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Interactive comment on "Mammal faunal response to the Paleogene hyperthermals ETM2 and H2" *by* A. E. Chew

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I wish to preface this with an apology that I was unable to finish and post this response sooner. The concerns raised by Gunnell were also initially raised by Clyde and addressed first in my response to his review. Clyde's review required extensive consideration and came at a busy time.

Gunnell presents two main criticisms of this project and three technical corrections. The first main criticism relates to the precision of the stratigraphic correlation that ties the FC fossil framework to the isotope records of the McCullough Peaks. Gunnell writes "Given the difficulty in precisely correlating one section (or series of sections) with the other, one has to wonder how these disparate records can provide the precision need to test whether or not these short-lived hyperthermal events can be correlated with the

proposed faunal changes documented in the central basin section. I find the arguments for correlating one to the other to be rather unconvincing." This criticism was also one of Clyde's main criticisms and was addressed extensively in my response to his review. I will recapitulate here: I agree in that I also believe it is impossible to precisely correlate the isotope and fossil sections given available information. It was a mistake to provide a discussion and "rough correlation" of common biostratigraphic and geomagnetic events in both areas, my misguided purpose for which was to demonstrate that the CIEs in the McCullough Peaks isotope records and the faunal events described herein occur in common, limited stretches of stratigraphic section (<140 m stratigraphic thickness compared with total section thicknesses >700-3000 m) that document a brief ($\sim$450 ka according to Abels et al., 2012) interval of the early Eocene in the Bighorn Basin. This is not in dispute and I believe the fundamental hypothesis of this paper remains valid but clearly needs to be restated in a way that avoids the misapprehension of it hinging on a precise correlation. To be perfectly clear, I have removed all discussion of, and reference to, the rough correlation I originally attempted to make as outlined in my response to Clyde. I have also explicitly restated my hypothesis along the lines of Clyde and colleagues' work in the McCullough Peaks (Abels et al., 2012) as follows: two faunal events described in the FC section are hypothesized to be related to the McCullough Peaks isotope excursions based on the proximity of the C24r-C24n.3n magnetic polarity reversal and the Wasatchian 4-Wasatchian 5 biozone boundary, and the pattern of faunal change within each event. Within this brief interval of Bighorn Basin time, there were two pronounced CIEs interpreted to represent significant climatic and environmental change AND two pronounced, rapid, and appropriately scaled (in terms of section thickness) events of significant faunal change. The hypothesis that they are related is more reasonable and parsimonious than the alternative, which is that the faunas were immune to the climatic and environmental change indicated by the isotope excursions, instead experiencing within this brief interval two other, unassociated episodes of significant change related to some as-yet unknown external perturbations or to intrinsic controls.

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Gunnell's second main criticism is twofold. Gunnell writes: "Beyond that the complex data manipulation, rarefying, and resampling involved in producing 'comparable' faunal sample bins makes one wonder what actual biological reality is being compared and contrasted." The concepts of species richness, evenness, turnover and body size change are widely employed in paleoecological analysis and are defined and described in detail in the Methods section 2.3 (and references therein). The 'manipulated' data are also plotted against non-standardized (i.e., non-manipulated) rates of species first and last appearances, turnover and range-through species richness in Fig. 4.

Gunnell continues: "This is especially true given that no central basin localities are precisely stratigraphically controlled enough to be able to eliminate or minimize time averaging in these surface collected samples. It may be a case of trying to look too closely at data that simply can't answer the questions being asked, at least at the resolution required to test the potential correlations between these two hyperthermal events and these two potential faunal turnovers, if that is, in fact, what they are." The precision of the stratigraphic framework of the FC fossil localities was also one of Clyde's main criticisms and was addressed extensively in my response to his review. I will recapitulate here: This study is based on the stratigraphic framework of Bown et al. (1994), which was conceived, designed and implemented at meter-level resolution, as described in their monograph in detail (1994: p. 9-15, emphasis mine): "In 1974, it was discovered that a suite of geographic localities in the Sand Creek-No Water Creek area of Willwood badlands (pl. 2) yielded abundant vertebrate fossils from a single, exceptionally continuous bed. . .Further collecting in that area in 1975 demonstrated that the vast majority of Willwood fossils there could be precisely related to the beds that produced them. . .Shortly thereafter, other exceptionally productive, stratigraphically explicit fossil occurrences were also discovered in Willwood rocks exposed in the drainages of Elk and Fifteenmile Creeks. . .Recent collecting operations in the Fifteenmile Creek drainage. . .were undertaken, following the 1974 season, with the specific goal of collecting large samples of Willwood vertebrates with tight stratigraphic controls tied to fossil provenances in paleosols. Field collecting began to be consciously restricted to

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specific stratigraphic intervals that could be related to fossil provenances, and these are almost invariably in paleosols...This technique has afforded greater stratigraphic resolution than was possible in the study of Schankler (1980) [in the Elk Creek], in his correlation of the strictly geographic YPM localities (nearest 1.0 m instead of 10.0 m), for which bed provenance was unknown and commonly could not be reconstructed." It is apparent that great care was undertaken in collecting efforts along the FC from 1975-1994 (and thereafter) to ensure tight stratigraphic control and that the authors believed they were able to achieve meter-level stratigraphic resolution. Given that one meter of section is approximately half the height of the average stratigrapher, this does not seem to be a particularly extraordinary or unreasonable achievement. The FC composite stratigraphic section is the culmination of 20 years of work by a skilled stratigrapher (Bown) and has been widely accepted and in general use for ~20 years. Gunnell also mentions time averaging, which is an issue here and in all surface lag deposits throughout the Bighorn Basin. It apparently did not interfere with the recovery of the ETM2 and H2 CIEs in the McCullough Peaks (Abels et al., 2012). I see no reason to believe that it is any worse in the FC or would preclude recovery of a related faunal signal in the FC.

Technical corrections:

Line 2, page 1374. Corrected spelling.

Line 16, page 1380. The Caron and Jackson reference is added to the reference list and provided here: Caron, J. B., and Jackson, D. A.: Paleoecology of the Greater Phyllopod Bed community, Burgess Shale: Palaeogeogr. Palaeocl., 258(3), 222-256, 2008.

Gunnell writes "I found most of the Figures to be adequate but difficult to decipher based on the minimal captions." I have expanded all figure captions.

References

Abels, H. A., Clyde, W. C., Gingerich, P. D., Hilgen, F. J., Fricke, H. C., Bowen, G.

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J., and Lourens, L. J., 2012, Terrestrial carbon isotope excursions and biotic change during Paleogene hyperthermals: Nature Geoscience, v. 5, no. 5, p. 326-329.

Bown, T. M., Rose, K. D., Simons, E. L., and Wing, S. L., 1994, Distribution and Stratigraphic Correlation of Upper Paleocene and Lower Eocene Fossil Mammal and Plant Localities of the Fort Union, Willwood, and Tatman Formations, Southern Bighorn Basin, Wyoming, Denver, USGS Professional Paper 1540, 103 + maps p.:

Schankler, D., 1980, Faunal zonation of the Willwood Formation in the central Bighorn Basin, Wyoming, in Gingerich, P. D., ed., Early Cenozoic paleontology and stratigraphy of the Bighorn Basin, Wyoming, Volume 24: Ann Arbor, University of Michigan Papers on Paleontology, p. 99-114.

Interactive comment on Clim. Past Discuss., 11, 1371, 2015.