

New additions to the Lancian mammalian fauna from southwest North Dakota

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ABSTRACT

Gaining a detailed understanding of the geographic and temporal variations between Lancian mammalian faunas within the Western Interior Basin requires specimens to be associated with precise stratigraphic data, but only a few mammal-producing localities are documented in such detail from The Hell Creek Formation of southwestern North Dakota. Recent work at two sites in southwestern North Dakota resulted in the discovery of additional mammal specimens from previously documented localities for which the stratigraphic position is precisely recorded. The most productive site is situated 12.02 meters below the K/Pg boundary and produced 18 mammal specimens that are referable to at least six species, two of which (the multituberculate *Essonodon browni* and the marsupial *Glasbius twitchelli*) are first occurrences for North Dakota. Another important specimen (NDGS 1719) was collected as float approximately one meter below a documented vertebrate locality that is positioned 2.72 meters below the K/Pg boundary. NDGS 1719 is also referable to *G. twitchelli* and consists of a right dentary preserving p2–m4, making it the most complete dentary yet referred to that species. NDGS 1719 is stratigraphically the highest mammal specimen referred to a specific taxon yet reported from North Dakota and its completeness facilitates a detailed description of the dentary dentition of *G. twitchelli*. These discoveries expand our knowledge of the Lancian fauna from southwestern North Dakota, aid comparisons to other well-sampled faunas from the Western Interior Basin, and demonstrate that further work is needed to ensure our understanding of the Lancian fauna from North Dakota is comprehensive.

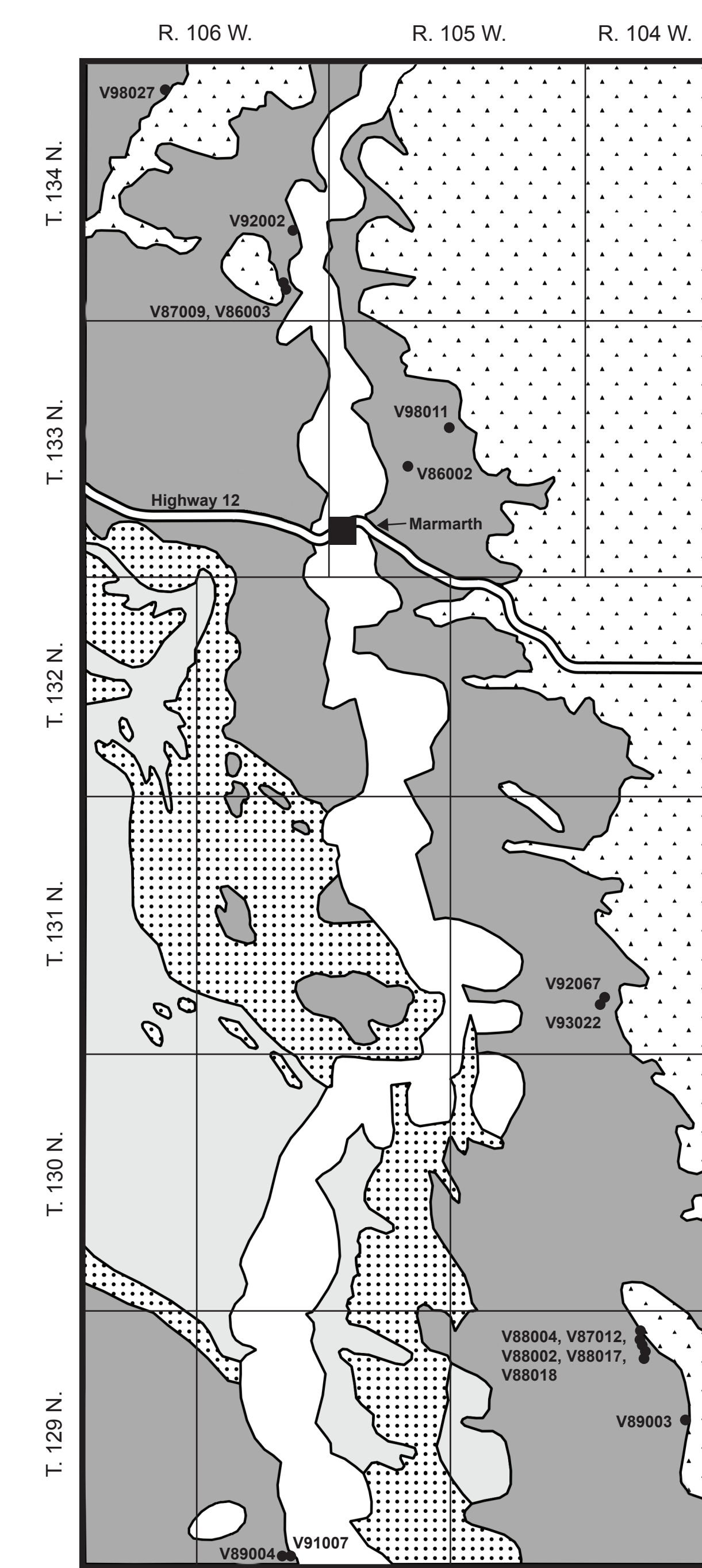


Table 1. Mammalian fauna of the Hell Creek Formation, southwestern North Dakota.

