A New Late Paleocene Vertebrate Fauna from the Ohio Creek Formation of Western Colorado[1]

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1. Manuscript received October 25, 2006; Accepted May 15, 2007
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ABSTRACT

Despite recent drilling for hydrocarbon tight-gas resources in conglomerates and sandstones in the Piceance Creek Basin, controversy still exists over the age and lateral extent of the Ohio Creek Formation. This controversy originated from the proposition that these deposits belonged in the late Cretaceous Mesaverde Group. However, recent pollen analyses suggest a late Paleocene age. Here I report the first fossil vertebrate fauna from these deposits, which corroborates the late Paleocene age and further refines it to the early Tiffanian NALMA (Ti3 lineage zone). Identified fossils comprise several genera of mammals and reptiles. Reptilian fossils consist of a dorsal osteoderm of a eusuchian with affinity to Borealosuchus and a partial hyoplastron of the turtle Compsemys. Both genera range from the late Cretaceous through the Paleocene. Mammalian taxa represented are: Gelastops, Haplaletes, Promioclaenus, Colpoclaenus, and Mimotricentes, which range from the Torrejonian into the early part of the Tiffanian NALMA. Presence of the index fossil Nannodectes simpsoni further constrains the deposits to an early Tiffanian age (Ti3 lineage zone). Lithologically the Ohio Creek Formation is characterized by the absence of coal and shale, and the presence of tan mudstones and siltstones spaced between thick and widespread units of clay pebble and chert conglomerates and sandstones. The revised age and unique lithic characteristics of the Ohio Creek Formation excludes it from the late Cretaceous Mesaverde Group. Revising the biostratigraphic zonation of the late Cretaceous and early Tertiary strata of the Piceance Creek Basin is important for understanding the complex tectonic history of the Rocky Mountain region.

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INTRODUCTION

The Ohio Creek Formation is a conglomerate and sandstone dominated unit at the base of a thick series of early Tertiary mudstone and siltstone units in the Piceance Creek Basin of western Colorado. Until recently, little was known of the exact age of the Ohio Creek Formation. Previous studies report either late Maastrichtian (Cretaceous) (Johnson and May, 1980) or Paleocene (Gaskill and Godwin, 1963) ages. The most recent palynological studies from well cores indicate a late Paleocene age (Patterson et al., 2003). This study confirms those findings by presenting a definitive fauna of reptiles and mammals that unequivocally proves that the Ohio Creek Formation is late Paleocene in age (early Tiffanian NALMA).

GEOLOGICAL AND STRATIGRAPHIC SETTING

The Piceance Creek Basin is a large asymmetrical basin in western Colorado (Fig. 1). At its center, the basin contains a thick sequence of early Tertiary units including the Fort Union, Wasatch, and Green River Formations. These units record a long period of subsidence along the western flank of the Southern Rocky Mountains, the onset of which is believed to coincide with the Laramide Orogeny. During the Laramide Orogeny the uplift of the Sawatch and Park Mountain Ranges to the east and southeast resulted in the deposition of large pebble-sized clasts at the base of the Ohio Creek Formation (Lorenz and Rutledge, 1987). These conglomeratic facies, containing chert and porphyritic volcanic pebbles, are restricted to the eastern and southeastern margins of the basin. However, sandstones composed of intra-basin clay clasts dominate the remaining part of the Ohio Creek Formation. In the study area, the Ohio Creek Formation is 75 m thick, comprising three widespread sandstone units (Fig. 2). The lowest and largest sandstone is 24-27 m thick. The upper two sandstones are smaller measuring 3.0-8.0 and 5.1-10.5 m thick. The sandstones exhibit large-scale trough-cross bedding, with paleoflow directions bearing north-south. Clasts range in size from 2 cm clay pebbles to medium-sized sand grains. Poorly permineralized logs are common in the lower sandstone unit. Interspersed between the sandstones are light tan to olive colored mudstones and siltstones. The entire formation exhibits grain sizes fining upwards to the upper contact. An unusual feature characterizes this top contact – as a consequence of a fluctuating water table due to the presence of highly permeable and porous sand beneath, freshwater invertebrate burrows penetrated as deep as 1.5 m. This action lead to the formation of vertically elongated burrow traces (*Camborygma eumekenomos)* in the lower portion of the Fort Union Formation especially along the well-drained eastern margin of the Basin (Hasiotis and Honey, 2000 p.137, Fig. 11).

