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Climate of the Past Discussions



# *Interactive comment on* "Early Paleogene variations in the calcite compensation depth: new constraints using old boreholes across Ninetyeast Ridge in the Indian Ocean" *by* B. S. Slotnick et al.

**Anonymous Referee #1**

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Review of the manuscript entitled "Early Paleogene variations in the calcite compensation depth: new constraints using old boreholes across Ninetyeast Ridge in the Indian Ocean" by B. S. Slotnick, V. Lauretano, J. Backman, G. R. Dickens, A. Sluijs and L. Lourens.

This is a very interesting contribution focused on the CCD evolution in the Indian Ocean during the early Paleogene (62-48 Ma). What the authors performed is a revision of old boreholes drilled in the Indian Ocean during DSDP Leg 22. This revision is obviously based on previous data reported in literature (appropriately cited) but also and, more interestingly, on either new data or re-interpretation of old data. To construct a firm stratigraphic frames for the sites analyzed (213, 214 and 215), the authors provide (biostrati-



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graphic and biochronologic) calcareous nannofossil data strictly integrated with CaCO3 content and $\delta$13C profiles. Although sediments used for these exercise are not ideal because they are recovered in single holes using rotary coring methods (which implies the presence of core gaps and disturbed intervals), they provide a geochemical dataset that is consistent with those observed at other locations (Atlantic and Pacific Oceans). The authors also emphasize the potential of Indian Ocean record and suggest that this area surely deserve a special attention, especially in the future planning of drilling expedition focused on early Paleogene time. The manuscript is generally well written and organized but there are some issues that need to be addressed in order to further improve the robustness of the proposed age model and, consequently, of the correct interpretation of CaCO3 content and $\delta$13C curves. In the following the authors can find a list of minor to major issues (moderated revision is needed) ordered as they appeared in the text (plus figures and tables): TEXT Page1: Affiliations 2 and 4. To me they look very similar. Am I wrong?. Page 2, line 7: delete “assemblage”. Page 2, line 8: “sediments” instead of “sediment”. Existing sites: I would delete existing because this gives the idea that Site 213 still exists on the sea floor, which is unlikely. Page 3, line 25: add “from the ocean-atmosphere” after carbon. Page 3, line 26: add “to the ocean- atmosphere” after carbon. Page 4, line 3: “deep-sea carbonates” instead of” deep-sea carbonate accumulation”. Page 4, lines25-27: The amount of carbon is certainly crucial but. . . Does the magnitude of these changes be also controlled by the rate of the input? Comparing with the ongoing release of GHG into the ocean-atmosphere, this also is a crucial factor to take into account. Page 5, line 8: see comment on Page 2, line 8. Page 6, line 24: “Sediment age was determined primarily through calcareous biostratigraphy”. Biostratigraphy does not give absolute ages, but relative. Ages are determined with biochronology. These are two substantially different concepts. The sentence should be re-phrased so that it is immediate what the authors mean. Page 7, line 2: may be “sediments” instead of “sediment”. Page 7, line 9: delete “depth”. Page 7, lines 10-12: This mostly due to the fact that the Paleogene Time Scale is not fixed. Even the recalibration (absolute ages) proposed by the authors is going to



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change shortly, I guess. Page 7, line 18 to Page 8, line 7: I do not know if I get it correctly: the authors assumed a core gap of 1m between successive cares, they also assumed that the total length of core gaps are variable because the total length of the gap is equal to 1m (constant for each core) plus the difference between and ideal core length (9.5m) and the actual length of the recovered core. If this is what you mean, this is lost in the text and the sentences should be probably rephrased. Page 8, line 19: "Calcareous nannofossils were investigated in 62 samples to refine ages." The authors are not calibrating CN datums, they simply provide the better positioning for each calcareous nannofossil datum. The sentence should be: "Calcareous nannofossils were investigated in 62 samples to refine biostratigraphic datums". Again biochronology is not a synonymous od biostratigraphy. Page 9, lines 7-8: make reference to previous works that provide this kind of biochronologic data Page 9, lines 6-9: This is confusing to me. I would suggest to change this sentence because its meaning is ambiguous at this moment. . .I would say something such "some of these biohorizons have been used to construct CN zonal schemes such as those of Okada and Bukry (1980) and Martini (1971), the latter adopted as biostratigraphic scheme in this work. Page 9, lines 8-11: This sentence is floating delete it or, better, define all the biohorizons you are going to use. In this contest you can mentioned the particular case of the Base/Base common of D. lodoensis. Page 9, lines 23-25: Specify How many samples did not give reliable values. Page 10, lines 3-5: Looking at Figs 4-6 it seems more from NP7-8-NP13 (Site 213), NP475-NP12 (Site 214) and NP7/8-NP13 (Site 215). Page 10, line 9: "selected taxa" instead of "assemblage components". Page 10, line 10: "Age estimates are from Agnini et al. . .." add "of CN biohorizons" after Age estimates. Page 10, line 12: "constrains" instead of "criteria" Page 10, line 15: upper case for Top (T), add (base of Zone NP13) after T. orthostylus. Page 10, lines 17-18: upper case for Base (B), add (base of one NP12) after D. lodoensis. Page 11, lines 8-9: delete "several of these criteria" and add "information derived by the integration of CN stratigraphic ranges". "The simultaneous presence" instead of "the overlap in range". "Observed" instead of "occurs". Page 11, line 12: "its disappearance is calibrated" to instead of "disappears" (that refers to a



