

## ***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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This is an important discussion paper, given the number of competing hypotheses for the cause of the PETM and other hyperthermals that have arisen in recent years. Many important points have already been raised by the other reviewers that have already posted comments, so I will only add a few points that don't seem to have been covered yet.

It is true that the 'more modest' hyperthermals are comparable in their character to

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the PETM. However, the use of phrases such as 'self-similar  $^{13}\text{C}$ -depleted carbon injections' gives the impression that the hyperthermals and the PETM share a common origin. This assumption of a common origin is prevalent throughout the manuscript and, regardless of whether it is true or not, it seems to be based on false evidence. For example, in section 3 it is stated that the size of hyperthermals shrinks over time. I have seen this assumption frequently made, but it is nearly always based on consideration of just 3 events – the PETM, ETM2 and H2 (spanning the interval from 56 to about 53.5 Ma). However, there are now about 19 events in total documented throughout the early Palaeogene (summarised in Sexton et al., 2011). If one considers all the hyperthermal events for which moderately high resolution  $\delta^{13}\text{C}$  data exist (e.g. Cramer et al., 2003; Lourens et al., 2005; Sexton et al., 2006; Edgar et al., 2007; Nicolo et al., 2007; Quillévéré et al., 2008; Stap et al., 2010; Zachos et al., 2010; Sexton et al., 2011), the typical magnitude of the  $\delta^{13}\text{C}$  anomalies is consistently 0.8 to 1.0 per mil (Sexton et al., 2011). It is hardly surprising that the assumption of diminishing size through time has arisen if only the PETM, ETM2 and H2 are considered – the PETM clearly dwarfs everything else, while ETM2 (immediately following the PETM), appears to be of the larger of the 'more modest' hyperthermals. However, this false assumption of diminishing size through time highlights the pitfalls of only considering a subset of the available data.

As for whether or not the hyperthermals and the PETM share a common origin, the more modest hyperthermals do indeed display characteristics similar to the PETM. But this, by itself, does not necessitate a common source of carbon fuelling them all. Specifically, the sheer number of these events being discovered calls into question the hypothesised role of a gas hydrate capacitor that, by necessity, can only recharge relatively slowly (on multi-Myr timescales) (e.g. Sexton et al., 2011).

Section 7, paragraph '1157':

“Many papers concerning the PETM begin with the premise that the massive carbon input associated with the CIE drove the warming (e.g., Higgins and Schrag, 2006; Pa-

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gani et al., 2006a; Archer, 2007; Handley et al., 2011). There is no evidence to support this notion. Indeed, all information to date suggests the opposite.” I presume this is referring to the fact that some warming is thought to have preceded the PETM? That may be so, but surely the vast majority of the warming that post-dates the onset of the CIE (i.e. the vast majority of the total warming seen during what people consider to be the ‘PETM’) could have been driven by the carbon input related to the CIE (as opposed to this post-CIE onset warming being driven by the same mechanism responsible for the pre-CIE warming)?

“Many papers have focused on the PETM as an isolated event (e.g., Kent et al., 2003; Svensen et al., 2004; Higgins and Schrag, 2006; Pagani et al., 2006a). Recent papers do not support this idea.” Which ones do not support this idea? Some citations needed here.

“Entertain the idea that release of CH<sub>4</sub> from the seafloor might be the correct explanation for the  $\delta^{13}\text{C}$  excursion across the PETM and other hyperthermal events of the early Paleogene (Dickens, 2003). This possibility is intriguing because it will demand some creativity to explain, to test, and to prove, and it would force the overturning of entrenched ideas.” I agree, but might add that the discovery of the ultimate mechanism driving hyperthermals will undoubtedly be intriguing almost regardless of whether it was methane or not, because our existing rudimentary knowledge of these events already shows that the exogenic carbon cycle must have operated in a quite exceptional manner.

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