



# ***Interactive comment on “What makes seep carbonates ignore self-sealing and grow vertically? The role of burrowing decapod crustaceans” by Jean-Philippe Blouet et al.***

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## **Answers to comments of Referee 1**

**Referee 1:** General comments I have carefully read this manuscript and found it to be of interest. The manuscript focuses on the role of bioturbation in creating fluid pathways at methane seeps. Burrows, in particular those of decapod crustaceans, are suggested to favor the vertical aggregation of seep deposits despite of the self-sealing effect of carbonate crust formation. By providing a detailed description

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of the burrow network of a Jurassic seep deposit, this works adds to the literature on seep environments. Two of my comments are of a more general nature.

(1) It is a missed chance that silicification, formation of chalcedony, and precipitation of euhedral quartz crystals are not put into perspective with the same phenomena [at] other seeps described in the literature. Like for the studied Aurel seep deposit, silicification and silica authigenesis have been observed to postdate the precipitation of methane-derived carbonate, but to predate later diagenetic phases lacking C-13 depletion. This relationship has now been described for many seep deposits and a hypothesis to explain the observed paragenetic sequence has been developed (Kuechler et al., 2012, *Lethaia* 45, 259-273; Smrzka et al. 2015, *Palaeogeography Palaeoclimatology Palaeoecology* 420, 13-26). Discussing the context of silicification and silica authigenesis will help to elaborate the postulated timeline of events.

**Authors:** Thanks for providing this insight into a subject we were not that familiar with, along the key references. The hypothesis proposed by the authors would apply quite well in our case, where siliceous microfossils are abundant in background sediments.

**Referee 1:** (2) It is mentioned that carbonate crusts may grow downward at seeps (Bayon et al. 2009). Yet possible implications of downward aggregation are not discussed. If, indeed, seep deposits will preferentially grow downward into the sedimentary column, the impact of bioturbation on maintaining fluid flow on longer time scales will be more limited than suggested in this manuscript. Based on the study of mesofabrics of seep limestones, it had been suggested that the aggregation of methane-derived carbonate may proceed downward (Greinert et al. 2002, *Int. J. Earth Sci.* 91, 698-711; Peckmann et al. 2002, *Sedimentology* 49, 855-873). While downward growth may indeed occur, the work of Liebetrau et al. (2014, *Int. J. Earth Sci.* 103, 1845-1872) suggested that upward growth is typically more pronounced. These findings, particularly the work of Liebetrau and co-workers, should be discussed and their relevance should be put into perspective to the inferred role of bioturbation in the formation of the Aurel seep deposit. The authors seem to suggest preferential upward aggregation in case of the Aurel deposit, but this needs to be clarified and

should be discussed in more depth.

**Authors:** Our interpretation was probably poorly explained. The hypothesis we made, which we will of course revisit in the light of the references provided and the reviewers' comments, was that the density of callianassid burrows, along with their capacity to block sediment infill at turning chambers (our fig. 17, 17c in particular) meant that they could ensure a connection inside the burrows from the seabed down below the base of the SMTZ. Downward growth would then occur only in the few intervals of isotropic permeability, i.e. limestone beds thick enough not to be fully homogenized by near-surface biohomogenization. We will clarify and discuss in more depth, as requested.

**Referee 1:** I found it difficult to follow the captions of the figures with photomicrographs. Figure captions should be self-explanatory on the one end – these are not – and should be succinct on the other end – which they are not either. Consider to focus on what is really needed for the description of the micrographs and what can be moved to the main text. The paragenetic sequence should be apparent from the caption itself.

**Authors:** OK, thanks for this comment, we will do our best to simplify and focus.

**Referee 1:** The authors manage to get the message across, but the standard of the English is less than ideal. The manuscript would benefit from linguistic editing of a native speaker.

