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Comment on cp-2021-83

Gabriel Bowen (Referee)

Referee comment on "Terrestrial carbon isotope stratigraphy and mammal turnover during post-PETM hyperthermals in the Bighorn Basin, Wyoming, USA" by Sarah J. Widlansky et al., Clim. Past Discuss., <https://doi.org/10.5194/cp-2021-83-RC2>, 2021

This manuscript reports new pedogenic carbonate isotope data from the Bighorn Basin in an attempt to link central/southern basin fossil localities to a global timescale and sequence of Eocene climate events. The substantial new dataset and goal of exploring within-basin variability in environmental proxy data and faunal change are strong aspects of this contribution. The manuscript also highlights challenging limitations to the correlation of local sections within their study area, which frankly leave some ambiguity with respect to the stratigraphic interpretations presented by the authors. I do think that the work has inherent value despite the uncertainties that remain, but given that the primary contributions of the manuscript derive from and rest on the correlations, I request that the authors try to further justify some of their reasoning and interpretations.

My biggest concern relates to the identification and interpretation of CIEs in the new records. In section 4.2 the authors identify a series of CIEs in their local study sections and implicitly propose and interpretation of those (that they are stratigraphically coherent and can be correlated between sections, and are therefore likely to be reflective of large-scale or global forcing). I think that both parts of this presentation need stronger support and justification.

First, the authors need to more clearly describe what criteria they identify excursions in their records. Like many continental records, the ones presented here are noisy, and their features are not always obvious. Some of the excursions are pretty obvious (e.g., the one in the "Basal" local section). Others less so (e.g., why is the feature at ~440 BCM in the Basin Draw section a CIE and the one at ~400 BCM not?). I understand that it may be challenging or impossible to offer a fully objective and quantitative set of metrics used to guide these interpretations, but I'd like to see the authors try to get as close as possible to this, and then elaborate and justify other information used to (more subjectively) guide their interpretation. Since the identification of the CIEs is the major contribution of the paper, this deserves more attention.

Second, the correlation of different CIEs between sections is implied in section 4.2, and then revisited in the discussion sections. The initial presentation implicitly accepts that the BCM levels are an accurate basis for correlation between sections (the identification of the CIEs and association between them is introduced in terms of their being associated with certain BCM intervals). This is then revisited and questioned, and a second basis for correlation (GPS elevations) introduced and discussed. Arguments are made for preferring the GPS data in some cases (e.g., correlation from the N to S sides of the wash). Given that bed tracing is difficult in the area, and that GPS does not account for structural and depositional surface features, we're left with a pretty inconclusive case. I'm left wondering why two other potentially-useful sources of information, namely patterns in the CIE records and fossil evidence, aren't used in the correlation exercise. For example, both the up-section trend and the relative amplitude of the excursions (IMO) strongly support the correlation of the two CIEs at Kraus Flats with the lower two features in the North Fork section (and would imply slight deviations from both the BCM and GPS-based correlations). Conversely, I continue to struggle with the proposed correlation between Basin Draw and Basal sections given the strong isotopic 'structure' exhibited in the lower part of Basin Draw (and not at Basal). The authors have discussed local effects on soil carbonate $\delta^{13}C$ at length, and it's possible that's what we're seeing here, but I'm not so sure. In addition, the authors are drawn to work in this area because of the extensive history of fossil collecting, and there are several well-described faunal turnover events documented in their study sections. The text implies that there may be some noise or ambiguity in the pattern of turnover that might in part reflect incorrect correlation between sections (that could be resolved here)...why isn't this information tapped and discussed/leveraged as part of building the correlation model here? Finally, what about lithostratigraphy? Are there any coherent patterns that might support the correlation model?

In summary, I think that this will be a nice contribution to our understanding of the stratigraphy of the BHB and advance our ability to link environmental and biotic events in the basin to global changes. I think some revision focused on shoring up interpretation of the new carbon isotope stratigraphy is need to accomplish that. As a final thought, I'm not sure that the discussion of the local controls on soil carbonate C isotope values adds much (it is important background, but doesn't really support any clear or important conclusions from this work)...this could be cut substantially, IMHO, and some of the space allocated toward shoring up the stratigraphic interpretations.

Minor points:

Abstract: here 15 Mile Creek is described as being in the 'central Bighorn Basin', whereas throughout the introduction it is stated to be in the 'southern Bighorn Basin'

Section 3.2: Were the nodules collected from/tied to individual paleosol B horizons? Was any attempt made to constrain depth below the paleo-soil surface?

L233: Cite these packages if you're going to mention them here

L331-333: This makes it unclear why you prefer to associate the Basin Draw CIE with the lowest of the three events (as shown in Fig 4).

L409-421: These arguments are reasonable but not particularly strong...for example one could argue that the $\delta^{13}\text{C}$ values around the $\sim 30\text{m}$ level in the Basin Draw local section represent the H1 CIE. What does the fossil evidence say? Is there anything there that provides evidence for the alignment of this section wrt the faunal events?

Paragraph starting on L422: Is there value in doing this work without recollecting the fossils with higher stratigraphic resolution? High-resolution isotope data combined with ambiguous fossil locality extents is still likely to yield confusion.

L476-479: This explanation isn't quite right...atmospheric CO_2 isn't 'penetrating deeper into the soil', it's always there at all depths. It's just that it constitutes a larger fraction of the total CO_2 in this situation. (Correct this in the subsequent paragraph, too.)