

The Brown Ranch Locality Area, “Mid” Paleocene Mammals and the Tongues of the Cannonball Formation, Slope County, North Dakota

John P. Hunter¹ and Joseph H. Hartman²

¹New York Institute of Technology, Department of Anatomy, Old Westbury, NY 11568

Current Address: Ohio State University at Newark

Department of Evolution, Ecology, & Organismal Biology

1179 University Avenue, Newark, OH 43055 hunter.360@osu.edu

²University of North Dakota Department of Geology and Geological Engineering

Box 8358, Grand Forks, ND 58202 joseph_hartman@und.nodak.edu

Introduction

The Brown Ranch area is a patchwork of private and leased federal land (United States Forest Service) mainly on the west side of the Little Missouri Scenic River north of Marmarth and southeast of Golva in Slope County, North Dakota. From Marmarth, most of the ranch can be accessed in good weather by Forest Route 783 or West River Road (the road is impassible by vehicle when wet). The Brown family has owned and managed the ranch since 1944 (for a brief history of the ranch see <http://www.midrivers.com/~nikkib>), and today John and Nikki Brown and their children raise Herefords and Angus–Hereford crosses on the land. Brown Ranch also offers views of fossiliferous exposures of the lower Paleocene Ludlow Member of the Fort Union Formation. One convenient marker horizon visible from the overlook is the T Cross coal (of Moore; see Hartman, 1993) clinker horizon, which is visible at numerous outcrops and which locally effectively divides the Ludlow Member into lower and upper parts.

In the late 1980s, “Bud” Brown, then owner of Brown Ranch, opened access to the ranch to paleontologists including invertebrate stratigrapher Joseph Hartman, vertebrate paleontologist David Krause, and paleobotanist Kirk Johnson, who was working on his dissertation at the time. Notable vertebrate finds include a few mammalian fossils of a “mid” Paleocene Torrejonian North American Land Mammal Age (NALMA) in the upper part of the Ludlow Member just above the T Cross coal