**Authors:** All right, we will seek for appropriate assistance.

**Referee 1:** In conclusion, I recommend publication of this interesting work after moderate to major revision.

**Referee 1:** A brand new publication that should be considered during revision: Gay et al. (2020) Poly-phased fluid flow in the giant fossil pockmark of Beauvoisin, SE basin of France. BSGF-Earth Sciences Bulletin 2020, 191, 35.

**Authors:** OK

**Referee 1:** Specific comments on the manuscript Note: I do not use special characters in this web-based review (1) Line 45: I do not want to be nit-picking, but the precipitation of dolomite requires magnesium ions in addition to calcium.

**Authors:** OK

**Referee 1:** (2) Line 141: Chemosymbiosis can only be assumed in case of ancient taxa

**Authors:** OK

**Referee 1:** (3) Lines 239 to 240: What would be an “altered peloid” – please specify.

**Authors:** Altered by diagnosis / recrystallization, will be specified.

**Referee 1:** (4) Line 264: The work of Rolin et al. (1990) is not the latest publication on the Beauvoisin lucinids. A new species has been formally described by Kiel et al. (2010; Zootaxa 2390, 26-48).

**Authors:** Thank you

**Referee 1:** (5) Result chapter, petrography (e.g. page 10): The circumstance that the mineral phases of the paragenetic sequence are not described in chronological sequence impedes comprehensibility.

**Authors:** The problem we had is that sedimentation, bioturbation and diagenesis are intricately mixed, especially with intra-burrow collapse sedimentation taking place several meters below regional seabed and alternating there with cement growth. We will try to find the most suitable structure to pass the message in the clearest possible way.

**Referee 1:** (6) Chapter 5.2: The reasoning about carbon stable isotopes is mostly okay. Yet, based on the carbon stable isotope data alone, a relation to methane seepage cannot be proven.

**Authors:** fair enough!

**Referee 1:** The described limestone deposit should be compared with the nearby Beauvoisin seep deposits, for which the involvement of anaerobic oxidation of methane in carbonate formation has been proven with lipid biomarkers.

**Authors:** OK

**Referee 1:** (7) Lines 509 to 510: “limestone column” – The sedimentary strata do not consist of limestone only.

**Authors:** OK

**Referee 1:** (8) Line 533, and throughout: “MDAC” – This abbreviation has not been

introduced. But why would you like to use it anyway? ‘Seep carbonates’ are one type of ‘methane-derived authigenic carbonates’. Carbon-13 depleted phases of septarian concretions are another example. The designation ‘seep carbonate’ is consequently more specific than the acronym ‘MDAC’.

**Authors:** Being not a big fan of acronyms, I can only be happy with this comment!

**Referee 1:** (9) Line 535: Silicification predates the formation of burial cement. I would not call such silicification ‘late’, although it is admittedly later than the formation of methane-derived cement.

**Authors:** OK

**Referee 1:** (10) Line 537: “calcite precipitation” – You cannot exclude that much of the calcium carbonate precipitated as aragonite cement like at most modern and Phanerozoic seeps.

**Authors:** OK

**Referee 1:** (11) Line 543: “brown color of BM spar – Based on its position in the paragenetic sequence, I consider it more likely that this phase corresponds to primary yellow or brownish aragonite (e.g., Zwicker et al. 2015; Marine and Petroleum Geology 66, 616-630).

**Authors:** That was our first idea, but with high magnification micrographs evidencing the presence of brown filaments in a clear background, we shifted to the filament-based rather than iron-based color. We will reexamine this hypothesis in the line of the references provided and this comment.

**Referee 1:** (12) Lines 554 to 572: This is where authigenic silica formation and silicification at seeps needs to be discussed (see general comment).

**Authors:** OK

**Referee 1:** (13) Chapter 5.3.3.: This chapter does not add much to the manuscript – the discussion is vague to say the least.

**Authors:** OK

**Referee 1:** (14) Line 607: “burrowers feeding on chemosymbiotic microbial communities” – ‘Chemosymbiosis’ refers to the association of a metazoan host (e.g., bivalve,

tubeworm) with endosymbiotic, chemotrophic bacteria. The term ‘chemosynthetic’ would work in this instance.