Multituberculata

- Essonodon browni* Simpson 1927
- Mesodma thompsoni* Clemens 1964
- Mesodma* sp. cf. *M. thompsoni* Clemens 1964
- Cimolodon nitidus* Marsh 1889
- Cimolodon* sp.
- Meniscoessus robustus* (Marsh 1889)
- Meniscoessus* sp.
- ?*Meniscoessus* sp.

Metatheria

- Alphadon marshi* Simpson 1927
- Alphadon* sp.
- Didelphodon vorax* Marsh 1889
- Didelphodon* sp.
- ?*Didelphodon* sp.
- Protolambda florencae* (Clemens 1966)
- Protolambda* sp. cf. *P. florencae* (Clemens 1966)
- Glasbius twitchelli* Archibald 1982

Eutheria

- Altacreodus magnus* (Clemens and Russell 1965)
- Gypsonictops illuminatus* Lillegraven 1969
- Gypsonictops* sp.

Modified from Hunter and Archibald (2002: table 2). Updated taxonomy based on Davis (2007) and Fox (2015).

FIGURE 1. (Left) Geologic map of southwest North Dakota showing the geographic positions of paleontological localities within the Hell Creek Formation where fossils of mammals were recovered. Modified from Hunter and Archibald (2002:fig. 1) with geology based on a digitized version of the map produced by Clayton (1980).

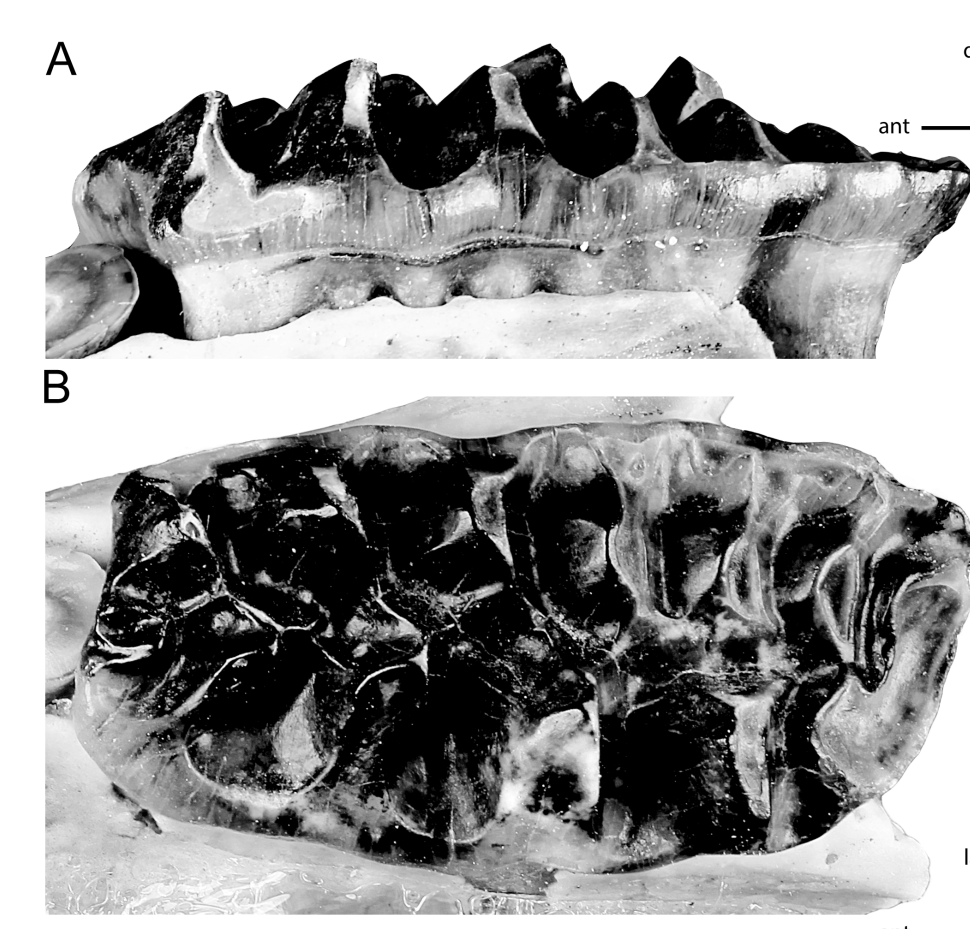


FIGURE 2. (Right) Photographs of partial right dentary with m1 (NDGS 1792) referred to *Essonodon browni*. A, photograph in labial view (image reversed); B, photograph in occlusal view. Abbreviations: ant, anterior; dor, dorsal; lab, labial. Scale bar equals 5 mm.

