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Terrestrial mammal fossils from the Wildcat Creek Beds (Paleogene), Tieton River Area, south-central Washington, USA

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ABSTRACT

Fossil mammals from two units of the Wildcat Creek beds, a distal facies of the volcanogenic Ohanapecosh Formation in the Tieton River area, 30 miles southeast of Mount Rainier are described. A tooth fragment of a rhinocerotid or hyracodontid from the Milk Creek tuff is suggestive of a post middle Chadronian age and is supported by a published zircon fission track age of 34 Ma. This date places the fossil as the oldest terrestrial mammal recovered from Washington. Isolated elements collected from the overlying upper Wildcat Creek beds belong to *Cormocyon copei*, *Enhydrocyon* sp., *Parenhydrocyon josephi*, a cricetid rodent, cf. *Palaeolagus* sp., ?*Miohippus equinanus*, *Miohippus equiceps*, *Diceratherium annectens*, *Promerycochoerus superbus*, *Eporeodon* sp., *Merycoides* sp., *Mesoreodon* sp., *Hypertragulus* sp., and a tayassuid. These taxa comprise the Wildcat Creek local fauna and represent a biogeographic extension of the middle John Day fauna of eastern Oregon of late early Arikareean age. This biochronology is supported by $^{40}Ar/^{39}Ar$ radiometric ages of 27.16 ± 0.19 and 26.97 ± 0.30 Ma from beds constraining the upper Wildcat Creek beds. The Wildcat Creek local fauna lived in a moist seasonal environment, indicated by a Goshen-type paleoflora in the lower Ohanapecosh Formation and supported by a succession of Argillisols and Gleysols to gleyed Protosols.

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KEY WORDS: Paleogene; North America; mammals; sedimentology; faunal composition; geochronology

INTRODUCTION

Fossil mammals preserved in distal volcaniclastic sediments of the Ohanapecosh Formation record late Eocene and Oligocene terrestrial environments in the Tieton River area, located 30 miles southeast of Mount Rainier in south central Washington (Figure 1). Fieldwork since the 1930s resulted in the collection of 34 specimens of terrestrial mammals along Wildcat Creek and one specimen along Milk Creek. These fossils are the oldest non-marine mammals recovered from Washington and represent a new data point to examine the biogeography of mammals in North America. This

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FIGURE 1. Location map of the Tieton River area in North America. Modified from Grant (1941).

study is the first detailed description of the specimens and seeks to understand them by developing a stratigraphic and paleoenvironmental framework.

MATERIAL AND METHODS

Specimens examined in this study are curated at the University of California Museum of Paleontology (UCMP), Burke Museum at the University of Washington in Seattle (UWBM), and the John Day Fossil Beds National Monument (JODA). Specimen identifications and descriptions were facilitated by comparison to collections at the UCMP and UWBM, and literature descriptions and figures. During the fieldwork for this study, the author and colleagues measured sections and systematically collected fossils to document their stratigraphic occurrence.

The general stratigraphic context of the Tieton River area, shown in Figure 2, is based on Swanson (1964, 1978) and Vance et al. (1978). Stratigraphic sections were measured for the Milk Creek tuff and the Wildcat Creek beds where fossils were collected from prior fieldwork (Figure 3). Two additional sections measured along Thunder Creek record the complete sequence of the upper Wildcat Creek beds. Geological hand samples were collected systematically and identified by thin section and x-ray diffraction analyses. Geological descriptions follow White and Houghton (2006) for grain size classifications, Fisher (1961) and Smith (1987) for rock descriptions, and Mack et al. (1993) for paleosol classification.

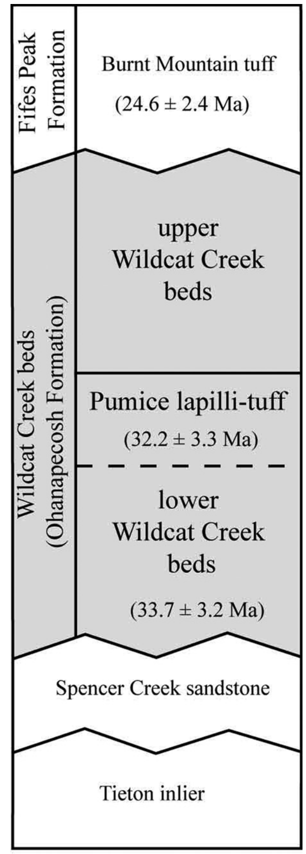

FIGURE 2. Generalized stratigraphy of the Tieton River area. Based on Swanson (1964, 1978) and Vance et al. (1987).