**Authors:** OK, thanks

**Referee 1:** (15) Lines 609 to 610: See also Zwicker et al. (2015, see above) for the role of burrows as part of the shallow plumbing systems in sediments affected by seepage.

**Authors:** OK

**Referee 1:** (16) Line 640: “methane generation zone” – This should be replaced by ‘methanic sediments’ (i.e., sediment containing methane). Methanogenesis (i.e., methane formation) occurs at greater depth, although minor methanogenesis may also occur at or close to the sulfate-methane transition zone.

**Authors:** OK

**Referee 1:** (17) Fig. 7 (E) and (F): Could this be *Beauvoisina carinata* (see comment 4)? The shell seems pretty asymmetric, maybe more asymmetric than in *B. carinata*.

**Authors:** We will check this point

**Referee 1:** Technical corrections and suggestions:

**Authors:** Many thanks to the reviewer for taking the time to spot and report all these mistakes, there is not much to comment or respond to here, we will just correct as requested in the resubmission.

**Referee 1:** (1) Line 26 and throughout: omit blank between numbers and per mil symbol.

**Authors:** OK

**Referee 1:** (2) Line 30: “post-dating the burial” is an ambiguous formulation. It could be misinterpreted in the sense that this phase formed after uplift during telogenesis.

**Authors:** OK

**Referee 1:** (3) Line 31: “late final blocking” – I do not understand. Do you mean that the fluid pathways have been plugged at some point?

**Authors:** What we interpret as fluid pathways (tubular structures) are now (at the time of studying the outcrop) filled with cements, with the dominant final mineral phase in a

burrow being saddle dolomite. Assuming temperature equilibrium between circulating fluids and the host formation, saddle dolomite (the “final blocking phase”) would have precipitated when the pseudobioherm was buried to an ambient temperature of 60-80°C at least. The tubes must then have remained open until this temperature was reached by burial, i.e. on the order of magnitude of 1 km (hence the term “late”), which we interpret to largely exceed the initial thickness of the pseudobioherm.

**Referee 1:** (4) Line 45 and 46, and throughout: “H<sub>2</sub>S and HS” – Why do you use formula instead of words? Before you used the word methane and not its formula. Be consistent. If chemical formula are used, charges (HS<sup>-</sup>) need to be indicated too.

**Authors:** OK

**Referee 1:** (5) Line 65: improve wording

**Authors:** OK

**Referee 1:** (6) Line 94: ‘implies’ instead of ‘imply’

**Authors:** OK

**Referee 1:** (7) Line 141: “PBH’s (pseudobioherms) – You use many abbreviations and acronyms; this does not make reading any easier. What is the benefit of replacing the word ‘pseudobioherms’ by the abbreviation ‘BHPs’? Saving space? Consider to refrain from introducing yet another new abbreviation

**Authors:** we will!

**Referee 1:** (8) Line 144: Consider to use ‘perimeter’ instead of ‘circle’.

**Authors:** OK

**Referee 1:** (9) Line 171: Same as for per mil. Omit blank between numbers and per cent symbol.

**Authors:** OK

**Referee 1:** (10) Line 246: Add blank before “As”.

**Authors:** OK

**Referee 1:** (11) Line 257, and throughout: It is ‘gray’ in American English.

**Authors:** OK

**Referee 1:** (12) Line 261: add blank after “of”

**Authors:** OK

**Referee 1:** (13) Line 268: “fabric is ” not “fabricis”

**Authors:** OK

**Referee 1:** (14) Line 294: “burrows have” not “burrow shave”

**Authors:** OK

**Referee 1:** (15) Line 296: add blank after “Burrow”

**Authors:** OK

**Referee 1:** (16) Line 310: add blank after “10”

**Authors:** OK

**Referee 1:** (17) Line 313: rather “Taken together”

**Authors:** OK

**Referee 1:** (18) Line 383, and throughout: “main silicification surface (MSS)” – the use of such abbreviation impedes comprehensibility.

