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Technical Session 3: Terrestrial Ecosystems – Early Cretaceous (Saturday, June 10, 2023, 9:45 AM)

PALEOBIODIVERSITY OF THE MUSSENTUCHIT MEMBER, CEDAR MOUNTAIN FORMATION (UTAH): NEW DISCOVERIES ENHANCE AND CONTEXTUALIZE AN EXCEPTIONAL WINDOW INTO MID-CRETACEOUS TERRESTRIAL ECOSYSTEMS

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The Cedar Mountain Formation (CMF) of Utah is an exceptional fossil archive, entombing terrestrial biodiversity data for western North America (NA) throughout ~45 million years of Earth's history. Documentation of paleobiodiversity patterns in the CMF stems from intensive, multi-institutional, collection efforts spanning decades. From these collective labors came early recognition that the gross composition of CMF vertebrate communities was shaped, in part, by changing paleobiogeographic influences. Specifically, the CMF is hypothesized to preserve a shift from pre-Albian communities with European ties, to assemblages resembling coeval Asian faunas in its uppermost members, although the initiation and duration of this turnover are unresolved. Perhaps more germane, the uppermost CMF records climate and environmental changes leading up to a global

temperature spike dubbed the Cretaceous Thermal Maximum (CTM) that mimic (albeit at a profoundly different rate) some aspects of our current climate crisis. The CTM, together with ongoing foreland basin evolution (Phillips et al., 2021), are linked to corollary effects across the Western Interior (WI) such as eurybatic changes (Haq, 2014), increasing humidity and precipitation rates (Suarez et al., 2012), and the eventual commandeering of landscapes by angiosperms (Davis et al., 2005); all of which are suspected of having shaped regional patterns of vertebrate extinction and evolution.

Ultimately, we should expect that the drivers of faunal transformations within the CMF were multifarious, and perhaps in some instances, inextricable. Nonetheless, parsing broadly between the impacts of Laurasian paleobiogeographic exchange (EKLInE) and habitat evolution on Aptian-Cenomanian assemblages in western NA is a tractable and relevant problem. Addressing it requires granular and coupled paleobiodiversity, paleoclimatic, and spatiotemporal data across multiple scales, and relies on broad collaborative efforts. Here we present updated assemblage data for the uppermost CMF strata—the Cenomanian age Mussentuchit Member (MM)—based on our efforts over the past 15 years. Historical paleobiodiversity data for the MM was compiled almost exclusively from abundant microvertebrate

bonebeds, producing an extraordinary record of >100 taxa and one of the most diverse Cenomanian terrestrial assemblages documented worldwide (Cifelli et al., 1997, 1999; Kirkland et al., 2016). With few exceptions, macrofaunal (dinosaur) taxonomy was initially assessed via isolated teeth, useful at coarse taxonomic scales. Among theropods, these records included tyrannosaurids (cf. *Alectrosaurus* sp.); dromaeosaurines, velociraptorines, troodontids, and avialans; therizinosaurs; a large-bodied indet. theropod; and the tooth morphotypes cf. *Paranonychodon* and cf. *Richardoestia*. Ornithischian assemblages were noted to contain “hypsilophodontids” (cf. *Zephyrosaurus* sp.), pachycephalosaurids, neoceratopsians, nodosaurids (cf. *Pawpawsaurus* sp.), hadrosaurids, and iguanodontians (cf. *Tenontosaurus* sp.), as well as rare records of diminutive, sauropod teeth (titanosaurimorphs, cf. *Astrodon* sp.). The collection of select macrovertebrate remains by prior teams produced key taxonomic resolutions early on, including updating “hadrosaurid indet.” to the hadrosauromorph *Eolambia caroljonesa* (Kirkland et al. 1998) and nodosaurid indet. to *Animantarx ramaljonesi* (Carpenter et al., 1999). However, much of the macrofauna remained tenuously identified and/or coarsely resolved.