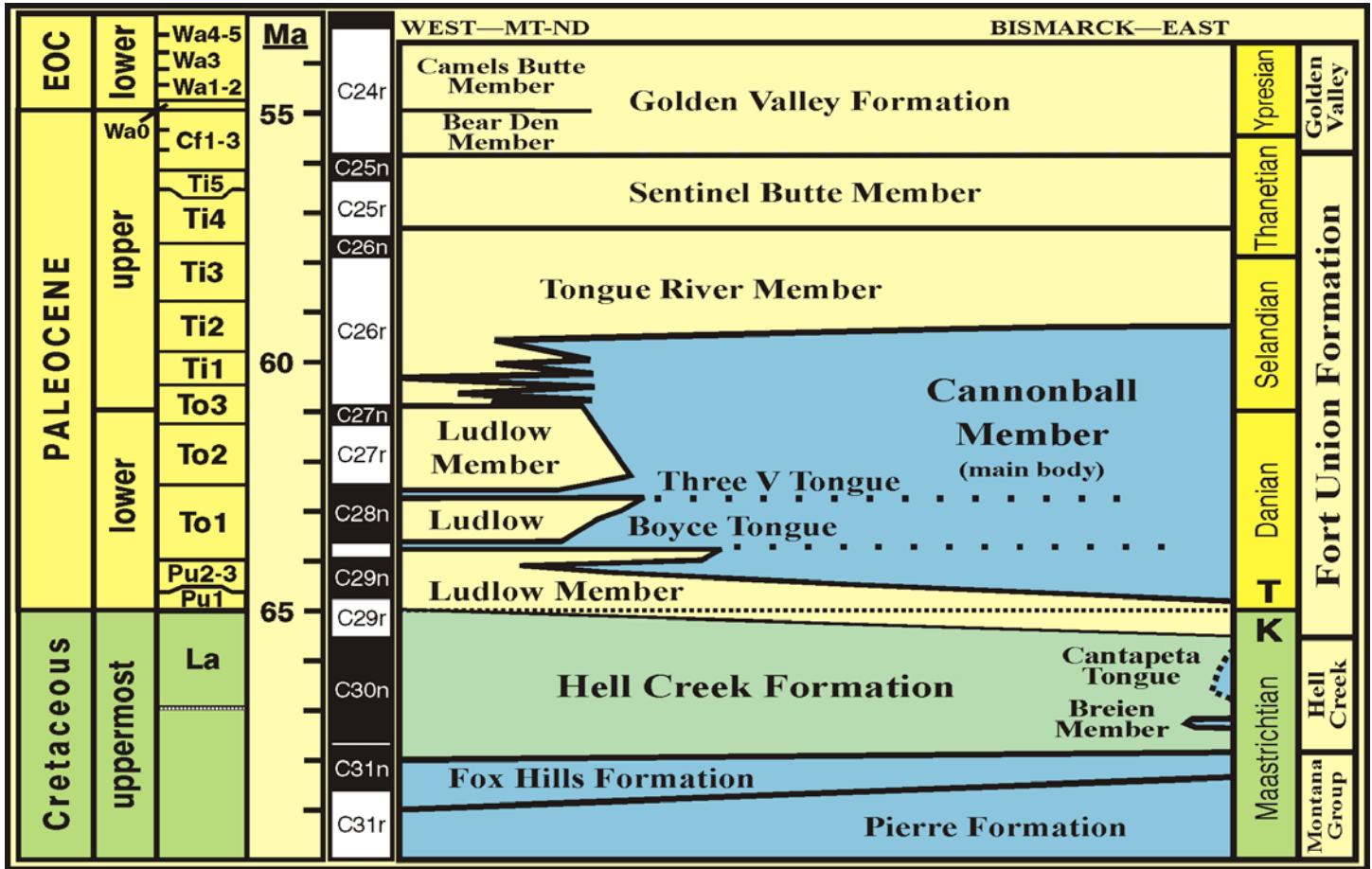
(Hartman et al., 1998; Hunter, 1999). Hunter accompanied Hartman and Krause in 1988 as an undergraduate to prospect for fossils of lower Paleocene freshwater snails and clams and terrestrial mammals and returned to prospect in later years, usually en route to other field areas (Makoshika State Park, Montana, and Hell Creek localities in southwestern North Dakota). More recently, current ranch owner John Brown has entered into an ongoing arrangement with the Pioneer Trails Regional Museum (PTRM) of Bowman, North Dakota, to donate fossils found on his land to this museum. Small crews under Hunter’s direction and working with the PTRM have, over the past couple of years, begun to prospect in the southern end of Brown Ranch in the lower part of the Ludlow Member. Notable vertebrate finds include a few mammalian fossils of the early Paleocene Puercan NALMA at a new locality, Merle’s Mecca, named after the site’s discoverer, rancher and PTRM volunteer Merle Clark (Hunter et al., 2003).

Brown Ranch offers a convenient place to discuss the sequence of Paleocene mammals in the Little Missouri River Badlands of North Dakota and their paleogeographic significance (Hunter, 1999).

Stratigraphy

Overlying the famous Upper Cretaceous Hell Creek Formation, with its well known vertebrate faunas, is the Paleocene Fort Union Formation or Group (Figure 1). In North Dakota, the Fort Union is represented by four members or formations. In stratigraphically ascending order they are the nonma-

Figure 1. Chronostratigraphy of the Fort Union Formation and adjacent strata (from Lund et al., 2002).



rine Ludlow, Tongue River, and Sentinel Butte and marine Cannonball. The Ludlow Member, seen at Brown Ranch, is characterized by large, gray, cross-bedded channels, yellow siltstone units, and numerous, thin, well-developed lignite beds, which have frequently been ignited, baking the overlying clays and silts a variety of shades of brick red. At the Brown Ranch section overview, these baked units, referred to as clinkers, and less appropriately as scoria, are well developed in exposures along the Little Missouri River. Chronostratigraphically equivalent to parts of the Ludlow and Tongue River Members and to the east are the marine, marginal marine, and brackish strata of the Cannonball Member. It contains sediments deposited by the Paleocene Western Interior Seaway, which was likely continuous north to the Arctic (Marincovich et al., 1990), northeast towards Hudson Bay (Ziegler and Rowley, 1996; Hartman et al., 1999), and south to the Gulf of

