Se-2020-187

What makes seep carbonates ignore self-sealing and grow vertically? The role of burrowing decapod crustaceans

by Blouet et al.

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 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 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.

(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.

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.

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.

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

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.

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.
(2) Line 141: Chemosymbiosis can only be assumed in case of ancient taxa.
(3) Lines 239 to 240: What would be an "altered peloid" – please specify.
(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).
(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.
(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. 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.
(7) Lines 509 to 510: "limestone column" – The sedimentary strata do not consist of limestone only.
(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'.
(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.
(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.
(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).

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

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

(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.

(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.

(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.

(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*.

Technical corrections and suggestions

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

(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.

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

(4) Line 45 and 46, and throughout: "H_2S 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^-) need to be indicated too.

(5) Line 65: improve wording

(6) Line 94: 'implies' instead of 'imply'

(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.

(8) Line 144: Consider to use 'perimeter' instead of 'circle'.

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

(10) Line 246: Add blank before "As".

(11) Line 257, and throughout: It is 'gray' in American English.

(12) Line 261: add blank after "of"

(13) Line 268: "fabric is " not "fabricis"

(14) Line 294: "burrows have" not "burrow shave"

(15) Line 296: add blank after "Burrow"

(16) Line 310: add blank after "10"

(17) Line 313: rather "Taken together"

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

(19) Line 410: “measurements” not “mearurement” when “are” is used

(20) Line 412: blank after per mil symbol

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

(22) Line 414: blank after “and”

(23) Line 422: insert blank after “limited”

(24) Line 467: “whereas” instead of “where as”

(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.

(26) Line 486: delete “depletion”

(27) Line 492: add blank before “of”

(28) Line 501: insert blank before “signature”

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

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

(31) Fig. 10 (B) seems out of focus.

(32) Line 1041: Add full stop after ‘side’.

(33) Fig. 12 (D) seems out of focus.

(34) Line 1093: ‘gray’ in American English

(35) Line 1108: add blank between numbers and units

(36) Line 1111: ‘13’ in superscript