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taxon not to a biohorizon) Page 11, line 13: Zones NP7 and NP8 are undifferentiated. Please use NP7/8 instead of NP7. Page 11, line 14: upper case for Base. Page 11, line 15: upper case for Base. Page 11, line 16: put 60.90 Ma in brackets after Zone NP5. Page 11, lines 17-18: upper case for Base. Page 11, line 22: upper case for Base. Page 11, line 23: add "Based on these data" at the beginning of the sentence. Page 11, line 23: "Biostratigraphic data" instead of "criteria" Page 11, lines 26-28: These two biostratigraphic data (diverse and abundant fasciculiths and absence of E. robusta) should be integrated to be used properly. ". . ..Diverse and abundant Fasciculithus spp. indicate an age older (minimum) than 55.47 Ma." Diverse and abundant fasciculiths are present up to the onset of the PETM (55.53 Ma). 55.47 Ma is the calibration for the CO between Fasciculithus spp. and Z. bijugatus that occurred during the PETM (after the onset). Decrease in diversity, also known as Top of Fasciculithus richardii group (see Agnini et al. 2014 for details) should be added in Table 1. What about D. multiradiatus? I suppose D. multiradiatus is also present in this interval (where you have diverse fasciculiths and no E. robusta) and the presence of D. multiradiatus is the datum based on which you are sure to be in NP9 and not in an older interval. Page 12, line 1: upper case for Base. Page 12, line 1: "These biostratigraphic data" suggest instead of "this composition suggests". Page 12, line 5: upper case for Base. Page 12, line 6: upper case for Base, add "within zone NP7/8" at the end of the sentence. Page 14, lines 12-14: Based on biostratigraphic data, I'd suggest that these lows in $\delta$13C document B1/B2 events. Because of the short stratigraphic range reported in literature for E. robusta (Raffi et al., 2005; Agnini et al., 2007) you might hypothesize that the core gap between core 14 and 13 is very limited. Page 15, line 8: "our nannofossil assemblage" should be substituted with "Our calcareous nannofossil biostratigraphic data" Page 15, line 9: add "and the presence of core gaps" Page 15, lines 11-15: This sentence is not clear to me. I would ask the author to re-write this sentence. Page 15, line 16: "have proved" to instead of "can" Page 19, line 24: "NP9" instead of "NP10" (see Table 2). This shift actually occurs within Zone NP9 as correctly reported in Table2. This should be corrected also in Figure 8, where NP9 is missing. Page 19, lines

27-29: The interpretation proposed by the authors is difficult to be proved. The K-X event (ca. 135 mcd at Site213, if the authors are right) usually occurs at the base of Zone NP12 (ca. 139 mcd at Site 213). These events are thus separated by four meters that likely represent a copious amount of time. Do you have any reliable estimation of sediment accumulation rates (SAR) in this interval ? I guess, It should be quite low since you are in a deep sea ocean setting with relatively low CaCO3 content. This could suggest low SAR, may be on the order of 0.5-1 cm/kyr. If this estimate is reliable then the four meter (separating the two events) document 400-800 kyr in term of time. This point is crucial and the authors should offer a more complete a substantiate explanation of their interpretation because at this point it is not very strongly supported by data. Page 20, lines 3-4: Not at Site 213, where the CaCO3 content remains very low throughout the interval (see Fig. 8). Page 20, lines 2-6: This sentence is quite weak because of previous comment on Site 213. Specifically it should be post-dated at Site 213, where your interpretation of the K-X event is questionable. In addition, you have no data available to support this interpretation at Site 215. Page 20, lines 6-7: see comment above and that (on the same issue) at page 19, lines 27-29. Page 23, line 13: delete “assemblage”, add “and” Page 24, line 13: delete “especially”

TABLES Table 1: -Add Fasciculithus decrease diversity or Top F. richardii group ( 55.53 Ma), see comment on page 11, lines 25-27. - Fasciculithus tympaniformis should be in italic Table 2-4. Nannofossil indicators should be substituted witH nannofossil taxa or something similar.

