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Geology 2009;37;e184-e185
doi:10.1130/G25070C.1

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Mechanisms of PETM global change constrained by a new record from central Utah: COMMENT and REPLY

COMMENT: doi: 10.1130/G25070C.1

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Bowen and Bowen (2008) proposed increased aridity at the Paleocene-Eocene boundary carbon-cycle perturbation, whereas my study (Retallack, 2005) found increased rainfall. Their interpretation of climatic drying during a past CO_2 spike is also at variance with predictions of increased precipitation with future CO_2 rise (Alley et al., 2007). The new paleoclimatic record of Bowen and Bowen is from a section less than 2 km from the paleosol record of my study, which reoccupied the steep paleomagnetic section of Talling et al. (1994) in Axhandle Canyon, near Wales, Utah (Fig. 1). Bowen and Bowen miscorrelated their section 100 m higher than shown in Figure 1, which shows their negative carbon isotope excursion characteristic of the Paleocene-Eocene boundary. Deep-calcic paleosols at the same stratigraphic level of siltstones between conglomerate and limestone (Fig. 1F) are evidence of increased mean annual precipitation (MAP) to as much as 779 ± 147 mm from a previous background level of 460 ± 147 mm (error is one standard deviation from transfer function of Retallack [2005]). The carbon isotopic excursion does not correlate directly with climatic seasonality inferred from the thickness of the paleosol with nodules (Fig. 1G), but this seasonality proxy does correlate with negative oxygen isotopic excursions flanking the main carbon isotopic anomaly of Bowen and Bowen. There are also problems with red mudstones (below 78 m in the section of Bowen and Bowen), which are lithologically similar to disconformable Late Cretaceous calcareous paleosols of the North Horn Formation in nearby Wales Canyon (Talling et al., 1994). The study of Bowen and Bowen reveals how miscorrelation of records yields misleading interpretations in paleoclimatic records with rapid short-term fluctuations in structurally complex regions.

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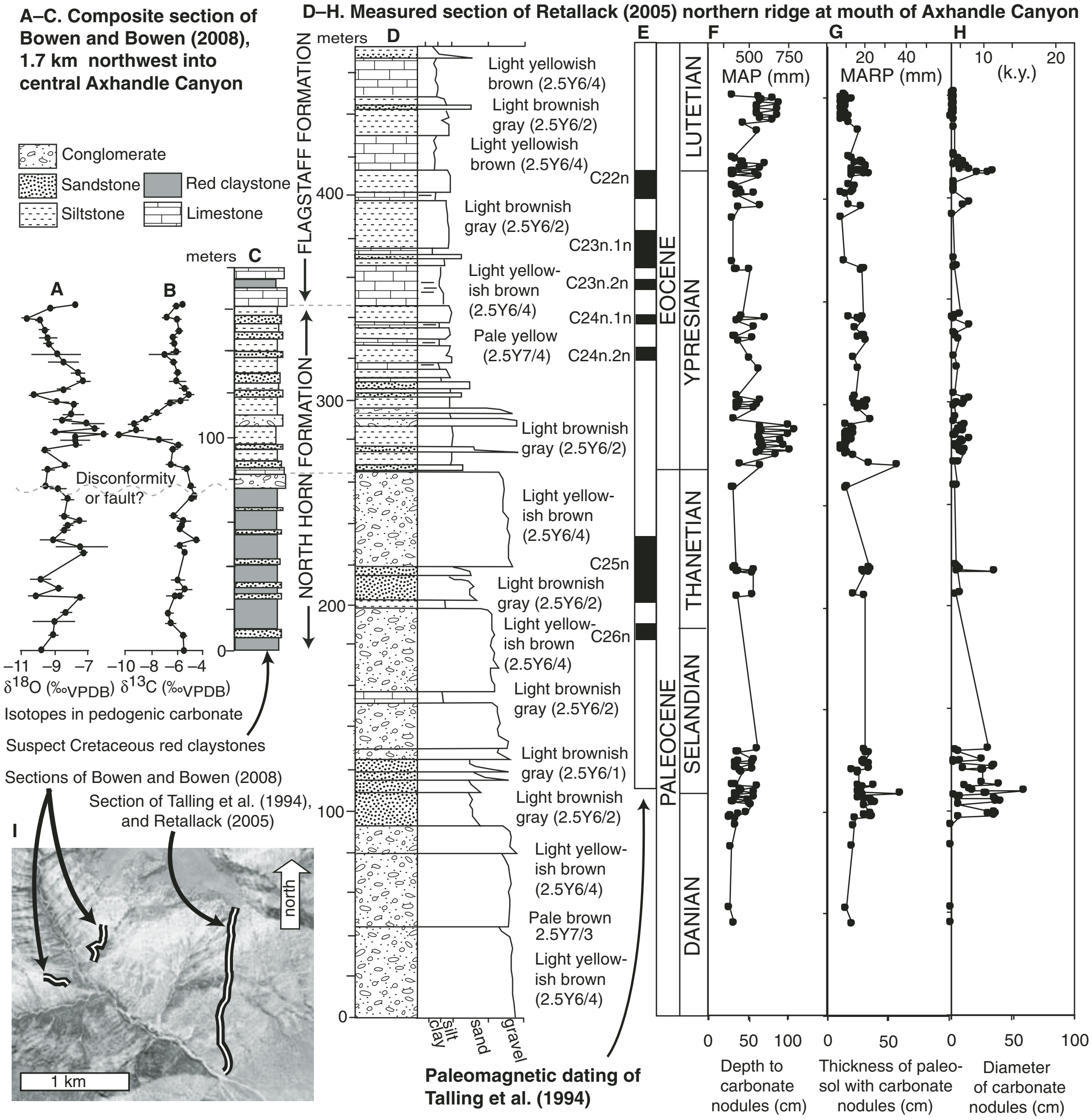