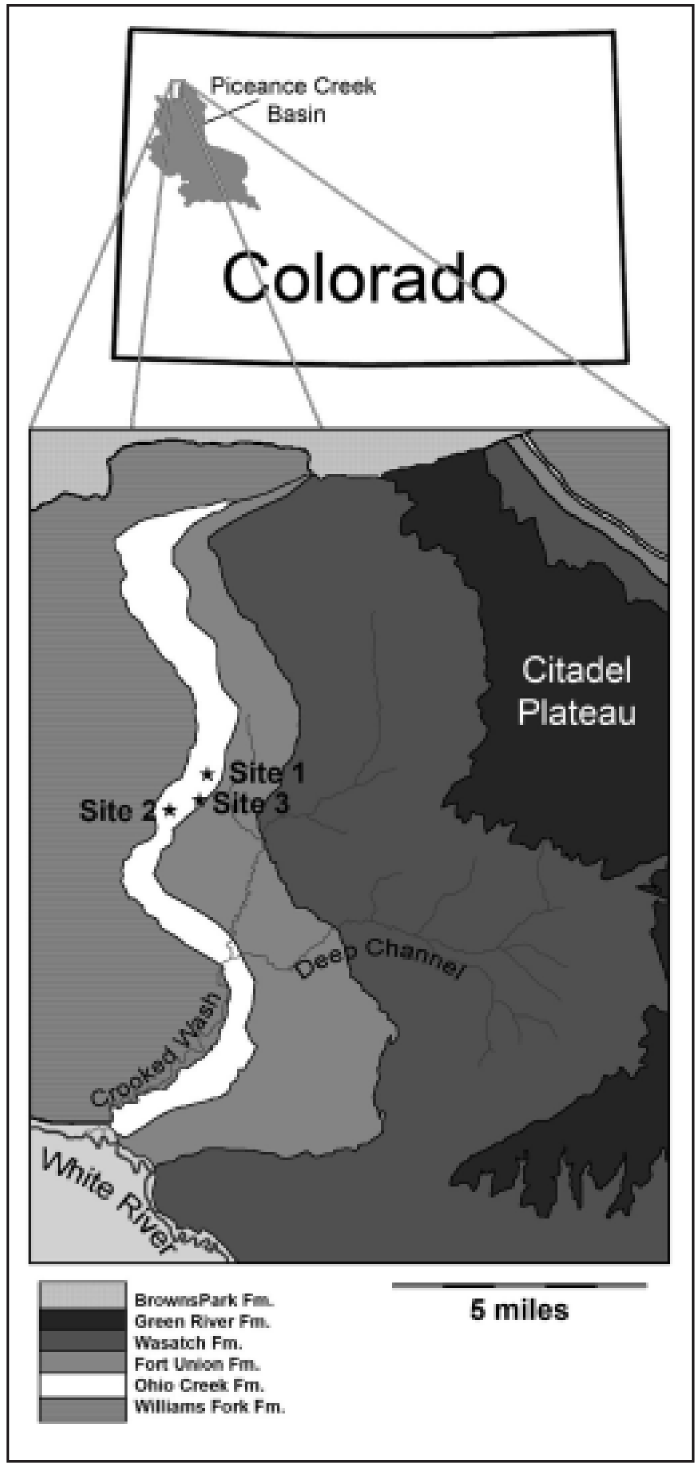

Figure 1. Map showing fossil sites.

