

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material from past carbonate structures, couldn't the microbial markers just be residues of microbes forming these old carbonates?

- Page 4449 line 4: Write "sn-2-".

To Discussions:

- You might use italic subtitles "Whitish aragonite (page 4449 line 18) / Lucent aragonite (page 4450 line 20) /Grey micrite" (page 4450 line 27) for structuring the discussion chapter.

- You might add "as indicated by the factor analysis (fig.2)" page 4449 line 18.

- You might write on page 4449 line 24 "On a first view" this spread "might" be interpreted... .

-Where is the bicarbonate for the precipitation of carbonates coming from in the lucent aragonite phases in the chemoherms (page 4450 line 25)! Can a microbial role totally be excluded? What about diffusion of bicarbonate from AOM layers? What do you think, how the lucent aragonites have formed during these "intermittent periods of low fluid supply" as outlined in the conclusions (page 4452 line 3). Be more detailed. Carbon isotopes might be helpful to check about the origin of the carbonates! Thus, your statement "that there is no direct involvement" might possibly not be correct down to the word. You should check this and maybe adopt this statement a bit if necessary.

- There are already some interpretations on the formation of the different carbonate phases in Teichert et al. (2005) you should refer to this or should include their interpretations into your discussion, when providing your final interpretation.

To conclusions:

- You might add ...containing "mainly" ANME-2 Archaea.. .

- You might set a break before "By contrast (page 4451 line 27)..." and "The gray micrite (page 4452 line 3)..." for structuring the conclusions.

- The meaning of lower Sr-contents for the formation of the lucent carbonate phase was, as far as I can see, not addressed in the discussion chapter. You should revise this (page 4452 line 1).

- How do you get to your final statements on the formations of the carbonate phases (page 4451 line 25ff, page 4452 line 3 and 6)? You should explain this more detailed in the discussion chapter to enable the readers to follow your argumentation. Be more precise here.

To Table 1:

- Add explanations for all abbreviations in the table caption (e.g. PMI, DAGE IIa etc.) also if already done in the text.

- The ratio of hydroxyarchaeol to archaeol could be set to "0" if there is no hydroxyarchaeol to indicate that there is at least archaeol detected. If both biomarker were not detected in a sample you might use "n.d."

- If the biomarkers are assorted concerning their potential sources (archaeal-, SRB- and allochthonous biomarkers), as suggested above, you might also add percentage proportions of the total lipid content of the different biomarker groups for each sample.

To Figures:

Figure 1:

- Add the sample names to the chromatograms provided (at least in the figure caption).

- Add the x-axis (retention time) for orientation.

- Give full compound names in the figure caption also for "DAGE If...".

- Add: "PMI = ...".

Figure 2:

- Increase line width of the ellipse.

- Do you think the ellipses could be labelled: microbial and allochthonous source?
- Give full compound names in the figure caption also for DAGE If... .
- Add: PMI = ... .

Figure 3:

- You might use other numbers or letters for the different image areas e.g. 1,2,3 or a,b,c. Otherwise this could be mixed up with the carbonate phases in figure 1.
- The link "see Fig.1" is a bit misleading, because there are no reflected light images of area III in figure 1. You might write "for an enlarged image of area III see Fig. 1".

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Interactive comment on Biogeosciences Discuss., 4, 4443, 2007.

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