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Interactive comment on “Experimental mineralization of crustacean eggs leads to surprising tissue conservation: new implications for the fossilization of Precambrian-Cambrian embryos” by D. Hippler et al.

Anonymous Referee #2

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This paper report results from a taphonomic experiment designed to fossilize crustacean embryos. The authors found that crustacean eggs and embryos can be partially mineralized by brushite when embedded in a gel-like medium loaded with H_3PO_4 and excessive $CaCO_3$ in an oxygen-free environment. They further report that pre-heating the eggs/embryos prepares them for better three-dimensional preservation. The results add to a growing literature in experimental taphonomy and have implications for the phosphatization processes responsible for the preservation of Ediacaran-Cambrian embryo fossils.

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My main concern is that the experiment conditions may be geologically irrelevant. The embedding medium consists of a gel-like material (what is the composition of the gel? Silica gel? Agar?), distilled water, H_3PO_4 , and CaCO_3 . Thus, it is not a good approximation of seawater or pore water. The rather high PO_4 content (0.5 ml H_3PO_4 mixed with 2.5 ml H_2O) in the experiment is not characteristic of geological environments. Along this line, I urge the authors to calculate, estimate, or measure the brushite supersaturation levels in the embedding medium, and ask the question whether brushite would precipitate regardless. I have suspicion that brushite should precipitate in such high supersaturation levels even in distilled water. In fact, Table 2 shows that brushite was detected in the embedding medium, in abundance comparable to mineralized embryo surface, indicating that phosphate precipitation is pervasive and not selectively focused on embryos. Fossil embryos, however, were selectively phosphatized (matrix is largely carbonate). I think the author should carry out additional experiment at lower brushite supersaturation levels to define a threshold supersaturation level required for selective fossil phosphatization.

I have reservations on the taphonomic importance of hydrothermal venting in embryo phosphatization. The authors have shown that pre-heated (actually, boiled) embryos have better potential for three-dimensional preservation than untreated embryos, and argue that perhaps heating near hydrothermal vents may played a similar role. However, the geographical and geochronological distribution of early Cambrian hydrothermal vents in South China does not coincide with the distribution of embryo fossils. Not to mention late Cambrian and Ordovician embryo fossils.

The statement that chorional envelope was not preserved in the experiments is not entirely correct. The new experiments, as well as those reported by Martin et al. (2003), do show that the chorional envelope was replicated by phosphate encrustation. Yes, the organic material of the chorional envelope was no long there, but its morphology has been replicated. Replication (casting, molding, encrustation) is an important mode of preservation that is responsible for many examples of soft tissue preservation.

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I also think the experiment conditions are not adequately documented. For example, the composition of the gel-like material should be determined and reported; the pH value of the embedding medium should be monitored, recorded, and reported (particularly given that pH is a major factor controlling phosphate precipitation); the experiment number (e.g., E1a, E4.3, etc) should be given for each illustrated specimens in Figs.1-4.

Table 1: experiment 2a was carried out in atmosphere, but this is inconsistent with the statement in page 12057, line 14-15, "... whereas experiment E2 proceeded under an N2-atmosphere". Also, what does the column "EDS peaks of minerals" mean? Only three experiments show P and Ca peaks in that column. Does that mean only three experiments resulted in mineralization or EDS was carried out on specimens from only three experiments. I suggest that the columns in Table 1 be grouped in two categories: experiment conditions (CaCO₃, H₃PO₄, H₂O, C, N₂) and experiment results (surface mineralization, cellular mineralization, CaCO₃, brushite, etc).

Page 12054, "The latter finding in turn would rather confirm hypotheses based on molecular clocks indicating that the last common ancestor of Metazoa appeared in the Neoproterozoic between 676 and 766Ma (Peterson et al., 2005, 2008)." This is not correct. The finding of Ediacaran animal fossils does not CONFIRM the molecular dating of animal origin in the Cryogenian. It is consistent, but not confirmative, evidence.

Page 12054 and elsewhere, on phosphate replacement and encrustation: perhaps some of the direct textural evidence for phosphate replacement and encrustation was presented in Xiao and Knoll (1999, Lethaia).

Did mineralization occur in oxygenated experimental conditions? There seem to be some confusion. P. 12060 "Fresh crayfish eggs exposed to excess CaCO₃ (experiment E1b, E2b, E3 and E4; Table 1) in an oxygenated or a reduced atmosphere, in contrast were preserved over several weeks". P. 12061 "This finding holds true for all

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experiments applying the excess CaCO_3 medium and anoxic conditions". This can be clarified by adding an experiment result column in Table 1.

p. 12061: The ratio of calcium phosphate to CaCO_3 of the crystallites was measured to be 55 : 45 and 62 : 38 (in wt.-%) IN EXPERIMENT 7.2 and 7.3, respectively (Table 2).

P. 12063: A thin SHEET of fine-grained authigenic minerals . . .

Fig. 5: please provide an enlarged image to show (and mark with arrow) the phosphatized cells and nuclei. Also, it would be nice to confirm the phosphatic nature of the preservation by presenting P and Ca maps (as in Fig. 3).

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