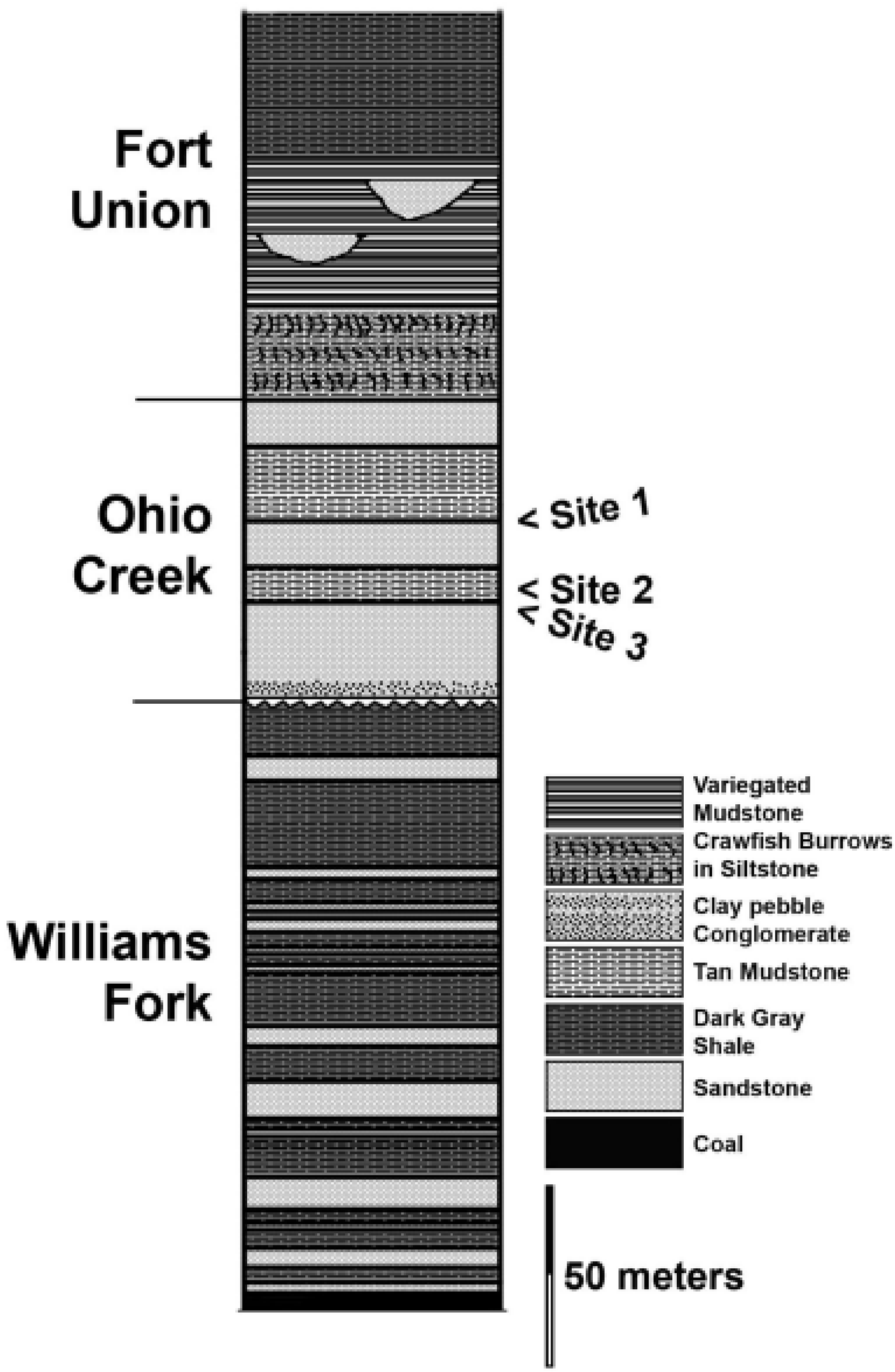

Figure 2. Composite stratigraphic column measured through the fossil producing sites.

MATERIAL AND METHODS

Fossils obtained in this study are restricted to the northern edge of the Piceance Creek Basin north of the White River, where the Ohio Creek Formation is readily distinguished from the coal-rich Williams Fork Formation below and the variegated mudstone and carbonaceous shales of the Fort Union Formation above (Fig. 1). The 2005 field crew collected fossils from the surfaces of anthills composed of eroded grains from lag deposits of the major sandstone units. A single unidentified turtle carapace fragment was found in situ. Other fossil reptiles were discovered from surface collection associated with site 1. Vertebrate fossils from the Ohio Creek Formation are scarce and show evidence of wear and breakage associated with fluvial transport. Specimens required minimal preparation. My assistant and I measured three stratigraphic sections across the fossil bearing sites using a Jacob staff and alidade (Fig. 2). All specimens collected are deposited at the University of Colorado Museum in Boulder (Catalogue designation UCM). Additional locality information is available at the University of Colorado Museum. Anatomical terminology follows that of Van Valen (1966).

SYSTEMATIC PALEONTOLOGY

REPTILIA Laurenti, 1768
EUSUCHIA Huxley, 1875
CROCODYLIA Gmelin, 1789
BOREALOSUCHUS Brochu, 1997
Type species—Borealosuchus sternbergii (Gilmore, 1910)
?BOREALOSUCHUS sp.
Figure 3

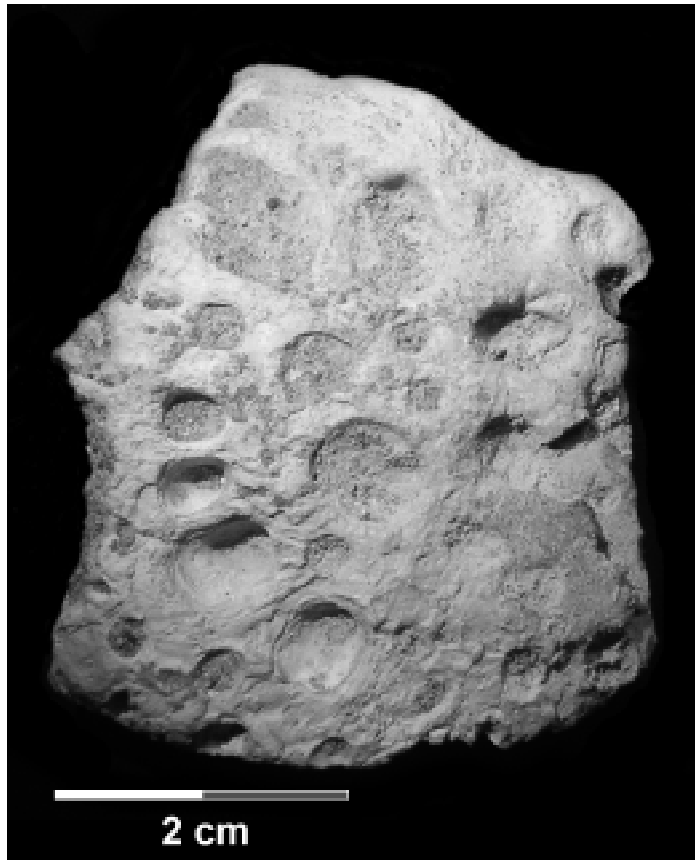

Figure 3. Dorsal osteoderm of ?Borealosuchus, UCM 99896 from Site 1 (L. 2005168).

Referred specimens— UCM 99896 from Site 1, dorsal osteoderm and possible cervical neural arch.