FIGURES AND FIGURE CAPTIONS Figure 1 caption: -“. . .such as for much of the early Eocene at Sites 1219 and 1221, as noted by Hancock et al., 2007).” I can not see any data from Site 1221 in Figure 1. -“Calcareous Nannofossil biozones are taken from Martini (1971), but adjusted to the current time scale”. This sentence is misleading and formally wrong and needs to be re-phrased. For instance you should say something like. . .... The biozonal scheme adopted is that of Martini (1971). Ages of calcareous nannofossil biohorizons are those proposed by Agnini et al. (2006, 2007) recalibrated



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using Option 1 of Westerhold et al. (2008). -Add something on how you put PCIM, PETM,H,I; EECO on this figure. Which data do you use? And Why do you decide not to put K-X event on this figure? - Add something on CCD reconstruction curve (in brown). This is not even mentioned in the caption. Explain how you built up this curve. Figure 2 caption: There are no green numbers in the figure 2. FIGURES 4-6 General comment: In Fig. 1 x-axis represents time with older ages positioned on the left. Figures 4-6 show an inversed x-axis and this makes confusion. I would suggest the authors to maintain consistency between figures. I personally prefer the general set up of Figure 1. Vertical dashed lines defining biozones: -I would prefer to have the numbers of biozones on the right of the figure on the y-axis. -Dashed lines are misleading because, based on your biostratigraphic data, you generally know that you are within a specific Zone but you are not able to determine the base and top of that Zone. I would suggest the authors to use solid lines when they have identified the precise position of the biohorizon defining the boundary of a Zone (see for instance Zones NP11 and NP12 at Site 213). I would also suggest to add horizontal grey bands to emphasize floating biostratigraphic data. For instance, in Fig. 4 the interval Ft-Zb lies within Zone NP9 and should be highlighted with a grey band but it does not define the base or the Top of Zone NP9 (no solid lines are thus necessary). Basically, what I suggest is to rotate all biostratigraphic data (numbers of Zones as well as solid lines and grey bands) by 90° (clock-wise). This would guarantee a better readability of these figures (4-6). FIGURES 8-10 -Solid lines at biozone boundaries should be used only when a precise position of the biohorizons used to define the Zone (base or Top) has been really identified. In all the other cases you should use dashed lines or, even better, “grey uncertainty bands” because you are approximating boundaries with alternative biohorizons (e.g., the base of Zone NP10 is approximate with B D. diastypus) or, even worst, data just above core gaps. -Early/Middle Eocene. Early and Middle are not formally described in more recent timescales (GTS04; GTS12). Do you refer to Berggren et al. (1995)? If this is the case you should mention it, at least in the figure captions of Figures 8-10. Alternatively, you can use Ypresian (stands for Early

Eocene in Berggren et al., 1995) and Lutetian (for the lower part of Middle Eocene as defined by Berggren et al., 1995). Figure 10 caption: -"The H events are in the core gap between cores 11-10. The NP10, NP11, and NP12 biozones and depleted 13C enabled the EECO identification in core 10. The K/X event is in the core gap between cores 10-9.". . .. This is wrong. Based on biostratigraphic data available H1/H2 events are always recorded in the lower part of Zone NP11. At Site 215, the entire Zone NP11 is found within core 10 and this implies that H1/H2 should be in core 10, likely in correspondence of the decrease in $\delta$13C observed between 88.77 and 88.29 mcd. If this is right, the base of the EECO should be moved upward at least within Zone NP12. High carbonate contents recorded in core 10 also support this hypothesis (see also Site 213 for comparison). Figure 11 caption: "Calcareous Nannofossil biozones are taken from Martini (1971), but adjusted to the current time scale". Again, this sentence is not correct, I would prefer the same sentence suggested for Figure 1 caption, that is "The biozonal scheme adopted is that of Martini (1971). Ages of calcareous nannofossil biohorizons are those proposed by Agnini et al. (2006, 2007) recalibrated using Option 1 of Westerhold et al. (2008)."

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Interactive comment on Clim. Past Discuss., 10, 3163, 2014.