INTRODUCTION

The Late Cretaceous Hell Creek Formation of western North America records an important interval of time during which early mammals were diversifying and dispersing across the continent just prior to the Cretaceous-Paleogene (K/Pg) extinction event. The Late Cretaceous mammalian fauna of western North America is best documented in Montana and Wyoming where large numbers of specimens were meticulously collected with detailed geographic (Clemens, 1963, 1966, 1973; Archibald, 1982; Lofgren, 1995) and stratigraphic data (Wilson, 2005, 2014). In contrast, these patterns in adjacent North Dakota remain less well-resolved. The most detailed studies of the mammalian fauna from the Late Cretaceous of North Dakota were done using specimens collected over the past few decades in southwestern North Dakota (Bowman and Slope counties) by the Pioneer Trails Regional Museum in Bowman, ND (Hunter and Pearson, 1996; Pearson et al., 2002; Hunter and Archibald, 2002). Those specimens were tied into a detailed stratigraphic framework, with the vertical distance between each locality and the contact between the Hell Creek Formation and the overlying Ludlow Formation precisely recorded (Pearson et al., 2002). The distance between each locality and the K/Pg boundary, which is not always coincident with the formation contact in that area, was also calculated using the palynology data reported by Nichols and Johnson (2002). Those studies laid the groundwork for future work on the diversity and stratigraphic distribution of mammals from the Hell Creek Formation of North Dakota.

Only a handful of mammal specimens collected from the Hell Creek Formation of North Dakota by the North Dakota Geological Survey (NDGS) are published (Hoganson et al., 1994; Murphy et al., 1995). Though those reports focused on collections from southcentral North Dakota, the NDGS also works extensively in the Hell Creek Formation of southwestern North Dakota. This study expands upon the work of Hunter and Archibald (2002), detailing new additions to the mammalian fauna of southwestern North Dakota collected from stratigraphically constrained localities within the upper portion of the Hell Creek Formation (Fig. 1). This study adds to the growing body of work on North Dakota's Late Cretaceous mammalian fauna, enabling more accurate comparisons with other contemporaneous faunas across North America.

FIGURE 3. (Right) Illustrations and photographs of specimens from North Dakota referred to *Glasbius twitchelli*. A, illustration of the dentition (p2–m4) of NDGS 1719 in labial view; B, photograph of NDGS 1719 (right dentary with p2–m4) in labial view (view is oriented slightly more ventral than in A); C, illustration of the dentition (p2–m4) of NDGS 1719 in occlusal view; D, photograph of NDGS 1719 (right dentary with p2–m4) in occlusal view; E, illustration of the dentition (p2–m4) of NDGS 1719 in lingual view; F, photograph of NDGS 1719 (right dentary with p2–m4) in lingual view; G, photograph of NDGS 1720 (left m2) in occlusal view; H, photograph of NDGS 1721 (left m2) in occlusal view; I, photograph of NDGS 1722 (left m3) in occlusal view; J, photograph of NDGS 1723 (right m3) in occlusal view; K, photograph of NDGS 1724 (right m3) in occlusal view. In B, D, G, H, I, J, and K specimens were coated with magnesium oxide prior to photographing (see methods section). Abbreviations: ant, anterior; lab, labial; pit, possible feeding trace; post, posterior; vent, ventral. In A–F scale bar (positioned at top) equals 5 mm. In G–K scale bar (positioned lower right) equals 1 mm.