Discussion— The large dorsal osteroderm is characteristic of the genus *Borealosuchus*, although genotypic identification based on such scant material is only tentative. The osteoderm is square shaped and lacks any distinct crest or keel. The dorsal surface is pitted with large foramina. Named for a group of monophyletic species previous group with *Leidysuchus*, *Borealosuchus* is the sister taxon to modern alligators (Alligatoroidea) and crocodiles (Crocodyloidea) (Brochu, 1997). *Borealosuchus* is common in the late Cretaceous and Paleocene strata of North America. This specimen provides little information useful in determining the precise age of the Ohio Creek Formation.

TESTUDINES Batsch, 1788
DERMATEMYDIDAE Baur, 1888
COMPSEMYS Leidy, 1856
Figure 4
Type species—Compsemys victa Leidy, 1856
COMPSEMYS VICTA Leidy, 1856

Referred specimens— UCM 99897 from Site 1, hypoplastral bone fragment and fragments of costal plates from the carapace.

Discussion— Despite the fragmentary condition of this specimen, it nevertheless exhibits the characteristic relief indicative of the genus *Compsemys* (Hay, 1908, pt 34, figs. 2,3). *Compsemys* is known from the late Cretaceous and Paleocene of North America. Thus, it also provides little information useful in determining the precise age of the Ohio Creek Formation.

MAMMALIA Linnaeus, 1758
CIMOLESTA McKenna, 1975
CIMOLESTIDAE Marsh, 1889
GELASTOPS Simpson, 1935
Type species—Gelastops parcus Simpson, 1935
GELASTOPS PARCUS Simpson, 1935
Figure 5.1

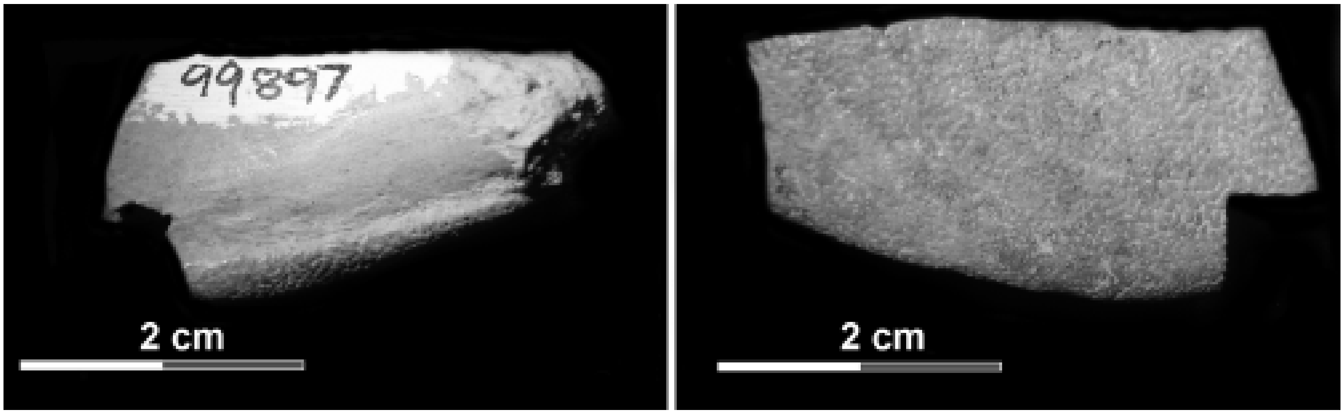

Figure 4. Partial hypoplastral of Compsemys victa, UCM 99897 from Site 1 (L. 2005168).