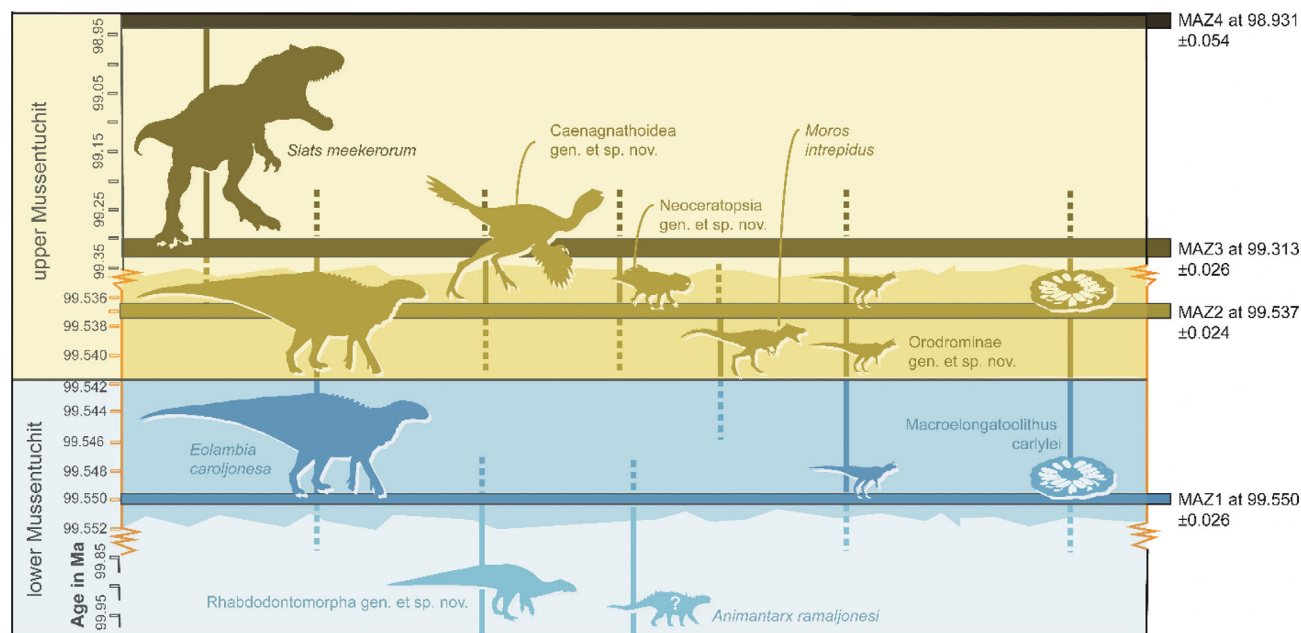


Figure 1. Known chronostratigraphic distributions of named dinosaurian taxa, definitive new species in review or prep, and outgroups from the Mussentuchit Member of the Cedar Mountain Formation, Utah. Based on our direct stratigraphic assessments, we agree with recent publications stating that ankylosaurs from PR-2 and equivalent quarries (*Peloroplites* and *Cedarpelta*, Carpenter et al., 2008) derive from the underlying Ruby Ranch Mbr. Solid bars represent known distributions between established boundaries (MAZs [Mussentuchit Ash Zones 1–4, *sensu* Tucker et al., in press] and the upper and lower submember boundary). Taxon silhouettes are placed on the lowermost boundary strata; their position does not reflect meters above or below those boundaries; they are not to scale. Orange ticks represent a change in temporal scale along the y-axis. Taxon silhouettes by Jorge Gonzales (*Siats*, *Moros*), Zachary Lukas (*Eolambia*, *Orodrominae*, *Rhabdodontomorpha*), Myra Doughty (nest). The remainder are derived from phylopic.org under license Public Domain Dedication 1.0.

Since then, our teams have made significant advances in MM biodiversity and spatiotemporal data, and have begun the long process of testing for intramember assemblages. We have reclassified the “indet. large-bodied theopod” as the enigmatic allosauroid/megaraptoran *Siats meekerorum* (Zanno & Makovicky, 2013) and reidentified the tyrannosaurid cf. *Alectrosaurus* as the tyrannosaurid *Moros intrepidus* (documenting cohabitation of these clades into the early Late Cretaceous; Zanno et al., 2019), and discovered a new record, a species of toothless caenagnathoid representing the largest of its kind in NA. The latter two taxa are also key for temporally constraining Laurasian interchange, as their closest relatives inhabited Asian landmasses. Additionally, we can now reclassify the “hypsilophodontid” to a new species of orodromine (sister-taxon to *Oryctodromeus*), and the “iguanodontian” or cf. *Tenontosaurus*, as a North American rhabdodontomorph, extending the record of the latter clade (and that of early-diverging ornithopods generally) into the Late Cretaceous. Moreover, we can definitively confirm the presence of an early-diverging neoceratopsian based on ongoing excavations of a partial skeleton, representing an elusive record and one of the oldest ceratopsians from the continent. Other key discoveries include a new species of lungfish (*Ceratodus molossus*, Frederickson & Cifelli, 2019), the earliest record of NA adocid remains (Avrahami et al., 2018), well-preserved helochelydrid turtles, mesoeucrocodylians, and the only clutches (>2 eggs) of elongatoolithid eggs from NA. Our taxonomic work is coupled with ongoing chronostratigraphic, facies, and paleoclimate reassessments. We have identified four, regionally continuous bedded dacitic ashes, temporally constraining the MM fossil assemblage to ~600 kyrs, with resolution between markers (and fossil localities) as high as ~13 kyrs—the tightest yet produced for Late Cretaceous strata of the WI (Tucker et al., in press). Altered base levels permit us to informally divide the MM into lower/upper submembers. The emplacement of historic localities in our new stratigraphic framework alters the temporal sequence of existing MM climate proxies (Suarez et al., 2012), yet does not contradict a trend of > relative humidity (~60% ± 10%), precipitation rates (616 ± 160 mm/yr), and mean annual temperatures of freshwater of 20 ± 2.5°C within the uppermost CMF (Hatzell, 2015; Suarez et al., 2011).

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