Figure 1. Late Eocene and early Paleocene paleoclimatic proxy records of mean annual precipitation (MAP, in mm), mean annual range of temperature (MARP, in mm) and time for soil formation (k.y.) in Axhandle Canyon, Utah, showing correlation of stable isotopic analyses in section of Bowen and Bowen (2008) (A–C) with paleosol data in paleomagnetic section of Talling et al. (1994) and Retallack (2005) (D–H). Only proxy paleosol values are plotted here: paleoclimatic curves with error envelopes and age model are published elsewhere (Retallack, 2005).

Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change: Cambridge, UK, Cambridge University Press, 996 p.

Bowen, G.J., and Bowen, B.B., 2008, Mechanisms of PETM global change constrained by a new record from central Utah: Geology, v. 36, p. 379–382, doi: 10.1130/G24597A.1

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REPLY: doi: 10.1130/G25173Y.1

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Retallack (2008) suggests that we miscorrelated our recent isotopic record for Axhandle Canyon to his earlier work (Retallack, 2005), and that this led us to a conclusion about climate change during the Paleocene-Eocene Thermal Maximum (PETM) that is at odds with expectation. We disagree with both points. In his Comment, Retallack (2008) misinterprets our published lithostratigraphy and revises the stratigraphy of his own previous work, without explanation, to accommodate his argument. His assertion that the distinctive "deep-calcic paleosols" (DCP) of his study formed during the PETM is based on a preconception of how this event should be expressed in his data, rather than robust lithostratigraphic correlation.

The lithostratigraphy of Retallack (2008) shows strong similarity, in terms of the distribution of coarse clastic units, to that reported for the upper half of our study section. Much of this similarity must be coincidental, however, since most of the sand bodies in our section are minor, laterally restricted sands that grade to fine-grained deposits over tens to hundreds of meters. Unfortunately, no lithostratigraphic data were given in Retallack's earlier work (2005), and our comparison to his work was based on the age model and paleosol data plotted therein (his Figs. 3 and 4). Our correlation of the two sections was pinned by the base of the Flagstaff Formation (FF), a transition from slope-forming, pedogenically modified clastic rocks to erosion-resistant lacustrine limestones and mudstones, which is clearly indicated in each paper (Bowen and Bowen, 2008; Retallack, 2005, 2008).