Mexico (Fox and Olsson, 1969), but the only interpretable remnants of the Cannonball can be found today in parts of the Williston Basin. In surface exposures, the Cannonball Member has been well documented to interfinger with the Ludlow Member in the Brown Ranch area (Hartman, 1993) (Figures 2, 3). The Cannonball Member has also been shown to interbed with the Ludlow in the subsurface (Hartman and Butler, 1995) (Figure 1) and to have significant and widespread influence on trace fossil and other invertebrate and microfossil distribution in the lower part of the Tongue River Member in far-southwestern North Dakota and easternmost Montana (Diemer et al., 1996; Belt et al., 1997; Tibert et al., 2001; Hartman and Anderson, 2002). The importance of a nearby “Cannonball Sea” during the early Paleocene evolutionary radiation of mammals in North America has largely been overlooked. On the other hand, the biochronologic dating of the nonmarine sediments of

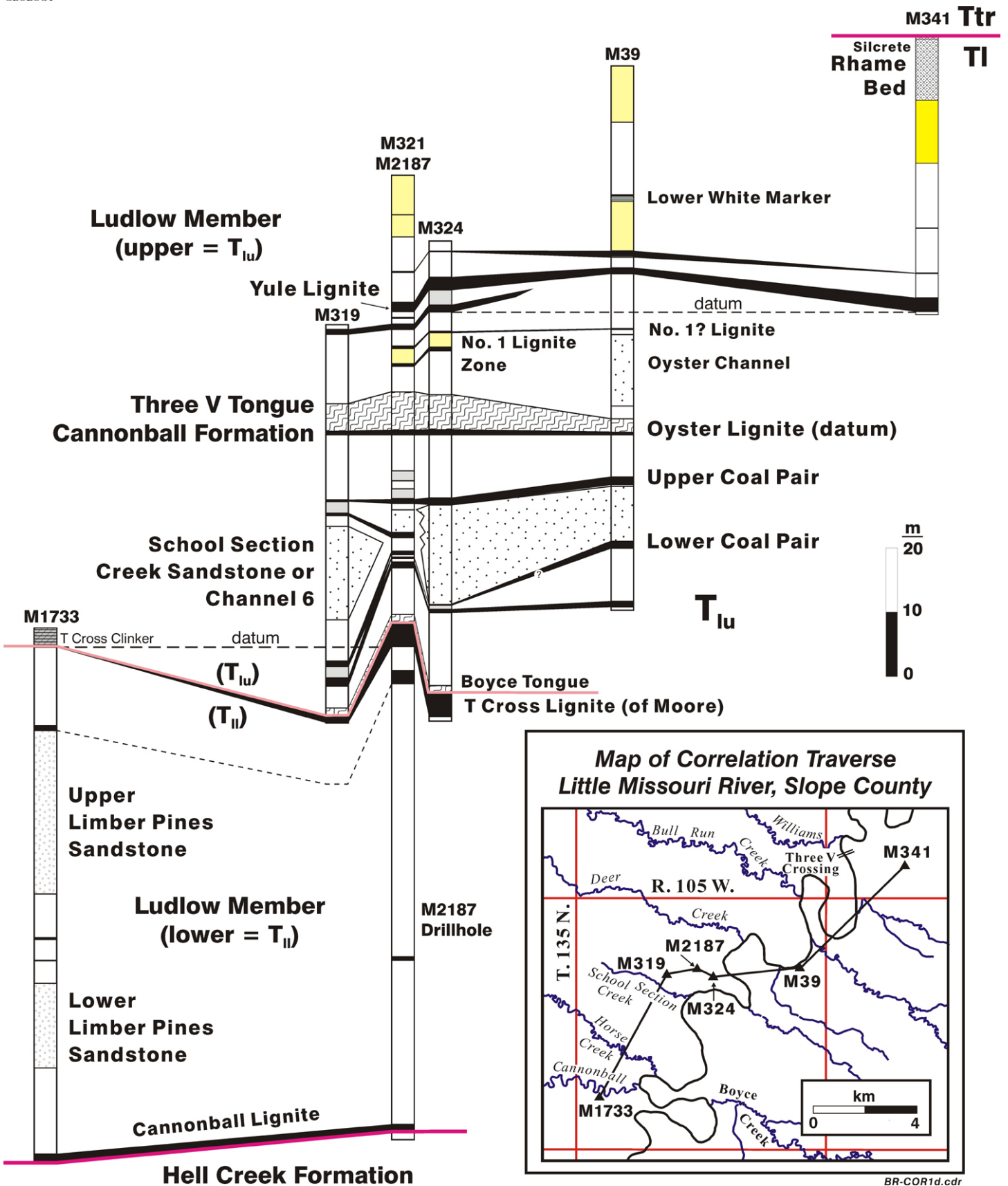


Figure 2. Stratigraphy of the Brown Ranch area.

the Fort Union Formation is helping to constrain the timing of various transgressions and regressions of the last vestiges of the Western Interior Seaway (Hartman et al., 1998; Hunter et al., 2003) (Figure 1).

Mammals

Fossil mammals of Lancian (Late Cretaceous), Puercan (early Paleocene), Torrejonian (“mid” Paleocene), and Tiffanian (late Paleocene) NALMAs occur in the Little Missouri River Valley (Hartman et al., 1998; Hunter, 1999; Hunter and Archibald, 2002).

Lancian mammals. As of 2002, 166 mammalian specimens have been recovered from 15 localities throughout the vertical extent of the Hell Creek Formation in southwestern North Dakota, well to the south of Brown Ranch. These fossils have been incorporated into comprehensive studies of the vertebrate biostratigraphy of the Hell Creek Formation and faunal dynamics approaching the Cretaceous–Tertiary boundary (Pearson et al., 2002). Like the rest of the vertebrate fauna, mammalian specimens remain a stable faunal component through the vertical extent of the Hell Creek Formation, which represents the last 1.3–1.7 million years of the Cretaceous. Similar in composition to other nearby Lancian mammalian faunas