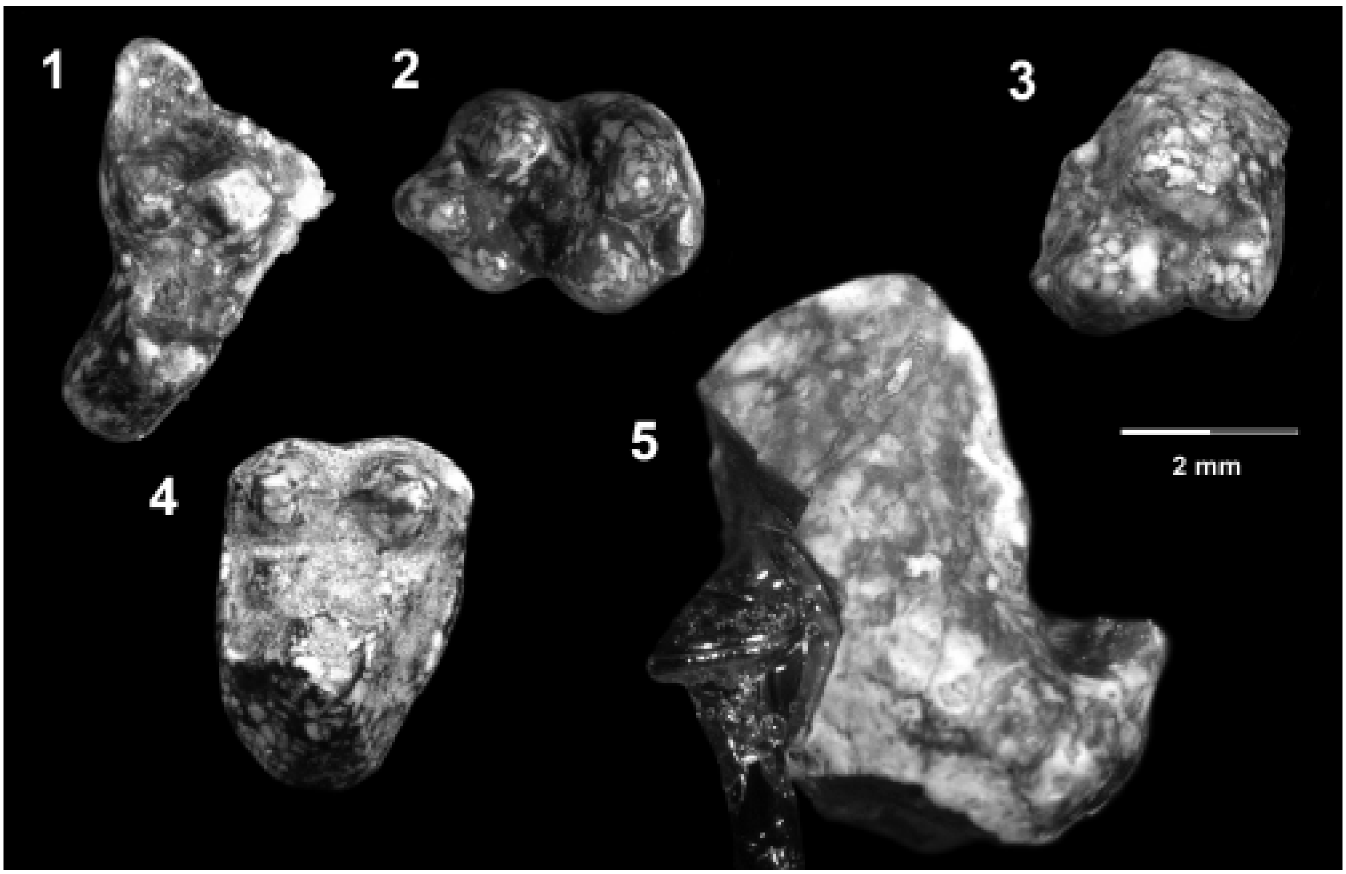

Figure 5. 1) Right upper first molar of Gelastops parcus, UCM 99898 from Site 1 (L. 2005168). **2)** Lower left third molar of Haplaletes pelicatus, UCM 99899 from Site 1 (L. 2005168). **3)** Left trigonid of the lower first molar of Mimotricentes subtrigonus, UCM 99921 from Site 1 (L. 2005168). **4)** Upper right first molar of Nannodectes simpsoni, UCM 99922 from Site 1 (L. 2005168). **5)** Left partial lower fourth premolar of Colpoclaenus keeferi, UCM 99920 from Site 3 (L. 2005169).

Referred specimens— UCM 99898 from Site 1, right upper first molar.

Description— Exhibiting a projecting metastyle, the narrow upper molar presents high paracone, metacone and protocone cusps, that approaches to some extent a zalambdodont condition. The metacone and paracone are closely oppressed with the metacone being the smaller of the two cusps. The tooth measures 3.10 mm in length and 4.78 mm in width.

Discussion— Similarities between the Ohio Creek specimen and specimens of *Gelastops parcus* collected from the Shotgun Member of the Fort Union Formation in Wyoming are apparent. Not only does the tooth exhibit identical morphology to the Shotgun specimens, but it is also of similar size (differing by less then 0.1 mm). *Gelastops* is restricted to the Paleocene of North American. This is only the second recorded occurrence of the genus south of the Wyoming border (Schiebout et al. 1987).

CONDYLARTHRA Cope, 1881
HYOPSODONTIDAE Trouessart, 1897
HAPLALETES Simpson, 1935
Type species.—Haplaletes disceptatrix Simpson, 1935
HAPLALETES PELICATUS Gazin, 1956
Figure 5.2

Referred specimens— UCM 99899 from Site 1, lower left third molar.

Description— Lacking a paraconid cusp and exhibiting a projecting hypoconulid, this specimen clearly represents a small hyopsodont mammal. The strong crista obliqua extends toward the buccal side of the metaconid. The entoconid and hypoconulid are well separated. The presence of pointed cusps indicates a relationship to the primitive hyopsodont *Haplaletes*. Distinguished by size, three species of *Haplaletes* are known from the Paleocene of North America. This specimen is in similar portions to the type specimen of *Haplaletes pelicatus* from the Saddle Locality of Bison Basin, Wyoming (Gazin, 1956). The tooth measures 3.45 mm in length and 2.36 mm in width.

Discussion.— Haplaletes pelicatus is only known from the late Paleocene (Tiffanian NALMA) of southwest and central Wyoming. This is the first report of this species in Colorado. As a consequence of its confined geographic range, *Haplaletes pelicatus* has limited biostratigraphic utility. However, the presence of *Haplaletes pelicatus* implicitly confines the age of the Ohio Creek Formation to at least the late Paleocene.