Table 1 gives the reported meter level of this lithostratigraphic boundary in each study, and shows that the stratigraphy reported in Retallack's Comment (2008) places the base of the FF ~50 m lower than in his original work. At the same time, the level of the DCP (which he assumes formed during the PETM) has been plotted ~23 m higher in the section than in the original work (the positions of the magnetochron boundaries have not changed). The net change is that the stratigraphic distance between the DCP and the base of the FF as reported in Retallack's Comment (2008) is some 73 m less than that shown in Retallack (2005). This adjustment, neither noted nor justified in Retallack (2008), brings the revised stratigraphy more in line with his interpretation that the DCP formed during the PETM, which occurs ~62 m below the base of the FF (Bowen and Bowen, 2008). Given the discrepancies in the various versions of Retallack's stratigraphy, and the lack of lithostratigraphic data in his primary publication, it is difficult to evaluate the strength of this newly proposed correlation.

TABLE 1: COMPARISON OF STRATIGRAPHIC LEVELS REPORTED FOR KEY STRATA IN AXHANDLE CANYON SECTIONS.

Datum	Bowen and Bowen, 2008	Retallack, 2005		Retallack, 2008
	Level (m)	Ma	Level (m)	Level (m)
Base FF	162	50.08[*]	395[†]	345
PETM CIE	100			
DCP		55.62[§]	242[*]	265
FF–Event[‡]	62		153	80

[*] Calculated using: age = –0.0362 x level + 64.38 (Retallack, 2005; his Fig. 3).
[†] Retallack (2005), Fig. 3.
[§] Retallack (2005), p. 335.
[‡] Stratigraphic distance from the PETM CIE or the DCP to the base of the FF.
FF—Flagstaff Formation; PETM—Paleocene-Eocene Thermal Maximum; CIE—Carbon isotope excursion; DCP—Deep-calcic paleosols.

Retallack (2008) also suggests that the bottom part of our section may represent the Cretaceous due to faulting or a major unconformity. Although there is little elaboration, the suggestion appears to be an attempt to reconcile his reading of the lowest 80 m of our section with his own. Part of the apparent problem results from his misrepresentation of the distribution of redbeds within our section (compare column C, Figure 1, of Retallack [2008] with Figure 2 of Bowen and Bowen [2008]), which are not concentrated in the "problematic" bottom half of our section as he suggests. Although we agree that the base of the congolomerate in our section is likely to be disconformable, it seems unlikely that the ~600 m of missing section required by Retallack's argument (Talling et al., 1994) can be accommodated between the two Axhandle Canyon sections situated ~2 km apart. The alternate possibility, equivalent to the correlation proposed in Bowen and Bowen (2008) and borne out by bed-tracing between the two sections in the summer of 2008, is that our section correlates above the distinctive coarse units exposed at the mouth of Axhandle Canyon.

We also disagree with Retallack's (2008) assertion that our "interpretation of climatic drying…is at variance with predictions of increased precipitation with future CO_2 rise." This generalization is incorrect. Although an increase in globally integrated precipitation rates is expected with global warming, every expectation is that future changes in precipitation and evaporation rates will be heterogeneous in space (Allen and Ingram, 2002; Held and Soden, 2006; Solomon et al., 2007). In fact, most models suggest that future climate in the vicinity of our study region will be more arid than present (Seager et al., 2007). To assess our climate hypothesis based on this mistaken generalization undersells the potential importance of paleoclimate research in understanding the spatially distributed response of the climate system to perturbation.

Our own interpretation of a drier PETM climate in central Utah was a hypotheses (and was framed as such in our paper) based on the limited data gathered from our own Axhandle Canyon sections. As acknowledged by us (Bowen and Bowen, 2008), additional work in central Utah will be important for clarifying the correlation and the interpretation of paleoclimate records spanning the Paleocene-Eocene boundary, and we look forward to the contributions this additional work will make toward refining our understanding of early Paleogene climate change.

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