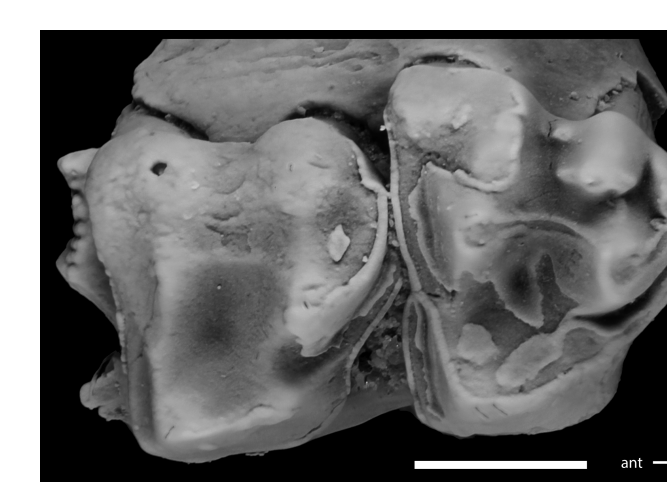
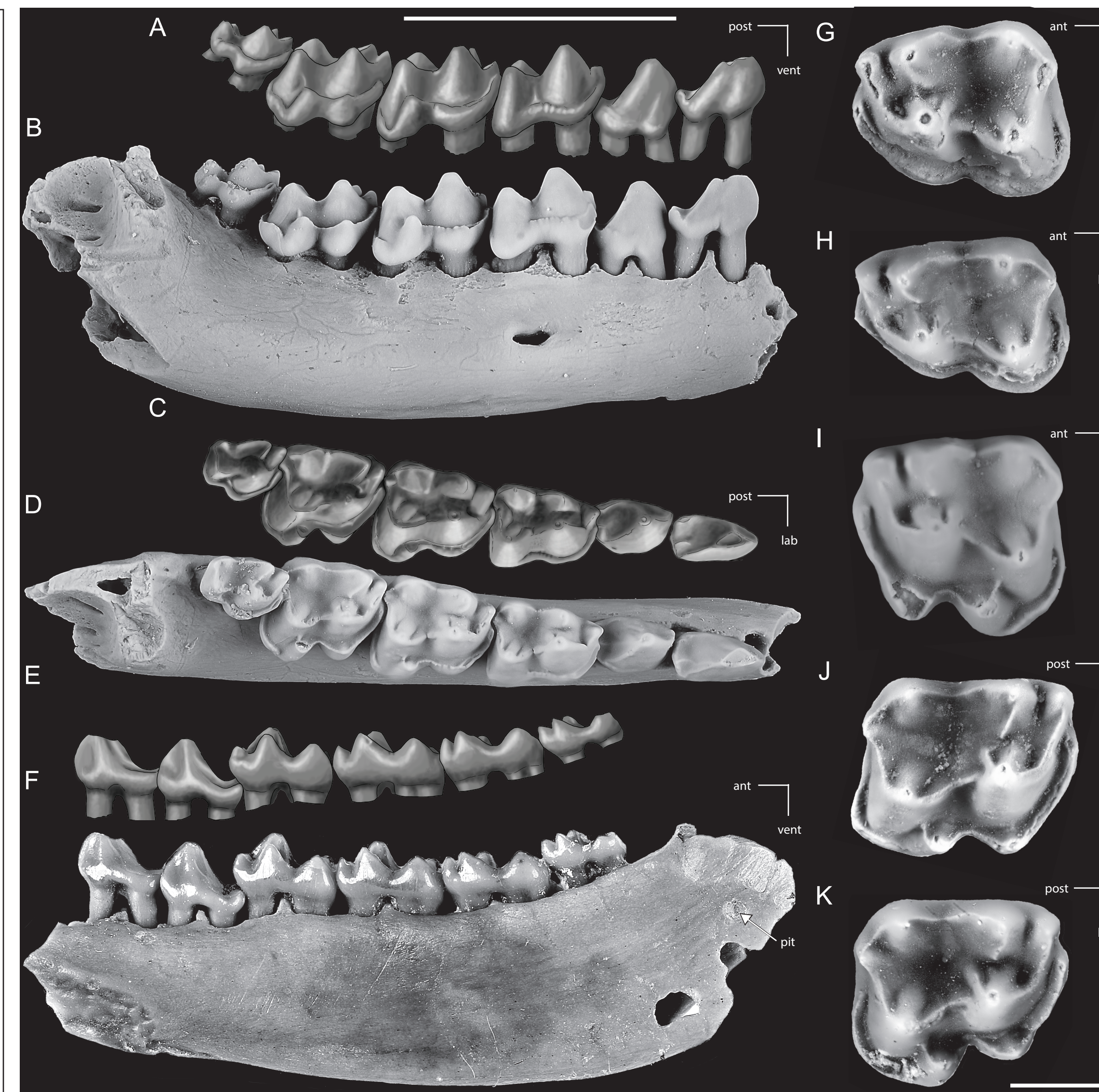


FIGURE 4. Partial left maxilla with M2–M3 (NDGS 1793) referred to *Glasbius twitchelli*. Photograph is in occlusal view. Abbreviations: ant, anterior; lab, labial. Scale bar equals 1 mm.

