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Solid Earth
Discussions

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 2

Referee 2: General comments: The manuscript describes a Jurassic seep carbonate body cropping out in the Aurel area (SE France basin) and focuses particularly on the control exerted by the bioturbation on the vertical growth of the carbonate body. Authors interpret that intense burrowing by callianassid-type shrimps in the central part of the seep enhanced vertical permeability during a long time, which avoided the

self-sealing process in the seep deposits and allowed the vertical aggradation of the carbonate body. This work contributes to a better understand on the sedimentation in seep environments and particularly on the formation of high aggrading carbonate bodies. I find this work interesting and it adds to the knowledge about seep-related processes and products. Therefore, I recommend its publication after moderate to major revision. In the manuscript, I find particularly well described, interpreted and discussed the sedimentary facies architecture and C isotopes. Nevertheless, I have two major general comments about the origin of the tubular structures and burrowing.
Authors: Thanks for this precise and detailed review. The most significant change will probably be the transfer of the section that concerns bioturbation from results (where we thought it was well-established enough to belong) to discussion, i.e. point 1 below. Other points are mostly matters of clarification (figures/wording/reasoning/etc.).
Referee 2: 1) Origin of tubular structures: It is presented the tubular structures within the seep carbonates as biogenic, e.g. trace fossils, but a discussion about other possible origins (abiogenic gas conduits) is missing. In this regard, abiogenic conduits have been well documented in the literature, both in present-day and ancient seeps, and some of their complex networks resemble that of the Aurel pseudobioherm. In addition, I find the interpretation as burrows should be supported on more data or evidences (the only macroscopic sample presented correspond to a single 11 cm-long rock fragment) and then a discussion on the origin would be relevant.
Authors: There are two comments here: one about the fact that the macroscopic interpretation is based on a single sample (actually, two of them are figured, respectively in Fig. 8 and Fig. 9+10). We will provide more, either as an extra figure, or possibly as supplementary material to avoid overloading the manuscript. The second comment is about the discussion of bioturbation vs. mechanical (fluid expulsion) cause for the tubular structures. We will develop and discuss this point.
Referee 2: 2) Burrowing: Burrows are classified in three size categories (large, medium and small) each of which is interpreted (based on crosscutting relationships) as formed in three consecutive phases at progressively deeper tiers. However,

manuscript's Figure 8 shows that large burrow (Ba) contains centered medium burrows (B1-B3) and they present a parallel and no cross-cutting relationship. It seems, at least from that figure, that medium burrows are actually cement-filled holes of the large burrow and not different burrows.

Authors: This is why we included the sample shown in Figs. 9-10. The sample in Fig. 8 is the one we found clearest in showing large burrows filled with peloids (later interpreted as pellets), clearest in our interpretation because it underwent a single population of large burrows. Other samples (e.g. Figs 9-10) have a much more complex distribution of micrite and grainstone patches, which we interpret to an increased degree of burrowing with many intersecting burrows all filled with similar peloids, and likely with micrite intraclasts. The latter set would represent remnants of the initial sediment homogenized by bioturbation at a soupy, unconsolidated stage.

Referee 2: Nor do the figures show a clear crosscutting relationship between small and larger burrows.

Authors: Unfortunately, none of the sample photos/photomicrographs provide clear cross-cutting evidence. Our interpretation is deroved in good part from the similarity of the observed texture with that of a seep carbonate sample figured in Wetzel, A. (2013). Formation of methane-related authigenic carbonates within the bioturbated zoneâĂŤAn example from the upwelling area off Vietnam. Palaeogeography, palaeoclimatology, palaeoecology, 386, 23-33. We will revisit in detail all available material, illustrate the best way we can what is firmly established, and state explicitly what analogies support more tentative interpretations.

Referee 2: I think that this is a key point to interpret the temporal and spatial (depth) distribution of the burrows and, therefore, cross-cutting relationships among burrows should be better illustrated or with more figures (they could be in the "supplementary material").

Authors: Fair enough, we will indeed consider the "supplementary material" option since there are already 17 figures.

Referee 2: Specific comments: Lines 201: Show the three units in Figure 3.

Authors: OK

Referee 2: Line 280. It is not clear in Fig. 8 that medium burrows cut through large burrows.

Authors: OK, cf. response above

Referee 2: Line 289. Indicate figure (Fig. 8?). t3 in Figure 8 is too small to observe concentric bioclast orientation.

Authors: Sorry, T3 is actually a typo for B3. The figure is probably too small for the bioclasts to be clearly visible, we have a good photomicrograph showing this point, which we will include (as supplementary material if needed).

Referee 2: Lines 313-315: Add reference.

Authors: OK

Referee 2: Line 324. Smooth wall character does not indicate that it be Trypanites but other criteria as cut bioclasts, etc.

