Biogeosciences Discuss.,
https://doi.org/10.5194/bg-2018-493-AC2, 2019

Biogeosciences Discussions

Interactive comment on "The colonization of the oceans by calcifying pelagic algae" *by* Baptiste Suchéras-Marx et al.

Baptiste Suchéras-Marx et al.

sucheras@cerege.fr

Received and published: 27 May 2019

Answer to Nina Keul, reviewer 2

The comments are organized as :

Comment from R2

→ Anwer to R2

The manuscript "The colonization of the oceans by calcifying pelagic algae" by B. Sucheras-Marx et al. describes colonization of the oceans by coccolithophorids since the last 200 M. This well written manuscript is based on the compilation of nannoplankton accumulation rates in sediments, brought in context with previously published

species richness, coccolith size as well as atmospheric CO2. Results indicate a colonization of the oceans in distinct phases, shaped by the reproduction strategy, interactions with other planktonic organisms and the physical environment. The research is original and provides interesting findings to the community. The data set compilation seems to have been carried out with great care, even though, sadly, the available data is confined largely to the Atlantic, therefore I would suggest to maybe rephrase the main conclusions of the manuscript from "World Oceans" to "Atlantic". The manuscript is concisely written, however, could benefit from a re-organization of the Discussion paragraph in my opinion, so that each phase is discussed in its own paragraph, instead of discussing the colonization twice in 4.1 and 4.2.

→ We thank Reviewer 2 for her positive comments. Following the R2's remarks, we have now merged sections 4.1 and 4.2 and re-organized the Discussion by paragraphs, the first one introducing the models, andthe following ones describing each phase in a separate paragraph.

I have some reservations regarding the smoothing of the NAR and the seemingly arbitrary reference to sometimes the smoothed trend and sometimes the underlying raw data. The authors should carefully re-examine each time the NAR is discussed and elaborate on when which datatype is discussed (see major comments below).

I would recommend publication of this manuscript after minor revisions have been carried out. I wish the authors good luck with the revisions and remain available for further feedback and discussions.

Please see my comments below (p=page, l=line): Major comments:

NAR calculation: Since the majority of the manuscript hinges on the NAR, it would be great if the authors could provide an propagation of error for the NAR values, as they are calculated from 3 other variables. Additionally the NAR in Fig. 2 has a high variability of several orders of magnitude, can the authors elaborate on this a bit, e.g. is this caused by pooling different ocean locations, where changes could have happened

at a different point in time?

→ We strongly agree with R2's remarks, I am myself fighting for more control on uncertainties in Earth Sciences in general (see as an example Suchéras-Marx et al., in revision at Marine Micropaleontology titled "Statistical confidence intervals for relative abundances and abundance-based ratios: simple practical solutions for an old overlooked question"). Unfortunately, in the present case, we cannot propagate uncertainties simply because the original publications do not provide information on the counting uncertainties, stratigraphic uncertainties or density. Thus, propagation would be completely arbitrary and may suggest to the reader that we control uncertainties, which is unfortunately not true.

Smoothed curve versus raw data: Currently, in some time periods smoothed NAR values are discussed and sometimes the raw data. Please state each time, which data is taken (raw data or smoothed trend). Please be careful in not mixing the two. e.g. p9 l29 " a steady production for the rest of the epoch" seem to be rather subjective, as there seems to be rather a huge variability in observed NAR post K-Pg until the end of the Paleocene, just the chosen smoothing factor results in a steady NAR. How have the authors assessed "stable phases" in NAR versus "changing phases" of NAR? Only by visual observation of the smoothed trend?

→ Yes, we do not calculate any test for that, we prefer to directly observe the curve and compare it to the other ones.

By just looking at the smoothed curve, variability in the NAR data is lost. While I agree that in some time points a SF of 0.1 is influenced by the sampling resolution, however, in other time points variability and trends are lost by a higher smoothing factor (e.g. the increase in NAR since the middle Paleogene, which is "smoothed away" otherwise). Furthermore (p9 l27) here the average NAR shows no change during the K/Pg event, but NAR clearly changes, which is also discussed.

→ R2 is right. In the new version of our MS, we now state when the raw NAR or the

smooth NAR is considered.