**Authors:** OK

**Referee 1:** (19) Line 410: “measurements” not “meaurment” when “are” is used.

**Authors:** OK

**Referee 1:** (20) Line 412: blank after per mil symbol.

**Authors:** OK

**Referee 1:** (21) Line 412: “pole” – I do not understand. Do you mean ‘pool’? But even than such wording would be less than ideal.

**Authors:** Sorry, that was FrenGLISH. The term “pole” is commonly used in French for pure phases in a ternary phase diagram. That will be corrected with the help of a native speaker (end-members of a mixing trend?):... .

**Referee 1:** (22) Line 414: blank after “and”

**Authors:** OK

**Referee 1:** (23) Line 422: insert blank after “limited”.

**Authors:** OK

**Referee 1:** (24) Line 467: “whereas” instead of “where as”.

**Authors:** OK



**Referee 1:** (25) Line 467, and throughout: “depleted values” – Colloquial wording. What is it, a value would be depleted in? A values is a number; in this case ‘low values’ or ‘negative values’ would be appropriate. A mineral phase, for example, can be depleted in one isotope, in this case C-13, but not a value.

**Authors:** OK

**Referee 1:** (26) Line 486: delete “depletion”

**Authors:** OK

**Referee 1:** (27) Line 492: add blank before “of”.

**Authors:** OK **Referee 1:** (28) Line 501: insert blank before “signature” .

**Authors:** OK

**Referee 1:** (29) Line 531: What is “biodeformation”? Is this a good term?

**Authors:** Actually, there are lots of references for “biodeformational structures”, defined by Wetzel (1991) as follows: “In general, two types of bioturbation structures were distinguished as suggested by Schäfer (1956); trace fossils (“distinct burrows” sensu Frey and Wheatcroft, 1989), which show a defined shape and have sharp and distinct outlines allowing classification in terms of paleontological nomenclature (Häntzschel, 1975), and biodeformational structures (“indistinct burrows” or “burrow mottles” sensu Frey and Wheatcroft, 1989), which have indistinct outlines and features which destroy pre-existing structures”. Biodeformation was meant to be the process responsible for biodeformational structures. There are also references to biodeformation, e.g. Virtasolo et al. *Sedimentology* 2011. Basically, biodeformation refers to reworking by organisms of sediment not consolidated enough for the burrows to have a clear expression, i.e. the shallowest tier(s) of bioturbation. We will either replace the term by a periphrase (?) (Linguee suggests “paraphrase”,;but this is not what I mean; anyway. . .) or provide appropriate references, we’ll make sure anyway that the message is made clear.

**Referee 1:** (30) Line 599 to 600: “. . . starting from the top shallow within the seafloor” – improve wording.

**Authors:** OK

**Referee 1:** (31) Fig. 10 (B) seems out of focus.

**Authors:** This is UV fluorescence, and diffusion of light emitted within the sample likely blurs the image irrespective of focusing issues.

**Referee 1:** (32) Line 1041: Add full stop after 'side'. (33) Fig. 12 (D) seems out of focus.

**Authors:** this is very high magnification, and it was not possible to have a perfect focus over the whole 30- $\mu\text{m}$  thickness of the thin section.

**Referee 1:** (34) Line 1093: 'gray' in American English.

**Authors:** OK

**Referee 1:** (35) Line 1108: add blank between numbers and units.

**Authors:** OK

**Referee 1:** (36) Line 1111: '13' in superscript.

**Authors:** OK

**Referee 1:** comments are also provided in a pdf document I will upload Please also note the supplement to this comment: <https://se.copernicus.org/preprints/se-2020-187/se-2020-187-RC1-supplement.pdf>

**Authors:** OK

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Interactive comment on Solid Earth Discuss., <https://doi.org/10.5194/se-2020-187>, 2020.

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