in Montana and Wyoming, the Cretaceous mammals from North Dakota have also been incorporated into a quantitative study of faunal composition and abundance in the latest Cretaceous, suggesting that the differences among Lancian sites in the northern part of the Western Interior were probably not a latitudinal gradient (Hunter and Archibald, 2002).

PITA Flats Local Fauna. As of 2002, only nine isolated teeth belonging to five taxa of fossil mammals (*Mesodma* sp., *Protungulatum* sp., *Oxyprimus galadriela*, *Oxyacodon priscilla*, and Arctocyonidae gen. & sp. indet.) have been recovered at the surface and from an anthill at two localities comprising the PITA Flats local fauna. These localities are separated by about a kilometer in a

sandstone unit representing a large channel complex in the lower part of the Ludlow Member, southeast of the Brown Ranch. The locality from which most of this material derives, the PITA Flats locality, is approximately 8 m above the Hell Creek–Fort Union formational contact, or 5.6–7.1 m above the K/T boundary as Cretaceous pollen occurs in the lowermost parts of the Ludlow Member locally (Hunter and Archibald, 2002). The most informative of the fossil mammals from the point of view of correlations are *Oxyprimus galadriela* (known elsewhere from the Pu1 Interval Zone) and *Oxyacodon priscilla* (known elsewhere from the Pu2 Interval Zone). The best estimate for the age of PITA Flats based on mammalian faunal composition and paleomagnetic stratigraphy is that it is close to the Pu1/Pu2 boundary (Hunter and Archibald, 2002). This estimate may be refined as screen wash samples of sediment collected in 2002 are studied (Hunter, in progress) and a new paleomagnetic stratigraphic column, collected and measured in 2003 close to PITA Flats, is analyzed (Hicks, in progress). Finally, the recent discovery of new Puercan-age localities below (Wilkening Locality) and above (Merle’s Mecca) the PITA Flats faunas in the same general vicinity may also help to constrain the age relations of PITA Flats as work continues (Hunter et al., 2003). The PITA Flats fauna is close to the level of an unnamed tongue of the Cannonball Member and below the Boyce Tongue of the Cannonball Member.