Layout Figure 2: please mark the individual colonization phases in a way, that they are easy to be put into context with the NAR record. Currently, the phases are indicated on the far right and the NAR record is on the far left, making it hard to see the exact phase changes. I would suggest shading of the background. Please also indicate the Torcian and Valangian. And add a line for the K-Pg event, as some of the statements (e.g. p9 l28 " ..the NAR recovered to pre-extinction levels within less than 4 Myr") are hard to follow with the current Figure layout.

→ Fig. 2 has been largely amended following R1 and R2 comments.

Minor Comments:

p2 l2: represent (without s)

→ corrected

p2 l6-13: also refer to the Kuenen Event in the discussion or remove from Introduction

→ the Kuenen Event is the shift from carbonate system dominated by neritic production from benthic organisms to pelagic production from planktic organisms. Hence it is crucial to cite this event in the Introduction because it is linked to planktic organisms' evolution. But because we don't quantify carbonate in this study, we cannot speculate on the timing of this event thus we don't discuss it. We have made some modification in the text to derive the point from Kuenen to evolution transition P1 L7-16 "There is then a transition from Jurassic calcareous nannofossil-poor to Late Cretaceous and Cenozoic calcareous nannofossil-rich oceanic sediments which has shifted the carbonate accumulation in neritic environment by benthic organisms to accumulation in pelagic environments by planktic organisms. This major carbonate system change is known as the Kuenen Event (Roth, 1989), and has been referred to a tectonically-mediated intensification of the ocean circulation. This event is concomitant with the development of several planktic groups (e.g., planktic foraminifera (Hart et al., 2003), diatoms (Kooistra

et al., 2007)), may be seen as a Mesozoic Plankton Revolution (derived from Vermeij, 1977) and thus is also dramatically related to plankton evolution. The causes and consequences of this biotic revolution have been extensively discussed, but the transition itself remains poorly documented; most interpretations solely rely on species richness (Falkowski et al., 2004; Knoll and Follows, 2016), which does not provide an exhaustive framework to fully appreciate the evolutionary history of calcareous nannoplankton."

p3 l17 mm2

→ corrected.

p4 Fig. 1 caption: type of outcrop: rephrase outcrop; deep sea drilling is not an outcrop

→ corrected.

p5 l5: SI= suppl. inform. (define)

→ corrected.

p7 l 6: I would structure the paragraph according to the different phases, e.g. add a break in the middle of l. 6.

→ corrected.

p7 l 14: regarding the versatile readership of BGD, I would refrain from using too many specific terms such as Cope-Deperets rule, which are not explained in the Introduction, same for Margalefs mandala in p9 l12, also explain briefly K and r strategists (for readers from a more geological background).

→ corrected; we have also added short precision of each specific terms listed above P8 L27 "[. . .] Cope-Depéret's rule (i.e. increase in size over evolutionary time; Aubry et al., 2005)"; P11 L11-12 "(i.e. Fig. 2 from Margalef, 1978)"; P11 L12-15 "between K- (corresponding to organisms evolving in more stable, predicable and saturated environments) and r- (organisms living in unstable, non-predictable, and unsaturated environments) strategists (Reznick et al., 2002), living in intermediate nutrient-concentration

waters, turbulence and light availability (Margalef, 1978; Balch, 2004; Tozzi et al., 2004)."

p7 l 17: ecospace or ecological niche?

→ ecospace.

p7 l 24: dominance: rephrase, as modern oceans are not dominated by Ehux, but it is the dominant cocco?

→ rephrased P9 L2-4 "This Establishment phase reached a climax in modern oceans with the dominance within the coccolithophore community of the iconic small-sized species Emiliania huxleyi (e.g. Ziveri et al., 2000; Baumann et al., 2004)."

p8 Fig 3: please add also a time stamp to panel c (Valanginian?)

→ slight modification of the Fig. 3 with a stratigraphic column.

p9: when the term species is used, calc. nannoplankton species is meant? Or coccolithophorids?

→ calcareous nannoplankton, the term is added to species when needed.

p 9: I find the terms R-pole and K-pole confusing, are these commonly used terms? Or do they just hint towards the respective areas in Margalefs mandala?