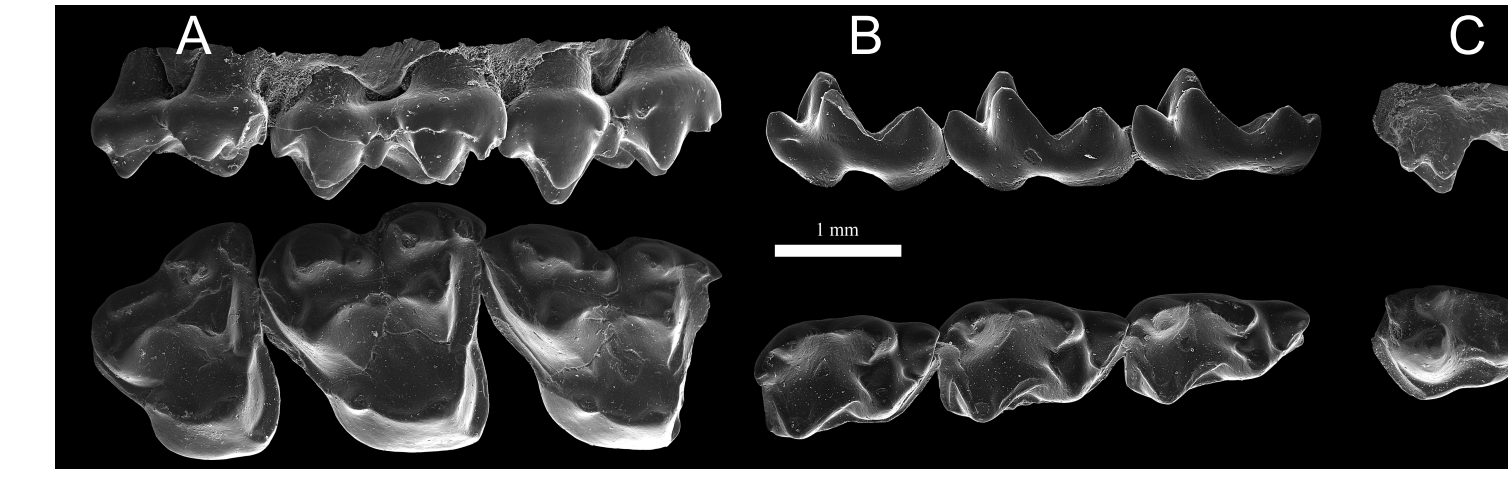


FIGURE 5. Upper and lower molars of *Glasbius intricatus*, in occlusal, labial, and lingual views. A, UM VP1593, LM1-M3; B, AMNH 58759, Rm1-m3 (in labial view anterior is left, in occlusal view anterior is right); C, AMNH 57960, Lm4. All from UCMP V5711, Lance Formation, Wyoming. Modified from Davis (2007, fig. 23).

Table 2. Comparisons between published measurements of the lower dentition of *Glasbius* and the specimens here referred from North Dakota.

Tooth	Measurement	N	This Study <i>Glasbius twitchelli</i> Hell Creek Fm. North Dakota			Archibald (1982) <i>Glasbius twitchelli</i> Hell Creek Fm. Montana			Fox (1989) <i>Glasbius twitchelli</i> Hell Creek Fm. Saskatchewan			Lofgren (1995) <i>Glasbius twitchelli</i> Hell Creek Fm. Montana			Clemens (1966) <i>Glasbius intricatus</i> Lance Fm. Wyoming							
			Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean					
p1	Length	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–					
	Width	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–					
p2	Length	1	–	–	1.62	2	1.47	1.49	1.49	–	–	–	–	–	–	–	–					
	Width	1	–	–	0.84	2	0.73	0.75	0.74	–	–	–	–	–	–	–	–					
p3	Length	1	–	–	1.51	2	1.40	1.68	1.54	–	–	–	–	1.53	–	–	–					
	Width	1	–	–	1.00	2	0.70	0.92	0.81	–	–	–	–	0.97	–	–	–					
m1	Length	1	–	–	2.02	3	1.95	2.04	2.00	–	–	–	–	–	–	–	1.80					
	Wtri	1	–	–	1.23	3	1.00	1.10	1.04	–	–	–	–	–	–	–	1.05					
m2	Length	3	2.02	2.13	2.07	4	2.13	2.26	2.20	1	–	–	2.10	3	1.98	2.29	2.15	4	1.90	1.95	1.93	
	Wtri	3	1.59	1.54	1.55	4	1.24	1.44	1.34	1	–	–	1.40	3	1.29	1.41	1.35	4	1.10	1.25	1.16	
m3	Length	3	1.68	1.91	1.78	5	1.51	1.73	1.61	1	–	–	1.60	3	1.51	1.76	1.66	4	1.30	1.40	1.34	
	Wtri	4	1.97	2.11	2.05	3	2.08	2.20	2.12	–	–	–	–	3	2.10	2.10	2.10	6	1.70	2.05	1.83	
m4	Length	4	1.59	1.77	1.68	3	1.42	1.53	1.48	–	–	–	–	3	1.60	1.78	1.69	6	1.20	1.55	1.38	
	Wtri	4	1.63	1.99	1.84	4	1.52	1.75	1.65	–	–	–	–	3	1.75	2.02	1.91	6	1.30	1.70	1.47	
mx	Length	1	–	–	1.14	1	–	–	1.10	–	–	–	–	–	–	–	–	–	–	–	–	
	Wtri	1	–	–	0.88	1	–	–	1.06	–	–	–	–	–	–	–	–	–	–	–	–	
	Mean																					
	Min																					
	Max																					

