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Interactive Comment

Interactive comment on "Constraints on ocean circulation at the Paleocene–Eocene Thermal Maximum from neodymium isotopes" *by* A. N. Abbott et al.

Anonymous Referee #1

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General comments In order to better constrain changes in thermohaline circulation across the PETM, this study provides 103 Nd isotopic compositions obtained from reductively leached decarbonated marine sediments. By combining new data with previously reported benthic foraminiferal δ13C and εNd values measured on fish teeth/debris as well as model simulations, the authors propose that a circulation changes in the Pacific Ocean was a trigger for carbon release. The large number of new Nd data has a potential to better understand the role of oceanic circulation during the PETM period. One of the essential contributions of this study is the application of leachate Nd isotopic ratios to reconstruct bottom water masses, which is not limited to the occurrence of fish teeth/debris. Consequently, the validation of the approach

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and usefulness of new data to constrain the ocean circulation are two major points. I, however, fond that these issues were not enough discussed in the present manuscript. Below I develop my suggestions and questions.

1. About faithfulness of leachate Nd isotopic compositions as a proxy of bottom water masses. The authors state that new εNd values of leachates generally agree with fish teeth values. I rather observe the offsets up to 1 ε-unit for sites 401, 527 and 690 in the early PETM (Figure 2). Indeed, comparison between leachates and fish teeth values is not always straightforward because of distinct temporal resolution. Furthermore, some recent studies pointed out the difficulty to extract bottom water εNd values using reductive leaching if samples contain volcanogenic material (Elmore et al., 2011). Possible bias caused by decarbonation (Molina-Kescher et al., 2014; Wilson et al., 2012) are also suggested. Did the authors optimize the leaching method for their samples taking into account these studies? This is a critical point in particular for Pacific samples because Martin et al. (2010) reported εNd comparison between fish teeth and leachate for site 690 in the South Atlantic but not for Pacific samples. More description about the leaching procedures is necessary including concentration and volume of leaching regents as well as leaching time. Also, "This may be. . .combination of the two" (P.2563, lines 20-23) is unclear and required to be further explained.

2. Insufficient explanation about the link between proposed circulation scenarios (Figure 3) and the new Nd data. The authors describe "a fundamentally different circulation system than present during the PETM (section 3.3)" but this statement is not clearly shown by new Nd isotopic data. Considering uncertainty of extracted seawater Nd isotopic signals (difference between fish teeth/debris and leachates), it is not obvious which changes are significant. The scenarios shown in Figure 3 are ambiguous and incomplete. I suggest that the authors add εNd values (and δ13C values) to each step in Figure 3 to clarify the link between the hypothesis and the data. Also, it would be useful to indicate already published data in Figure 3 to improve the spatial coverage even if the previous data do not totally cover the study time interval. Another issue

about the interpretation of εNd records is a lack of alternative hypothesis. For instance, the distinct εNd values in the Pacific (εNd of -6 to -3.7) and the Southern Ocean (εNd of -9.2) are interpreted as a sign of restricted water mass exchange between the two basins due to the shallow seas between Asia and Australia. Nevertheless, the present-day mean εNd values for the Southern Ocean, the equatorial Pacific and the North Pacific are -8.7, -3.9 and -3.8, respectively (Lacan et al., 2012). The difference of εNd values of about 5 ε-units between the Southern Ocean and the Pacific Ocean can be explained without any additional topographic barrier.

3. The role of a circulation change in the Pacific as a trigger of carbon release. This is an important hypothesis but not enough discussed in the present manuscript. Even if consistency exists with some previous studies, only site 1220 record shows the corresponding εNd variability and there is no discussion whether the observed variability is local/regional or basin-scale. I would suggest add a figure to discuss this point in more detail by comparing the site 1220 data with other reconstructed climate parameters.

Section 3 contains a number of statements that require more explanation (see my specific comments below). Since there exist already proxy reconstruction and modelling studies, synthesis of previous data and possible mechanism of inferred circulation changes would be appreciated.

Overall, it is necessary to clarify the original contribution of the new data. I believe that it will reinforce this work.

Minor or specific comments P. 2562, line 1, " Scher and Martin, 2006" would be deleted since the work uses fish teeth, not sediment leachates.

P. 2563, line 7, "Martin et al., 2012" would be deleted since the work uses fish teeth, not sediment leachates.

P. 2564, lines 3-4, "convection occurred in both the North and South Pacific". It is not clear which data support this statement, which time interval is concerned. εNd values of sites 1220 decreased just before and at the onset of PETM (Figure 2) but there is no data for site 1209 for the same time interval. The authors cite Thomas et al. (2014) for distinct overturning in the North and South Pacific but the paper discussed the Pacific trend for 70-30 Ma.

P. 2564, lines 9-11, “While. . . (Fig. 2)”. This sentence is unclear, in particular, “comparable changes”.

P. 2564, lines 4-5, about insignificant contribution of Tethyan deep-waters. More explanation is necessary for this point using the new data.

P. 2566, lines 8-9. Here the authors state that co-variation of εNd values from the three sites in the southern hemisphere (213, 527 and 690) was enhanced during the PETM (Figure 1a). I notice that the co-variation continued after the PETM and extended to 55Ma. The co-variation is not specific for the PETM.

P. 2566, lines 18-19, about “the contrast” between Southern Ocean and North Atlantic. The authors interpret that “the contrast” of εNd values as a sign of little water mass exchange between these basins. But the εNd values for the Southern Ocean is about -9.2 whereas the North Atlantic value is around -9.3 during the PETM. Consequently, the close values could be interpreted by the existence of water mass exchange.

P. 2566, lines 26-27, “a corresponding sensitivity. . . variable deep-water masses”. Please add more explanation.

P. 2567, line 7-9, about the difference of εNd values between the North and South Atlantic. Please indicate reference(s) showing the difference of 2 ε-units. According to Lacan et al. (2012), the mean values for the North and the South Atlantic are -11.5 and -10.5, respectively.

Figure 1. Add ticks of εNd and δ13C axis to all the three figures to improve the clarity.

Figure 2. It is confusing that age axis, symbols and the order of oceanic basins are different between Figures 1 and 2.

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Interactive comment on Clim. Past Discuss., 11, 2557, 2015.