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Climate of the Past Discussions

Interactive comment on "Methane release from gas hydrate systems during the Paleocene-Eocene thermal maximum and other past hyperthermal events: setting appropriate parameters for discussion" *by* G. R. Dickens

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Dear Phil,

Thank you for the comments. I am not sure how to address them best. I'll give a stab.

1/ To my knowledge, during the early Paleogene, only 5 or 6 events might be designated as "hyperthermals" with available data; that is, through analyses at multiple sites, they show clear evidence for Earth surface warming, a pronounced negative carbon isotope excursion, and significant deep-sea carbonate dissolution. These are, in

chronological order, the PETM, ETM-1/H-1, H-2, I-1, I-2, and K/X. In fact, of these, only the first-three have been nicely documented (the I-1, I-2 events are the source of consternation as they are missing in some sections; the K/X event is known mostly through several abstracts). It is certainly possible that other events exist (as has been suggested by you and others, including us at last year's Fall AGU). However, I think that it is premature, with current data, to argue strongly there were numerous of these events, although this may indeed be correct. Absolutely, a primary goal for the community right now should be to define, characterize, number and date the hyperthermals. What qualifies as a "hyperthermal" event and how are they related? I probably should clarify this matter in the text.

2/ Clearly, different mechanisms can cause Earth surface warming and prominent negative carbon isotope excursions. Moreover, it is certainly possible that there were at least two intervals (PETM and ETM2) and perhaps more (6+) that were associated with massive carbon injections that are very difficult to explain, they happen to be unrelated to each other, and they happen to be unrelated to the surrounding prominent long-term changes in carbon and sulfur cycling. I do not find this a very satisfactory answer, but maybe this is how the world works. The secondary purpose of this manuscript, after pointing out that all current arguments against gas hydrate dissociation for the PETM are flawed, is to follow-up on previous work (Dickens, EPSL, 2003) as to how this can occur.

3/ As I tried to emphasize in the current manuscript, the idea of slow gas hydrate recharge lies in faulty logic. I suppose I should take much of the blame here, because I think this idea ultimately stems from my 2003 EPSL paper where to my knowledge this potential problem was first presented and discussed.

First of all, we do not know the rate of methane inputs and outputs to seafloor methane systems very well at present-day; I suspect they are faster than most of us have assumed. It is possible that they are around 0.5 x 10+e12 mol. While modest compared to river/weathering inputs, and carbonate and organic carbon outputs, this is fairly im-

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portant on long time-intervals. A good fraction of the reservoir can be recharged on the 100,000-500,000 yr time scale, if outputs drop considerably during cooling after a hyperthermal.

Equally important, the inputs and outputs depend entirely on ocean temperature and ocean chemistry. In a warm ocean with low dissolved sulfate and low dissolved oxygen, it is certainly plausible that the recharge would be much faster.

The recharge argument, while possibly correct, may not be as extreme as originally suggested.

4/ Clearly, I need to rephrase the issue about warming and carbon input given all commentary on this notion. The point is that there is ZERO evidence to suggest that ALL the carbon input (marked by the d13C excursion) caused ALL the warming during the PETM. Everything to date suggests, instead, that the carbon input as marked by the by the d13C excursion was a feedback to environmental change. This does not mean that it did not contribute to part of the total warming. Here it should be noted, though, that overwhelming evidence to support the feedback notion, while robust, remains lean. It would be great to confirm or deny this aspect, and precisely why I emphasized this as the first point of research pursuits.

5/ Will add references here.

6/ I agree absolutely . . . but thought that I made this point with section 7.4. I am totally open to the idea that other processes, such as an enormous and dynamic terrestrial carbon reservoir, led to the massive carbon additions. My primary point is that, at present, seafloor methane release remains an entirely plausible explanation, and we should be fully appreciative of problems behind any other suggestion.

Jerry

Interactive comment on Clim. Past Discuss., 7, 1139, 2011.