Abbreviations: Fm. = Formation; p = lower premolar; m = lower molar; Max = maximum observed value; Min = minimum observed value; N = number of measurements; Wtri = width of talonid; Wtri = width of trigonid.

Table 3. Comparisons between published measurements of the upper molars of *Glasbius* and the referred specimen from North Dakota (NDGS 1793).

Tooth	Measurement	N	This Study <i>Glasbius twitchelli</i> Hell Creek Fm. North Dakota			Archibald (1982) <i>Glasbius twitchelli</i> Hell Creek Fm. Montana			Lofgren (1995) <i>Glasbius twitchelli</i> Hell Creek Fm. Montana			Clemens (1966) <i>Glasbius intricatus</i> Lance Fm. Wyoming					
			Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean			
M1	Length	2	2.01	2.08	2.05	–	–	–	–	–	–	–	–				
	Width	2	2.16	2.19	2.18	–	–	–	–	–	–	–	–				
M2	Length	1	–	–	2.11	5	2.05	2.11	2.07	3	2.08	2.18	2.14	2	2.00	2.00	2.00
	Width	1	–	–	2.20	5	2.13	2.45	2.31	3	2.31	2.53	2.42	2	2.00	2.20	2.10
M3	Length	1	–	–	1.98	5	1.68	1.89	1.77	2	1.78	1.93	1.86	4	1.65	1.75	1.71
	Width	1	–	–	2.38	5	1.80	2.15	1.97	2	2.14	2.35	2.25	4	2.00	2.15	2.08
M4	Length	2	0.91	1.24	1.08	–	–	–	–	–	–	–	–	–	–	–	–
	Width	2	1.32	1.50	1.41	–	–	–	–	–	–	–	–	–	–	–	–

Width measurements are maximum widths. Abbreviations: Fm. = Formation; M = upper molar; Max = maximum observed value; Min = minimum observed value; N = number of measurements.

DISCUSSION

Fossils were first collected by members of the North Dakota Geological Survey at locality NDGS L226 (= PTRM V98027) in 1995. All of the specimens here referred to *Glasbius twitchelli* from that locality were collected during that first year. Subsequent visits to the site have produced many additional vertebrate specimens, including additional mammalian fossils, but no additional specimens of *G. twitchelli* were recovered. This locality is situated 12.07 meters below the K/Pg boundary, and 10.62 meters below the contact between the Hell Creek Formation and the Fort Union Group (Pearson et al., 2002). Preserved within the sandstone channel deposit is a diverse fauna that includes more than twenty taxa of fish, amphibians, lizards, turtles, crocodylians, dinosaurs, and mammals (Pearson et al., 2002:table 2; this study). Though mammals were not reported from this locality based on study of the collections held at the PTRM (Pearson et al., 2002), collection efforts by the NDGS through the years at that site produced fossils of at least six mammalian taxa represented by eighteen specimens. This makes NDGS L226 the most diverse and productive site for mammalian fossils yet reported within 30 meters of the K/Pg boundary in southwestern North Dakota (Hunter and Pearson, 1996; Hunter and Archibald, 2002; Pearson et al., 2002). These new data from NDGS L226 increases the known diversity of the Late Cretaceous mammalian fauna from North Dakota (Table 1).

Reassessment of Some Specimens Previously Referred to *Glasbius*

Specimen AMNH 58759, a partial dentary preserving p2–m3 and the alveoli for p1, was tentatively referred to *G. intricatus* by Clemens (1966). It was the only specimen that preserved portions of the lower premolar dentition for that taxon. Archibald (1982) argued that AMNH 58759 should not be referred to *G. intricatus* in part because p3 was shorter anteroposteriorly and narrower labiolingually than p2, the opposite condition seen in the one specimen confidently referred to *G. twitchelli* that preserves the crowns of p2 and p3 (UCMP 117570). In NDGS 1719, the p3 is labiolingually wider than p2, but it is slightly shorter anteroposteriorly (Table 2). These observations demonstrate that the relative sizes of p2 and p3 are variable in *G. twitchelli* (Table 2) and should not be a feature used to either refer or exclude specimens from *Glasbius*. Archibald (1982) also used the fact that the p1 alveoli are not rotated relative to the long axis of the dentary as evidence that AMNH 58759 should not be referred to *Glasbius*. However, that unique orientation of the p1 alveoli is only observed in specimens of *G. twitchelli* and is unknown for *G. intricatus*, so it may be that this feature differentiates these two species rather than diagnosing *Glasbius* as proposed by Archibald (1982). However, several other differences between AMNH 58759 and other specimens referred to *G. intricatus* remain that may support the removal of this specimen from that taxon (Clemens, 1966; Archibald, 1982). Until a more detailed examination of AMNH 58759 is conducted its taxonomic affinities should be regarded as uncertain as proposed by Archibald (1982).

