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Climate of the Past Discussions

Interactive comment on "Mercury anomalies across the Palaeocene-Eocene Thermal Maximum" *by* Morgan T. Jones et al.

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We also thank the second reviewer for their detailed comments on the manuscript. As with the previous reviewer, we recognise that certain parts of the manuscript can be improved in terms of clarity and recognition of uncertainties when attributing Hg anomalies to volcanic activity. We have addressed all of the specific comments (marked by parentheses) below, and made small edits throughout the manuscript to improve the critical evaluation of this dataset.

[The extraordinarily high Hg concentrations in the Grane Field section are certainly worthy of attention, but difficult to interpret due to the potential effects of oil and gas seepage. Despite the possible effects of hydrocarbon migration, the authors conclude

that high Hg concentrations before/after the CIE are likely due to Hg release by hydrothermal vent complexes associated with the NAIP. They base this conclusion on two lines of reasoning: 1) sediments before/after the CIE have higher Hg concentrations (by orders of magnitude) than the oil sands lower in the section, and 2) there are no known processes that can decouple Hg and organic carbon in hydrocarbon systems. However, as far as I'm aware, there is very little research about Hg reservoirs in hydrocarbon systems or Hg loss/gain during hydrocarbon maturation/migration. Thus, it seems premature to discount the role of hydrocarbon systems in generating these unusual values.] We recognise that it is too early to be able to conclusively tie the Grane field Hg anomalies to volcanic activity due to the uncertainties associated with hydrocarbon migration, although given that decoupling of Hg and C usually occurs during volatilization, it is difficult to reconcile the lower Hg concentrations in the oil sands with the strata above. We have edited the text to draw the attention of the reader to these uncertainties and are more cautious in our interpretations. The sentences in section 5.1 now read: "We cannot discount the possibility that Hg and C could become decoupled during hydrocarbon migration, although how this might occur is not known as decoupling usually takes place during volatilization. It is our view that the most plausible hypothesis for these extreme Hg concentrations is a proximal Hg source that was very localized in depositional extent." We have also made small edits throughout the manuscript to address the reviewer's concerns.

[The evidence for dissolution/weathering during the body of the CIE at the Dababiya, Egypt locale makes interpretation of the Hg record difficult. It is not clear on what basis the authors suggest that it is "unlikely" that the Hg/TOC anomaly at Dababiya is purely a product of diagenetic and weathering processes. Since "the effects of such processes on Hg/TOC ratios are poorly understood," wouldn't it be prudent to reserve judgement?] We agree, and have altered the text accordingly. The text at the end of section 5.1 now reads: "It is conceivable that the Hg/TOC anomalies at Dababiya could purely be a product of diagenetic and weathering processes, given the amount of dissolution and acidification observed at this site (Figure 9; Keller et al., 2018; Khozyem et al., 2015).

However, the effects of such processes on Hg/TOC ratios are poorly understood."

[The authors may want to incorporate findings from a recent paper that investigated the Hg isotopic composition of PETM and Eocene sediments from Lomonosov Ridge in the Arctic (Gleason et al., 2017, Sources and cycling to mercury in the paleo Arctic Ocean from Hg stable isotope variations in Eocene and Quaternary sediments: Geochimica and Cosmochimica Acta 197:245-262.). In short, this paper found that sediment from the PETM had a Hg isotopic composition consistent with that of Holocene sediments from the Arctic Ocean. This supports the conclusion that there was no large perturbation to the Hg cycle at this locality during the PETM.] We thank the reviewer for bringing this paper to our attention. We have added a sentence to the first paragraph of the discussion, which reads: "A recent study on PETM sediments from the Lomonosov Ridge found that Hg isotopes across this interval were comparable to that of Holocene sediments (Gleason et al., 2017), supporting the conclusion that there was no large perturbation to the Hg cycle at this locality during the PETM in the available strata."

[Page 3, line 4: consider "temporal association" instead of "strong positive correlation"] As with the suggestion by reviewer 1, we have adapted the text based on the reviewer's recommendation. The sentence now reads: "There is a close temporal coincidence between the emplacement of LIPs and both rapid climate change events and mass extinctions in Earth history (Courtillot and Renne, 2003; Wignall, 2001), suggesting a possible causal connection."

[page 3, lines 13-14: Although there is a need for "a well-tested and uniquely volcanic tracer in sedimentary rocks" – Hg anomalies are not unique tracers of volcanism. Hg anomalies could theoretically be generated through many different processes that release Hg – wildfires, permafrost thawing, meteorite impacts, etc. This sentence seems to foreshadow the Hg/TOC ratios as a uniquely volcanic tracer – which gives the wrong impression.] To omit any foreshadowing, we have removed part of the text suggesting that this would be a uniquely volcanic tracer. The sentence now reads: "Therefore, a well-tested volcanic tracer in sedimentary rocks would be a powerful proxy for under-

standing the temporal relationship between large-scale volcanism and rapid climate change events.

[Page 3, line 19: Normalizing to TOC accounts for changes in Hg due to changes in the drawdown of organic carbon; it doesn't necessarily account for changes in sediment accumulation rate.] We have change the text accordingly. The sentence now reads: "Normalizing Hg to Hg/TOC helps to correct for variations in the drawdown of organic carbon, as organic compounds are generally the primary phases to complex Hg (Sanei et al., 2012)."

[Page 3, lines 20-21: - "proposed' instead of "reported"] We have change the text accordingly. The sentence now reads: "Such anomalies have been proposed as a tracer for volcanism for several major environmental perturbations and/or mass extinctions in the geological record."

[Page 3, lines 23-24: Rather than say "therefore, this method is an important proxy," consider, "therefore, we use this method as proxy" for volcanism. Given the potential for mercury anomalies to reflect processes/sources other than volcanism (as acknowledged in the paper and detailed above), I would be more careful with language here.] We have change the text accordingly. The sentence now reads: "Therefore, we use this method as a proxy to assess the relative importance of volcanism as a causal mechanism for the PETM, given the wealth of literature on the PETM and the availability of numerous sedimentary sections worldwide."

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