MIOCLAENIDAE Osborn and Earle, 1895
PROMIOCLAENUS Trouessart, 1904
Type species—Promioclaenus acolytus (Cope, 1882)
PROMIOCLAENUS ACOLYTUS (Cope, 1882)
Figure 6

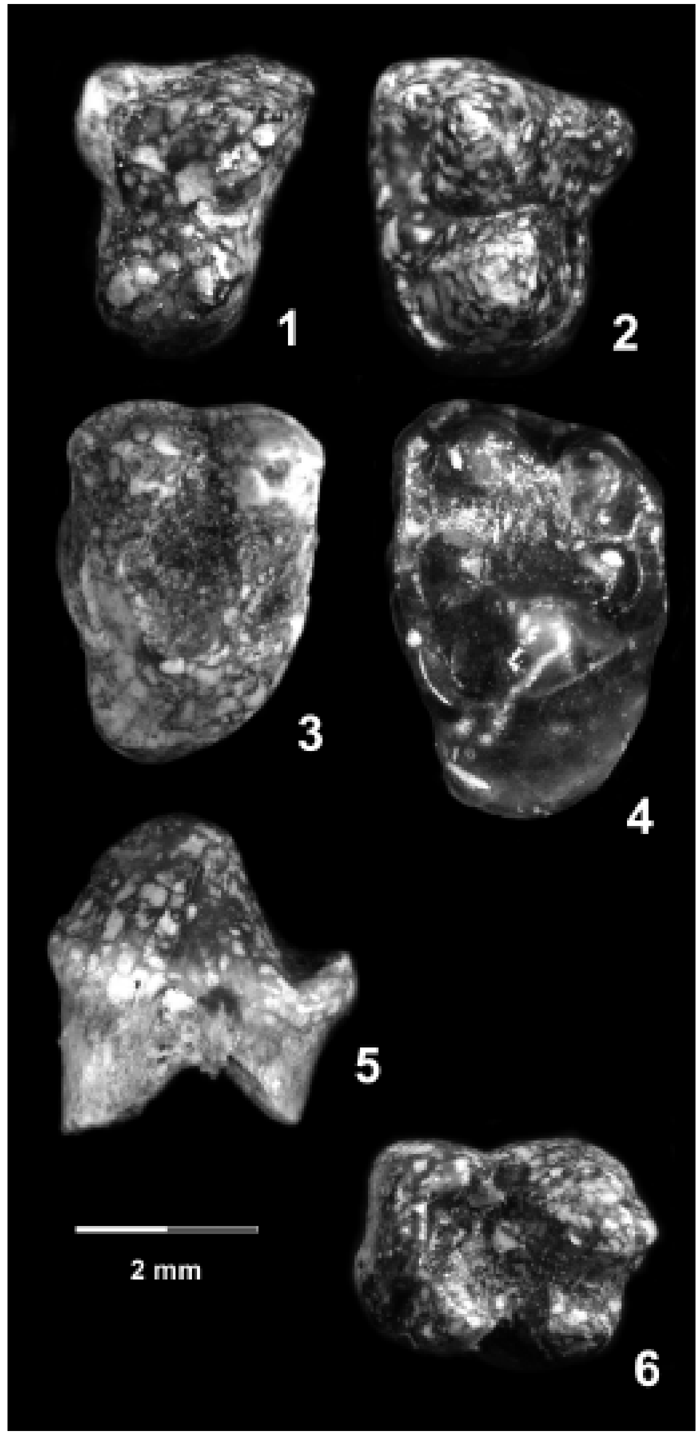

Figure 6. Promioclaenus acolytes specimens: **1)** UCM 99919 upper left fourth premolar from Site 1 (L. 2005168). **2)** UCM 99917 upper right fourth premolar from Site 1 (L. 2005168). **3)** UCM 99900 upper left second molar from Site 1 (L. 2005168). **4)** UCM 99915 upper left second molar from Site 2 (L. 2005174). **5)** UCM 99916 lower right third premolar from Site 1 (L. 2005168). **6)** UCM 99918 lower left second molar from Site 1 (L. 2005168).

Referred specimens— UCM 99900 upper left second molar, UCM 99916 lower right third premolar, UCM 99917 upper left fourth premolar, UCM 99918 lower left second molar, UCM 99919 upper right fourth premolar from Site 1 and UCM 99915 upper left second molar from Site 2.

Description— The upper fourth premolars contain two cusps, with a projecting mesial stylar shelf. The upper second molars lack hypocones and are bunodont. The mesial cingulum is better developed then the distal, which in UCM 99915 is barely present. The lingual edge of the upper molars is rounded and does not display much of a stylar shelf. The paraconule and metaconule are present, but rather indistinct. The lower third premolar is rather long, with a crest. The lower second molar has a highly reduced paraconid and a high metaconid and protoconid. The talonid basin is deep and crested distally by a low ecoloph. The lower second molar is square shaped. Measurements are given in Table 1. Comparisons with specimens of *Promioclaenus acolytes* from the Swain Quarry Fort Union Formation of southern Wyoming, reflect a similar size and morphology (Rigby, 1980). However, the Ohio Creek Formation upper molars are slightly less inflated, exhibiting a more tapered outline.

Discussion— Promioclaenus acolytes is the most common species in many Paleocene micro-mammalian sites across North America, having a range from Texas to Canada (Schiebout, 1974; Scott, 2003) and ranges from the late Puercan (Pu2) to the early Tiffanian (Ti3) NALMAs (Lofgren et al. 2004). *Promioclaenus acolytes* makes a good index fossil because of its wide geographic range and abundance.