Brown Ranch Local Fauna. Only four isolated specimens of fossil mammals have been recovered from localities in the upper part of the Ludlow Member above the T Cross coal (of Moore) on Brown Ranch (Hunter, 1999) (Figures 3–8). Their identification as the taeniodont *Conoryctella dragonensis* (To1) and the mesonychid condylarth *Dissacus* (To2–Eocene) suggest an early Torrejonian age (To1 or To2). Prospecting subsequent to the discovery of these fossils in 1986 has revealed no further finds. The Torrejonian Brown Ranch mammals occur above the Boyce Tongue and below the Three V Tongue of the Cannonball Member (Figures 3, 5, 8).

Figure 3. Aerial view northeast of type sections of the Three V and Boyce Tongues of the Cannonball Member of the Fort Union Formation on west and east sides (see Fig. 6) of the Little Missouri River, respectively. A discussion and illustration of these sections is given in Hartman (1993; included in guidebook). This view also includes the type section of the Slope Formation, the usage of which Kihm and Hartman (this guidebook) suggest should be abandoned (Hartman photo C2452).

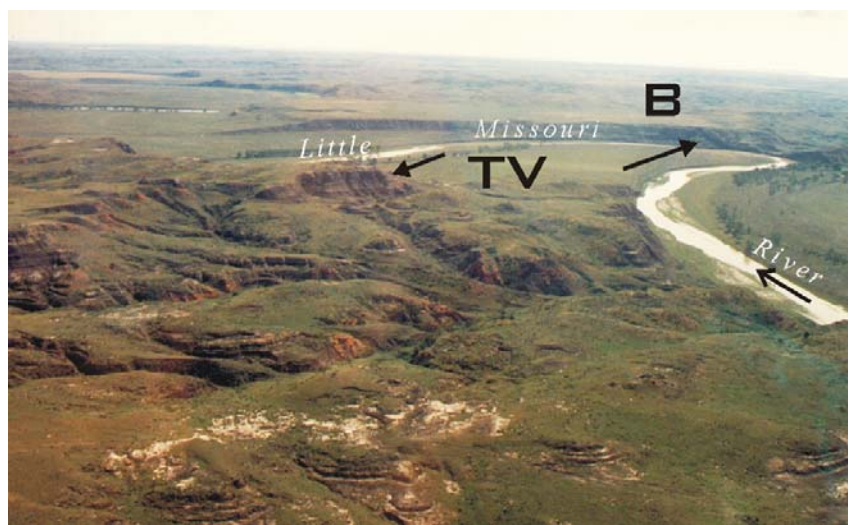


Figure 4. View northeast of yellow siltstone bed across upper tributary of “School Section” drainage to interbedded flood plain deposits and thin beds of the Three V Tongue of the Cannonball Member (Hartman photo C1268).



Figure 5. View north of vertebrate fossil locality with Tim Kroeger and Dave Krause actively engaged in collecting channel lag deposit. The Three V Tongue stratotype is due north (in the far distance), with the Little Missouri to the east in the pasture lands. Gray channel deposits can be seen in middle ground (Hartman photo C1236).



Figure 6. View northwest along rim of channel deposit typical of Brown Ranch area (Hartman photo P6504).



Figure 7. View northeast of yellow siltstone beds overlying gray flood plain deposits from near overlook. A highly winnowed yellow siltstone unit rims the “School Section” drainage of the Brown Ranch area (Hartman photo P1755).