Specimen UCMP 52045, an isolated m3 from the Lance Formation of Wyoming (Locality UCMP V5621) was part of the original hypodigm of *G. intricatus* (Clemens, 1966:fig. 18). Archibald (1982) reassigned some specimens previously referred by Clemens (1966) to *G. intricatus* to *G. twitchelli* (e.g., PU 17286), but no mention is made regarding the taxonomic status of UCMP 52045 in that or any other publication after the original referral by Clemens (1966). That specimen displays prominent posterior and anterior buccal cingulid cusps that are diagnostic for *G. twitchelli*, and the overall morphology of UCMP 52045 closely matches that of the m3s here referred to *G. twitchelli* (Fig. 3). Thus, UCMP 52045 is here transferred to *G. twitchelli*, making that specimen the first occurrence of that species from the Lance Formation of Wyoming. No other specimens were referred to *Glasbius* from locality UCMP 5621, so there remains no overlap of the two species of *Glasbius* from a single locality, though the geographic distributions of these taxa are now much closer based on this referral. It remains uncertain if these two species were contemporaneous, if the slight differences between them may be the result of anagenetic change within the lineage, or if larger sample sizes will eventually demonstrate that the two currently recognized species actually represent the extreme endpoints of the range of tokogenetic variation present within a single species. The collection of additional specimens with detailed geographic and stratigraphic data is needed to properly address those possibilities. Though information on the stratigraphic distribution of *Glasbius* from the Hell Creek Formation of Montana and North Dakota is available (e.g., Wilson, 2005, 2014; this study), comparable information is not yet available for the Lance Formation of Wyoming.