ARCTOCYONIDAE Giebel, 1855
COLPOCLAENUS Patterson and McGrew, 1962
Type species—Colpoclaenus keeferi Patterson and McGrew, 1962
COLPOCLAENUS KEEFERI Patterson and McGrew, 1962
Figure 5.5

Referred specimens—UCM 99920 left partial lower fourth premolar from Site 3.

Description— This specimen represents the largest mammal collected from the Ohio Creek Formation. The posterior edge of the tooth is missing, but the distinct parastyle and crest on the mesial side is diagnostic of *Colpoclaenus*. The tooth is of a similar size to other specimens of *Colpoclaenus keeferi* from Wyoming, but has a more symmetrical profile. The tooth is 4.00 mm wide, with an undetermined total length.

Discussion—Colpoclaenus is the only recognizable mammal from Site 3. It indicates a similar age as Site 1 and 2, since *Colpoclaenus* is limited to the latest Torrejonian to earliest Tiffanian NALMA (Archibald, 1998). The myriad of arctocyonids that lived during the Paleocene is a reflection of their rapid diversification. Omnivorous diets permitted arctocyonids to exploit a wide range of niches and to increase in size through the Paleocene.

MIMOTRICENTES Simpson, 1937
Type species—Mimotricentes latidens Gidley in Simpson, 1937
MIMOTRICENTES SUBTRIGONUS (Cope, 1881)
Figure 5.3

Table 1
Measurements of specimens. P upper premolar, M upper molar, p lower premolar, m lower molar, tri trigonid; with numbered tooth positions.

Species	Catalogue Number	Tooth	Length (mm)	Width (mm)
Promioclaenus acolytus	UCM 99917	P4	3.00	3.72
Promioclaenus acolytus	UCM 99919	P4	2.80	3.47
Promioclaenus acolytus	UCM 99915	M2	3.10	4.70
Promioclaenus acolytus	UCM 99900	M2	2.95	4.53
Promioclaenus acolytus	UCM 99916	p3	3.60	1.68
Promioclaenus acolytus	UCM 99918	m2	3.50	2.89
Gelastops parcus	UCM 99898	M1	3.10	4.78
Haplaletes pelicatus	UCM 99899	m3	3.45	4.78
Colpoclaenus keeferi	UCM 99920	p4	?	4.00
Mimotricentes subtrigonus	UCM 99921	tri	?	?
Nannodectes simpsoni	UCM 99922	M1	2.84	4.13

Referred specimens— UCM 99921 left trigonid of the lower first molar from Site 1.

Description— The paraconid is smaller than the metaconid, but both cusps are relatively close together. The paralophid curves in its path from the paraconid toward the large protoconid cusps. This character is unique to arctocyonids. The size of the trigonid further identifies the specimen as *Mimotricentes subtrigonus*, a species common in the Swain Quarry of the Fort Union Formation of Wyoming (Rigby (1980). Described from a maxilla, *M. tedfordi* from the Goler Formation of California is smaller than *M. subtrigonus* (McKenna and Lofgren, 2003).

Discussion— *Mimotricentes* ranges through the Torrejonian to Tiffanian NALMA, and is a common component of many Paleocene mammalian faunas. Despite the fragmentary nature of the specimen, it does add to the overall diversity of the Ohio Creek fauna.

PRIMATES Linnaeus, 1758
PLESIADAPIDAE Trouessart, 1897
NANNODECTES Gingerich, 1976
Type species.—Nannodectes gazini Gingerich, 1976
NANNODECTES SIMPSONI (Gazin, 1956)
Figure 5.4

Referred specimens— UCM 99922 upper right first molar from Site 1.

Description— The upper molar exhibits a distinct Nannopithex fold descending from the distal surface of the protocone. This feature is a unique trait of pleisadapids and higher primates. The metaconule and paraconule are distinct. The mesial edge of the tooth exhibits a wide cingulum. Measuring 2.84 mm in length and 4.13 mm in width, the specimen is within the mean values of *Nannodectes simpsoni* reported by Gingerich (1976) (Fig. 7).

Discussion— *Nannodectes simpsoni* is an index fossil for the *Plesiadapis rex/Plesiadapis churchilli* lineage zone (Ti3) (Lofgren et al., 2004). This further reduces the age of the Ohio Creek Formation to well within the Tiffanian NALMA. It is somewhat odd that the closely related *Plesiadapis rex* is absent from the Ohio Creek Formation, because it is one of the most abundant species from other Ti3 fossil sites, such as the Cedar Point Quarry in the Bighorn Basin of northern Wyoming (Rose, 1981). The absence of *Plesiadapis rex* is likely due to the scarcity of fossils from the Ohio Creek Formation.