Figure 8. View east across Little Missouri River of lower part of upper Ludlow including T Cross coal (of Moore) and Boyce Tongue of Cannonball Member of Fort Union Formation (just over coal) (Hartman photo P1858).



Figure 9. View of basal Tongue River Member channel sandstone complex including X–X Locality (at horizon of people). This locality is a significant vertebrate and mollusk deposit (Hartman photo P2034).



Figure 10. General view north of X–X bluff, Little Missouri River (flowing north, then east) and work on washing concentrate from shell bed (Hartman photo P2059).



X–X Local Fauna. Because of intensive screen-washing efforts in 1990–1992 by crews led by Krause and Hartman (Figures 9, 10), the mammalian fauna of X–X is reasonably well known from a few dozen isolated teeth. X–X (Locality L28 of Hartman) is so named because the site occurs on the Johnson Ranch, which historically has used the X–X brand. A faunal list has been published (Hunter, 1999), with the most informative mammal being the plesiadapiform *Plesiadapis anceps*, known only from the Ti2 Interval Zone. The X–X fauna occurs in the lowermost Tongue River Formation above the Three V Tongue of the Cannonball Member.

Annotated References in Chronological Order Representing a History of Study

1969, Fox, S.K., Jr., and Olsson, R.K., Danian planktonic foraminifera from the Cannonball Formation in North Dakota: *Journal of Paleontology*, v. 43, no. 6, p. 1397–1404.

This paper provided the first and then generally held view of the age of the Cannonball Formation on the basis of planktic foraminifera.

- 1990, Marincovich, L., Jr., Brouwers, E.M., Hopkins, D.M., and McKenna, M.C., Late Mesozoic and Cenozoic paleogeographic and paleoclimatic history of the Arctic Ocean Basin, based on shallow-water marine faunas and terrestrial vertebrates, *in* Grantz, A., Johnson, L., and Sweeney, J.F., eds., *The Arctic Ocean region*, v. L, *in* *The Geology of North America: Boulder, Colorado*, Geological Society of America, p. 403–426.
- Marincovich and company suggest an Arctic connection for the Paleocene Cannonball Sea, using marine mollusks and other lines of evidence, and ultimate outlets for the Arctic waters to the Atlantic through the North Sea.
- 1993, Hartman, J.H., The type areas of the Paleocene Slope Formation and intercalated tongues of the Cannonball Formation, Slope County, North Dakota, *in* Kihm, A.J., and Hartman, J.H., eds., *The Marshall Lambert Symposium: North Dakota Geological Society, Bowman, Pioneer Trails Regional Museum, North Dakota*, p. 78–86.
- In an effort to end the ambiguity of beds named after fossils or relative position, Hartman introduced the names, Boyce and Three V Tongues, for the various appellations applied to the two horizons of macrofossils found in the T. 135 N., R. 105 W. area.
- 1995, Hartman, J.H., and Butler, R.D., Extinction and recovery of nonmarine molluscan assemblages in the Late Cretaceous and early Tertiary: Geological Society of America (Rocky Mountain Section) Abstracts with Programs, v. 27, no. 4, p. 13.
- Using geophysical data across western North Dakota, this abstract indicated that a tongue below the Boyce in the Ludlow Formation could be recognized in the subsurface obviating the earlier proposed need for the Slope Formation and its distinction from the Ludlow Formation in North Dakota.
- 1996, Diemer, J.A., Belt, E.S., and Hartman, J.H., Base level changes as a consequence of tectonic, eustatic, and autogenic processes in Late Cretaceous and Paleocene strata, western Williston Basin: Geological Society of America Abstract with Programs, v. 28, no. 7, p. A373. This abstract first recognized that previously interpreted nonmarine strata in eastern Montana may have been influenced by eustatic sea-level rise.
- 1996, Hunter, J.P., and Pearson, D.A., First record of Lancian (Late Cretaceous) mammals from the Hell Creek Formation of southwestern North Dakota, USA. *Cretaceous Research*, v. 17, p. 633–643.
- This paper contains descriptions of the mammalian fossils recovered from PTRM Locality V92067, the most productive Cretaceous microvertebrate locality in the study area.
- 1996, Ziegler, A.M., and Rowley, D.B., The vanishing record of epeiric seas, with emphasis on the Late Cretaceous “Hudson Seaway,” *in* Crowley, T.J., and Burke, T.J., eds., *Tectonic boundary conditions for climate reconstructions: New York*, Oxford University Press, p. 147–165.
- Ziegler and Rowley provide analysis that Cretaceous seaways may have persisted northeast through the Hudson Bay area, as well as north to the Arctic Ocean into the Paleocene, providing an alternative dispersal route for North Atlantic marine vertebrates and invertebrates.
- 1997, Belt, E.S., Diemer, J.A., and Beutner, E.C., Marine ichnogenera within Torrejonian facies (Paleocene) of the Fort Union Formation, southeastern Montana: *Contributions to Geology*, University of Wyoming, v. 32, p. 3–18.