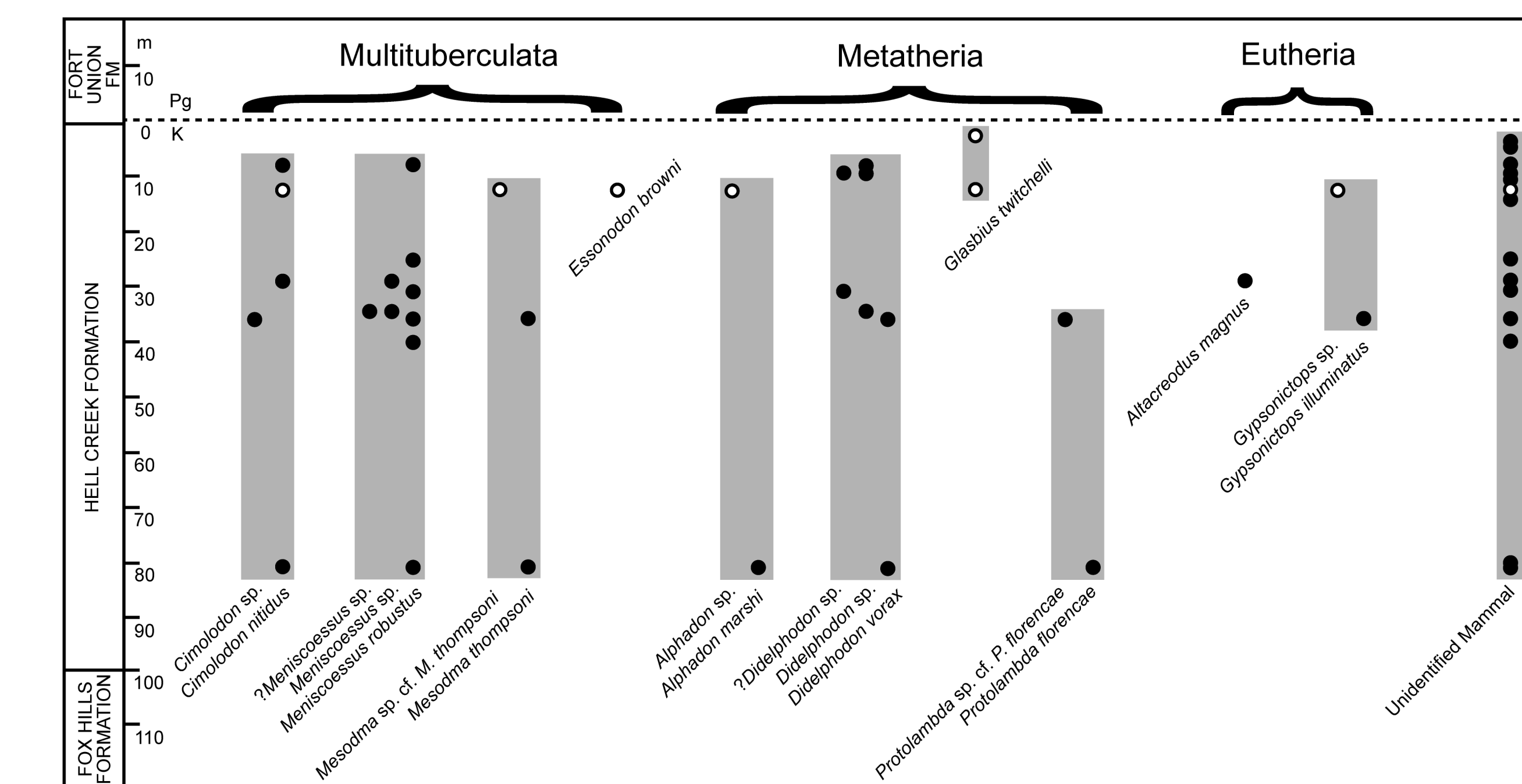


FIGURE 6. Chart of stratigraphic ranges of mammalian taxa in the Hell Creek Formation of southwestern North Dakota. All localities that produced fossils of mammals reported by Hunter and Archibald (2002) are included, along with the two new localities discussed in this study. Solid black circles represent occurrences of the species listed. Grey circles represent occurrences referred to that genus but not definitively identified to species. White circles represent new occurrences reported in this study. Note that the stratigraphic positions are measured from the K/Pg boundary, which is not always concurrent with the contact between the Hell Creek Formation and Fort Union Group in the study area (Pearson et al., 2002). Modified from Hunter and Archibald (2002:fig. 5).

REFERENCES

Archibald, D. J. 1982. A study of Mammalia and geology across the Cretaceous-Tertiary boundary in Garfield County, Montana. University of California Publications in Geological Sciences 122:1–286.
 Clemens, W. A. 1963. Fossil mammals of the type Lance Formation Wyoming: part I. Introduction and Multituberculata. University of California Publications in Geological Sciences 48:1–105.
 Clemens, W. A. 1966. Fossil mammals of the type Lance Formation Wyoming: part II. Marsupialia. University of California Publications in Geological Sciences 62:1–122.
 Clemens, W. A. 1973. Fossil mammals of the type Lance Formation Wyoming: part III. Eutheria and summary. University of California Publications in Geological Sciences 94:1–102.
 Davis, B. M. 2007. A revision of "pedionyiid" marsupials from the Late Cretaceous of North America. Acta Palaeontologica Polonica 52:217–256.
 Fox, R. C. 1989. The Wounded Knee local fauna and mammalian evolution near the Cretaceous-Tertiary boundary, Saskatchewan, Canada. Palaeontographica 208:11–59.
 Fox, R. C. 2015. A revision of the Late Cretaceous-Paleocene eutherian mammal Cimolestes Marsh, 1889. Canadian Journal of Earth Sciences 52:1137–1149.
 Hoganson, J. W., J. M. Campbell, and E. C. Murphy. 1994. Stratigraphy and paleontology of the Cretaceous Hell Creek Formation, Stump site, Morton County, North Dakota. Proceedings of the North Dakota Academy of Science 48:95.
 Hunter, J. P., and D. J. Archibald. 2002. Mammals from the end of the age of dinosaurs in North Dakota and southeastern Montana, with a reappraisal of geographic differentiation among Lancian mammals; pp. 191–216 in J. H. Hartman, K. R. Johnson, and D. J. Nichols (eds.), The Hell Creek Formation and the Cretaceous-Tertiary boundary in the northern Great Plains: an integrated record of the end of the Cretaceous. Geological Society of America Special Paper 361.
 Hunter, J. P., and D. A. Pearson. 1996. First record of Lancian (Late Cretaceous) mammals from the Hell Creek Formation of southwestern North Dakota, USA. Cretaceous Research 17:633–643.
 Lofgren, D. L. 1995. The Bug Creek problem and the Cretaceous-Tertiary transition at McGuire Creek, Montana. University of California Publications in Geological Sciences 140:1–185.
 Murphy, E. C., D. J. Nichols, J. W. Hoganson, and N. F. Forsman. 1995. The C