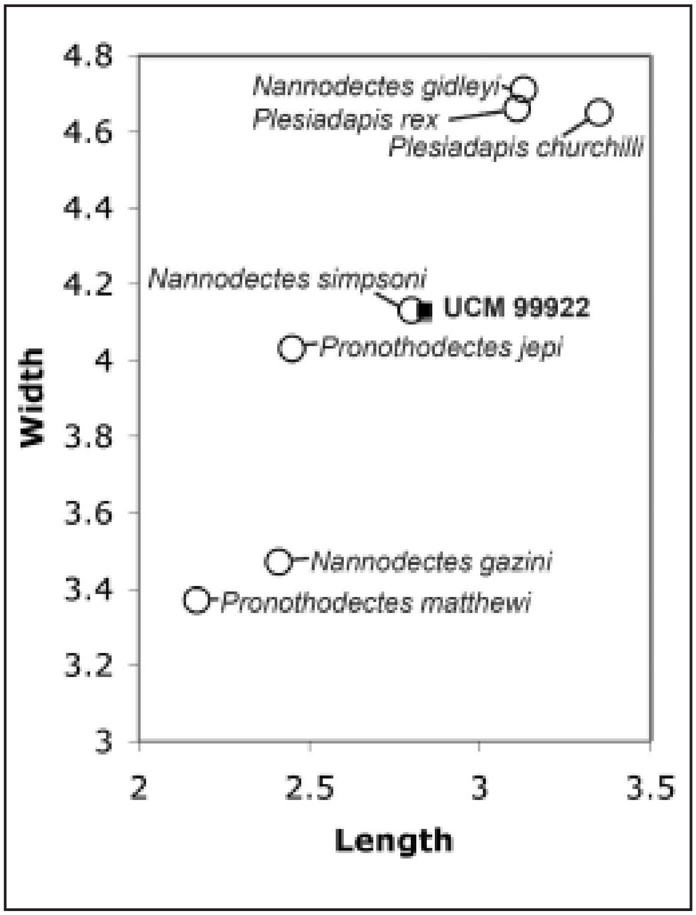

Figure 7. Graph of measured dimensions of UCM 99922 projected on mean values of width and length in millimeters of species of pleisadapids reported in Gingerich, 1976.

BIOSTRATIGRAPHY

The vertebrate fauna from the Ohio Creek Formation comprises both Torrejonian and Tiffanian species. However, the presence of both *Haplaletes pelicatus* and *Nannodectes simpsoni* places the age of the Ohio Creek Formation in the early Tiffanian, with *Nannodectes simpsoni* indicative of the Ti3 lineage zone. The Ti3 lineage zone is well represented from a number of fossil localities across western North America (Lofgren et al., 2004). The Ohio Creek fauna is most similar to fossil localities located in southern and central Wyoming, including the Ledge, Saddle Annex, and West End localities in the Bison Basin (Gazin, 1956). Further north in the Bighorn Basin and Crazy Mountain Field, paleomagnetic analysis has demonstrated that the Ti3 lineage zone is within the C26r chron (Secord et al., 2006; and others in Lofgren et al., 2004). This places the absolute age of the Ohio Creek Formation at ~60 m. y. (late Paleocene).

DISCUSSION

This study finds that the Ohio Creek Formation is late Paleocene in age (early Tiffanian, Ti3 lineage zone), placing the initial Tertiary sedimentation of the northern Piceance Creek Basin at roughly 60 mya. Comparison with surrounding

Laramide basins points out an apparent delay in sedimentation of 3-8 m.y. for the Piceance Creek Basin (Gries, 1983; Dickinson et al., 1988). The delay in sedimentation is interpreted as a consequence of a progradational succession toward the center of the basin from the southeastern margin. Following a sequence stratigraphic model, one would expect to find a wide range of ages for various portions of the Ohio Creek Formation and a significant increase in thickness toward the southeast. Isopach maps and published thicknesses for the Ohio Creek Formation do show a significant increase toward the southeast constant with this model (Johnson and Flores, 2003; Patterson et al., 2003; Cumella, 2006). However, to date there is no evidence of early Paleocene sediments in the Piceance Creek Basin. Further study of rocks, particularly in the southeast, need to be made to determine the age of the Ohio Creek Formation from a wider geographic region. Lacking fossils, paleomagnetic analysis may prove the most valuable tool in discerning the correct history of the Piceance Creek Basin.

CONCLUSIONS

This study presents the first vertebrate fauna from the Ohio Creek Formation, a fauna that corroborates a late Paleocene age. This late Paleocene fauna is further confined to the early Tiffanian NALMA, Ti3 lineage zone. Comparisons to adjacent Laramide Basins indicate a possible delay in the initial Tertiary sedimentation of the Piceance Creek Basin of 3 to 8 m.y. This delay is hypothesized to have resulted from a progradational succession of deposition westward. However, confirmation of this hypothesis will only come with the discovery of early Paleocene rocks in the Piceance Creek Basin.

ACKNOWLEDGMENTS

All fossils were collected from Bureau of Land Management Lands, under a permit issued to the University of Colorado Museum. The Tuttle family granted access to the site. The 2005 field crew included, J. Eberle, M. Eberle, T. Culver, P. Monaco, J. Honey and K. Lloyd who discovered Site 1. I. Sweeney and A. Dutchak assisted in measuring stratigraphic sections. Funding for this research was provided by the University of Colorado Museum William H. Burt Fund, Colorado Scientific Society Ogden Tweto Fund, and a Geological Society of America research grant.

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