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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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A. E. Chew has compiled and published exemplary documentation of successive early Eocene mammalian faunas in the central Bighorn Basin of Wyoming (U.S.A.). Here she analyzes collections from the Fifteenmile Creek area and identifies two richly-sampled intervals that are termed faunal events B-1 and B-2. Stratigraphic correlations are made between Fifteenmile Creek area and McCullough Peaks some 40 km away in the northern Bighorn Basin, where the carbon isotope excursions related to the ETM2 and H2 hyperthermal event have been documented. The high diversity and turnover in the B-1 and B-2 faunal events are subsequently attributed to ETM2 and H2 climate change. We strongly question, first, the correlations between these distant areas, and,

second, the interpretation of B-1 and B-2 as true faunal events.

Faunal evolution is often influenced by environmental change, with a case in point being the appearance and possible origin of modern orders of mammals during onset of the global Paleocene-Eocene Thermal Maximum (PETM; Gingerich, 2003, 2006). 'Biohorizon B' is the name for a subsequent early Eocene faunal turnover of mammals in the Bighorn Basin (Schankler, 1980; Chew, 2009). ETM2, related to the deep-marine clay layer labeled 'Elmo', is a global early Eocene hyperthermal event recognized by its light δ13C isotopic anomaly (Cramer et al., 2003; Lourens et al., 2005). In an earlier study, Biohorizon B and ETM2 were thought to be approximately the same age (Clyde et al., 2007), leading Chew to postulate that "the timing, characteristics, and magnitude of turnover at Biohorizon B support the possibility of the Elmo [ETM2] global warming event as a potential driver" (Chew, 2009, p. 28). This was reasonable as a possibility, but when Biohorizon B and isotopic ETM2 were identified in one and the same stratigraphic section, at McCullough Peaks in the northern Bighorn Basin, the Biohorizon B faunal turnover was found to be 60 m lower stratigraphically than the ETM2 δ13C anomaly (Abels et al., 2012): ETM2 could not be a driver of Biohorizon B faunal turnover because ETM2 warming occurred some 150–200 kyr too lateâĂŤ long after the turnover had already happened.

In this new study, Chew (2015) identifies B-1 and B-2 as events ancillary to Biohorizon B. These are stratigraphically above Biohorizon B proper, and below the 24R–24N magnetochron boundary at Fifteenmile Creek. The positions of Biohorizon B and the C24r-C24n.3n magnetochron boundary are used to transfer the CIEs related to ETM2 and H2 in the McCullough Peaks area into the Fifteenmile Creek mammal stratigraphy. For these correlations, the position of the first normal polarity related to C24n.3n at McCullough Peaks is used, which is however preceded by an interval of nearly 60 m of uncertain polarity at McCullough Peaks. For the correlation, the magnetochron boundary should thus be positioned in the middle of this uncertain polarity interval with ~30 m of uncertainty above and below, which in the Willwood Formation of the northern Bighorn basin represents roughly ∼91 kyr (30 m / 0.329 m / kyr). In view of this large uncertainty, correlation between McCullough Peaks and Fifteenmile Creek in order to position ETM2 and H2 in the Fifteenmile Creek mammal stratigraphy seems impossible at the scale required to relate the B1 and B2 events to the hyperthermals. In the correlations made by Chew, ETM2 and H2 are placed between 410–420 m and between 430–440 m, respectively. This results in sedimentation rates of 0.165 m/kyr at Fifteenmile Creek. A scaling factor of 0.68 implies a McCullough Peaks sediment accumulation rate 47% higher (1/0.68 = 1.47) than that at Fifteenmile Creek. The accumulation rate at McCullough Peaks would then be 0.243 m/kyr. However, the mean accumulation rate for McCullough Peaks, based on all information available previously, is 0.329 m/kyr (Abels et al. 2013, Table 1). The accumulation rate calculated from precession forcing of observed 7.1 m sedimentary cycles, for which there is increasing evidence, works out to be even higher at 0.355 m/kyr (Abels et al. 2012; 2013; 2015).

Placement of ETM2 and H2 in the 410–420 m and 430–440 m intervals at Fifteenmile Creek implies an ETM2–H2 separation of about 20 meters. A sediment accumulation rate of 0.165m/kyr yields about 121 kyr for this separation. The B-1 and B-2 events are however tied to diversity peaks at about 410 and 440 m, respectively, meaning that they are separated by about about 30 m and 181 kyr. Both separations at Fifteenmile Creek are substantially longer than the 100-kyr eccentricity-cycle spacing of the ETM2 and H2 hyperthermals (Cramer et al. 2003; Stap et al. 2009). These inconsistencies again demonstrate the substantial uncertainty in the McCullough Peaks to Fifteenmile Creek correlations, and so also in the interpolation of ETM2 and H2 within the relevant interval at Fifteenmile Creek. Finally, we question the identification of B-1 and B-2 as faunal events. These are the two narrow stratigraphic intervals that have yielded some 15–20 times more specimens than others in the broader Fifteenmile Creek interval being correlated to McCullough Peaks. A discrepancy in sampling this large is difficult to overcome statistically because standardized comparison requires degrading the better samples for comparison with the poorer ones, and the poorer samples in this case are biased in lacking many of the smaller and rarer taxa that only appear when samples

are large. The intervals identified as B-1 and B-2 are exceptionally fossiliferous, have been more intensely sampled than other intervals, or both (collectors naturally focus on productive intervals). B-1 and B-2 stand out for being rich and well sampled, but this does not make them biotic events. And the presence of two rich, well-sampled intervals at Fifteenmile Creek does not mean the intervals coincide with ETM2 and H2. Independent evidence of ETM2 and H2 isotope excursions at Fifteenmile Creek will be required to document this.

The new postulates, that ETM2 was the driver of B-1 and that H2 was the driver of B-2, are testable hypotheses, but the postulates will only be tested when ETM2 and H2 δ13C anomalies are found in the same stratigraphic section as B-1 and B-2. Pending documentation of the ETM2 and H2 δ13C anomalies at Fifteenmile Creek, it seems too premature to claim B-1 and B-2 as faunal responses to the hyperthermals ETM2 and H2

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