→ r- and K- strategists is a common term in ecology. We slightly modified it to highlight the fact that within plankton, calcareous nannoplankton are intermediate strategist and within calcareous nannoplankton there are species that are closer to one or the other side or "pole". We have now modified these lines to P11 L24-25 "Hence, the ecology of Jurassic-Early Cretaceous nannoplankton species was closer to the "r-strategist" pole of density-independent selection (Reznick et al., 2002). [. . .] P12 L9-10 Consequently, late Early and Late Cretaceous species were closer to the "K-strategist" pole of density-dependent selection, corresponding to organisms evolving closer to carrying capacity."

p9 l21: the maximum occurs much later, this need to be rephrased.

→ The sentence p9 l21 is: “It suggests that more and more species shared an increasingly filled ecospace (Fig. 2), therefore becoming more specialized to peculiar environmental conditions.” I am sorry but I don’t understand what R2 means.

p9 l24: please explain "roughly stable"

→ bad writing. Modified for “The raw NAR reached an optimum at ∼133 Ma and the smooth NAR is flat from ∼117 Ma until the K–Pg mass extinction event (66 Ma), which had a catastrophic impact on calcareous nannoplankton diversity with a species turnover up to 80 % during the crisis (Bown, 2005).”

p9 l. 32: where is the "ecological specialization" seen in the data?

→ the specialization is not seen in data per say but inferred based on the observation that more species sharing the same ecospace are producing a stable number of individuals. If the ecospace is split between more species, then the species must be more specialized to peculiar conditions.

p10 l10: What are "red lineage algae"? Those belonging to the Red Queen Model?

→ the red lineage algae are those using chlorophyll c and derivatives as accessory pigments. Added in text P11 L31-33 “[. . .] red lineage algae (i.e. using chlorophylle a, with chlorophylle c and fucoxanthin as accessory pigments typical in Haptophyte) such as coccolithophores (Falkowski et al., 2004)”

p10 l 18 - 20: please add citations.

→ citations added P12 L14-17 “This time interval is the paroxysm of the Mesozoic Plankton Revolution with the first occurrence of diatoms, a plateau of marine dinoflagellate species-richness, and the diversification of planktic foraminifera which, together with calcareous nannoplankton (Falkowski et al., 2004; Knoll and Follows, 2016), contributed to form massive chalk deposits (Roth, 1986).”

p 10 l 28: where is the "post crisis Invasion period" in Fig 2?

→ we can’t see it, we just speculate it must be one since the diversity and nannoplankton productivity dramatically dropped at the K-Pg boundary. We have added precision in the following P12 L29-32 “At a much shorter time-scale, the Paleocene appears therefore similar to the Jurassic-Cretaceous interval in that a first Invasion phase (the post-crisis biotic recovery) and the origination of new calcareous nannoplankton families (Bown, 2005) is followed by a period of species diversification and ecological specialization – a Specialization phase.”

p10 l 31: "smaller sized species than in the Mesozoic": to me it looks like the average coccolith size is relatively the same between this period and the Jurassic portion of the Mesozoicum.

→ modified to “Cretaceous”.

p11 l 1 The "decrease in pCO2" during the Neogene is not visible in Fig2, maybe another dataset would be more suitable? Also, how do the authors then explain the stable coccolith mean size and increasing NAR during the Jurassic, where pCO2 showed the largest drop?

→ Firstly, the Bolton’s model is based on reaching an unknown threshold in pCO2 during the Miocene with pCO2 too low to sustain CO2 diffusion through the cell wall for both organic and inorganic carbon fixation in large coccolithophore cell. The Lower Jurassic decrease just not reach this threshold. We have added P13 L4 “below a threshold” to the sentence. Secondly, the Miocene pCO2 discussion is really critical and controversial between specialists. In order to overcome this issue we have changed Hönisch’s data compilation in Fig.2 to Foster’s data compilation (which is really similar but more recent), added Witkowski et al. 2018 data (asked by R1) and added in grey Mejia et al. 2017 results (range due to uncertainties) which record the Miocene pCO2 decrease.