This paper specifically provides details on the extended influence of the Cannonball Sea into southeastern Montana during the interval of time represented by the Boyce and Three V Tongues in North Dakota (Hartman, 1993).

1998, Hartman, J.H., Hunter, J.P., and Krause, D.W., The last epeiric sea (Paleocene, Cannonball Formation) in North America—The age of incursions and bounding strata based on mammals, mollusks, and foraminifera: Geological Society of America Abstracts with Programs, v. 30, p. A33.

This abstract provides the best available data to date on the North American Land Mammal Age (NALMA) biochrons bounding the tongues of the Cannonball Formation. Mammalian local faunas of Puercan, Torrejonian, and Tiffanian age pre- and post-date each transgressive event. This abstract was augmented by the following abstract (Hartman et al., 1999).

1999, Hartman, J.H., Collins, L.S., and Aubry, M.-P., New interpretations of the Cannonball Formation (Paleocene): North America's last interior sea: Geological Society of America Abstracts with Programs, v. 31, no. 7, p. A105.

New studies on the Garrison core provided the first depth profile of the Cannonball Sea, the first records of coccoliths and diatoms from the Cannonball Formation, and the best-documented record of ostracodes from the formation. The coccolith taxon permitted assignment of a Selandian age to the upper part of the Cannonball Formation and the interpretation of normal marine salinity for the Cannonball Sea.

1999, Hunter, J.P., The radiation of Paleocene mammals with the demise of the dinosaurs: Evidence from southwestern North Dakota, *in* Hartman, J.H., ed., The paleontologic and geologic record of North Dakota – Important sites and current interpretations: North Dakota

Academy of Science, Proceedings, v. 53, p. 141–144.

This paper contains an interim report of fieldwork undertaken in the Paleocene Fort Union Formation of southwestern North Dakota, including preliminary faunal lists for the Puercan PITA Flats localities (Pu1 or Pu2), Torrejonian Brown Ranch localities (To1 or To2), and Tiffanian Johnson Ranch (X–X) locality (Ti2).

2001, Tibert, N.E., Curran, H.A., Hartman, J.H., Belt, E.S., and Diemer, J.A., Marine flooding intervals within the freshwater Tongue River Member (Fort Union Formation–Paleocene), western Williston Basin, U.S.A.: American Association of Petroleum Geologists, Official Program Book, 2001 Annual Convention, v. 10, p. A200.

Like preceding abstracts, this contribution provided evidence for marine influence in otherwise interpreted nonmarine lower Tongue River Member strata in far-western North Dakota and easternmost Montana.

2002, Hartman, J.H., and Anderson, L.C., Interpreting the influence of the last interior seaway in North Dakota (Paleocene, Cannonball Formation) in nonmarine strata (Fort Union Group): Reevaluation of a corbulid using an Amazonian analogue: Geological Society of America Abstracts with Programs, v. 34, no. 6, p. 355.

This abstract strengthened earlier interpretations of the freshwater environment inhabited by corbulid taxa in the Tongue River Member of western North Dakota and easternmost Montana and recognized a remarkably comparable fauna of Miocene age in western Amazonia.