Authors: Indeed, but difficult to image in the very fine-grained, bioclast-poor lithology. We actually draw an analogy to the example shown by Wetzel, A. (2013). Formation of methane-related authigenic carbonates within the bioturbated zoneâĂŤAn example from the upwelling area off Vietnam. Palaeogeography, palaeoclimatology, palaeoecology, 386, 23-33. The adverb "likely" acknowledges the absence of firm evidence.

Referee 2: Line 335-336. Why does homogeneous micrite-rich fabric reflects high bioturbation if there is no evidence of burrowing? Why sediment homogenization or mixing could not be due to other process, as for example gas bubble ascending?

Authors: We will discuss this point, going back to bibliography as needed.

Referee 2: Line 354: Description of microfacies and diagenesis (section 4.5) is organized in tiers 1, 2, and 3, but these tiers are interpretative, and interpretations should be located in the discussion. Therefore, I recommend to delete them from that section.

Authors: That is a significant change in paper architecture, we ended the manuscript being confident that sediment texture was convincing enough for their interpretation as burrows to be considered a result; this is clearly not the case, this point will be moved

to discussion and the "tier" terminology be replaced by non-interpretive terms.
Referee 2: Moreover, description of carbonate phases would be more understandable if they will be presented following cement stratigraphy.
Authors: We may add a bar diagram of the paragenetic sequence, this should help.
Referee 2: In general, I miss comparison with and references to other papers on seep carbonates and particularly on paragenetic sequences.
Authors: OK
Referee 2: Line 356: What was bioturbated, the original marl or the later micrite carbonate?
Authors: Sorry, the wording was not clear. Micrite is used in a too loose manner for both pure lime micrite (deposited as limestone beds) and for cemented marls (shaly limestone, which does not clarify the matter.
Referee 2: Line 397. It is used in this line and through the text "synsedimentary cements" (also "sedimentary cements") to indicate early diagenetic cements. I would be better to use always "early diagenetic cements" in contrast to "late diagenetic cements".
Authors: OK
Referee 2: Line 495: Most D18O values (table in Appendix I and Fig. 13A) corresponding to saddle dolomites are about -1 to -2 per mil. These values are very strange, are higher than reference sediments and early diagenetic cements, and they are not compatible with hot fluids (>60-80 °C) from which saddle dolomites precipitate. Common D18O values for saddle dolomites documented in the literature are around -6 per mil or lower. It needs some discussion.
Authors: OK
Referee 2: Line 575: "sediment-cement alternations" change by "sediment-cement sequences". Always use the same terminology for the same things.
Authors: OK
Referee 2: Line 593: Add reference to Fig.3 (". . .A and B; Fig.3").
Authors: OK

Referee 2: Line 597: It is mentioned the downward growth of concretionary crusts. However, it is not clear whether this interpretation corresponds only to layers A and B or to the entire pseudobioherm. It should be state more explicitly.
Authors: To A and B only, this will be written explicitly.
Referee 2: Line 605: It is mentioned that the axis of vertically stacked carbonates shows two lateral shifts coinciding with marker beds A and B. Then, these shifts are interpreted that hydrocarbon-charged fluids migrated upslope. However, Fig. 3B suggests that the axis of the PBH migrated in opposite directions, first westward and then eastward. How can this apparent contradiction be explained?
Authors: Fig 3D indicates a ca. 5 times higher northward than westward shift across marker bed B. What is shown in 3B is thus an apparent shift. Moreover, the axis is drawn as a best guess to illustrate a visual perception and cannot be defined from the outcrop with the precision suggested by the thin dash-dot line. The text will be revised accordingly.
Referee 2: What was the regional and/or local paleoslope orientation at Middle Callovian times?
Authors: Actually, there is no clue in this area where outcrop continuity is limited, and that has been subjected to several orogenic phases so that regional geology cannot help as regards the local setting, the one that influences local bubble migration. The interpretation we propose is the simplest we can think of, based on Casenave et al., 2017, which observes this type of upslope shift on a present-day slope offshore W Africa. We will refer to this paper.
Referee 2: Line 608: Change "chemosymbiotic microbial communities" by "chemosynthetic microbial communities".
Authors: OK
Referee 2: Figure 8: The legend of this figure is fragmentary and very complex with a lot of symbols, colors (not easily identifiable), etc. It should be a single and simpler legend.
Authors: OK

Referee 2: Technical corrections: - Omit blank spaces front and back "/" and "- "symbols. Revise throughout the document. - Omit blank spaces between number and °C symbol. Revise throughout the document. - Omit blank space between number and per mil and per cent symbols. Revise throughout the document. - Insert blank space between two words. In many places of the text, blank spaces between words are missing. Revise throughout the document.
Authors: Thanks for these, the manuscript will be corrected accordingly.

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