2002, Hunter, J.P., and Archibald, J.D., Mammals from the end of the age of dinosaurs in North

Dakota and southeastern Montana, with a reappraisal of geographic differentiation among Lancian mammals, *in* Hartman, J.H., Johnson, K.R., and Nichols, D.J., eds., *The Hell Creek Formation and the Cretaceous–Tertiary boundary in the northern Great Plains – An integrated continental record of the end of the Cretaceous*. Geological Society of America Special Paper 361, p. 191–216.

This paper provides descriptions of Lancian mammals recovered from the Hell Creek Formation in southwestern North Dakota that were not treated in Hunter and Pearson (1996) and of Puercan mammals of the PITA Flats local fauna, as well as updated faunal lists for Lancian-age localities near Ekalaka, Montana. In addition, the authors reexamined and rejected the hypothesis of differentiation of Lancian mammals along a north-south gradient, using multivariate analyses (correspondence analysis correcting for spatial autocorrelation) of occurrence and abundance data.

2002, Lund, S.P., Hartman, J.H., and Banerjee, S., Magnetostratigraphy of interfingering Upper Cretaceous–Paleocene marine and continental strata of the Williston Basin, North Dakota and Montana, *in* Hartman, J.H., Johnson, K.R., and Nichols, D.J., eds., *The Hell Creek Formation and the Cretaceous–Tertiary boundary in the northern Great Plains – An integrated continental record of the end of the Cretaceous*: Geological Society of America Special Paper 361, p. 57–95.

Using paleomagnetic interpretations across the Williston Basin, this paper concluded that the transgression of the Cannonball Sea, commenced prior to the end of the Cretaceous resulting in the initial widespread alternation of aquatic habitat space with the change in base level.

2002, Pearson, D.A., Schaefer, T., Johnson, K.R., Nichols, D.J., and Hunter, J.P., Vertebrate biostratigraphy of the Hell Creek Formation in southwestern North Dakota, *in* Hartman, J.H., Johnson, K.R., and Nichols, D.J., eds., *The Hell Creek Formation and the Cretaceous–Tertiary boundary in the northern Great Plains – An integrated continental record of the end of the Cretaceous*. Geological Society of America Special Paper 361, p. 145–167.

The authors of this paper document the observed stratigraphic range of vertebrate taxa, at the lowest diagnosable taxonomic levels, through the vertical extent of the Hell Creek Formation and uppermost Cretaceous part of the Fort Union Formation. Localities were measured in the field either to the Fox Hills–Hell Creek or Hell Creek–Fort Union formational contact, and the former adjusted to reflect distance to the palynological Cretaceous–Tertiary boundary. Using techniques to standardize for variation in sampling intensity (rarefaction) and test for trends, vertebrate richness was determined to have remained stable through the duration of the Hell Creek Formation.

2003, Hunter, J.P., Pearson, D.A., and Hartman, J.H., Additions to the Puercan mammals of North Dakota and a framework for study of post-K/T vertebrate recovery: *Journal of Vertebrate Paleontology*, v. 23 (supplement to no. 3), p. 64A.

This abstract contains a preliminary announcement of the discovery of two new Paleocene mammalian localities in the Fort Union Formation of southwestern North Dakota. The older of these, the Wilkening Locality (PTRM Locality V02017), occurs about 2–3 m above the top of the Hell Creek–Fort Union formational contact near the top of the Cretaceous part of the Fort Union. A basal Puercan mammalian fauna occurs at Wilkening (*Protungulatum donnae*, *Mesodma thompsoni*,



and *Stygmys kuszmauli*). The younger locality, Merle's Mecca (PTRM Locality V99011), occurs about 11 m above the top of the Hell Creek–Fort Union contact. A mid-to-late Puercan mammalian fauna occurs at Merle's Mecca (*Loxolophus schizophrenus* and a large “palaeoryctoid” comparable to the mid-Puercan *Alveugena* from the Hanna Basin).