Specimen measurements were made with Vernier-type dial calipers and are to the nearest 0.1 mm. Dental terminology follows Tedford et al. (1996) for canids, Dawson (1958, 2008) for leporids, Evander (2004) and Prothero and Shubin (1989) for equids, Prothero (2005) for rhinocerotids, Gentry and Hooker (1988), and Loomis (1925) for artiodactyls. Upper dentitions are designated with upper case letters, and lower case letters correspond to lower dentition.

North American Land Mammal Age designations follow Tedford et al. (2004). Taxonomic occurrences in North America were gathered from Janis et al. (1998) and supplemented by Wang (1994), Wang et al. (1999), Tedford et al. (2004), Stevens and Stevens (2007), and Albright et al. (2008). Age estimates of North American fossil localities follow Tedford et al. (2004) and are supplemented by Albright et al. (2008).

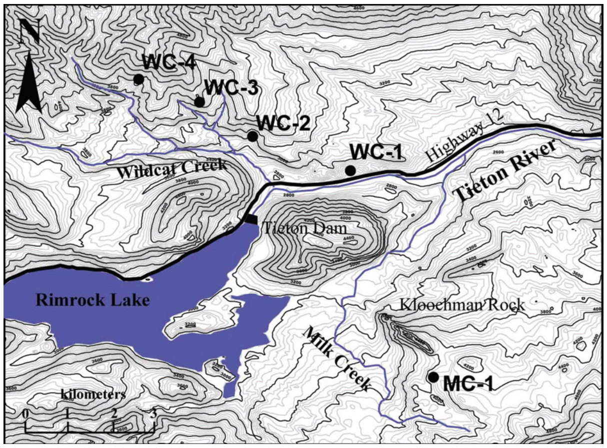

FIGURE 3. Study area map of localities and geographic features discussed in text. MC-1 = Milk Creek tuff, WC-1 = Highway 12, WC-2 = Unnamed Tributary-East, WC-3 = UnnamedTributary-West, and WC-4 = Thunder Creek.

STRATIGRAPHY AND SEDIMENTOLOGY

The Cenozoic geology of south central Washington is heavily influenced by volcanism and tectonism from the Cascade volcanic arc, shown by andesitic and dacitic lava flows, pyroclastic flows, and igneous intrusions (Vance et al. 1987). Volcaniclastics and lava flows of the Ohanapecosh Formation extend from the Columbia River Gorge to Snoqualmie Pass, and represent early volcanism of the Cascade arc in south central Washington (Vance et al. 1987). Early work (Grant 1941) defined these strata as the lowest unit in the Keechelus series, which was later split into the Ohanapecosh Formation and the Fifes Peak Formation (see Waters 1961 for discussion).

The Ohanapecosh Formation unconformably overlies Eocene quartzose sandstones, silicic volcaniclastic rocks, and subaerial basalt flows (Vance et al. 1987). The type locality of the Ohanapecosh Formation in Mount Rainier National Park comprises three major units: lava flows and interbedded mud flow tuffs; tuff-breccias; and debris-flow tuffs. It also includes minor accumulations of ash-flow tuffs (Fiske 1963). The Ohanapecosh Formation is over 1000 m thick, including near-source vent deposits (Fiske 1963; Fiske et al. 1963). Fiske et al. (1963) interpreted these as subaqueous deposits, citing normal grading and sheet-like deposition of the finer grained beds, splintering and shattering of the lavas, rare ripple marks, and channel crossbeds as evidence. Plant fossils preserved in equivalent-aged deposits west and south of the park indicate terrestrial input (Fiske 1963).

In the Tieton River area, the Cenozoic strata lie unconformably upon the Tieton inlier, metasediments of Jurassic and Cretaceous age (Swanson 1964, 1978, Vance et al. 1987). The Spencer Creek sandstones and volcaniclastic rocks, Eocene in age, crop out along the southwestern margin of the Tieton inlier (Swanson 1964, 1978).

The Wildcat Creek beds are over 300 m of volcaniclastic deposits exposed northeast of the inlier. The stratigraphic position, alteration, and normal grading common in the unit indicate that the Wildcat Creek beds are a distal volcaniclastic facies of the Ohanapecosh Formation (Swanson 1964, 1978).

This study follows Swanson's (1964, 1978) informal designation of three distinct units. The lower Wildcat Creek beds consist of over 20 m of pedogenically altered tuffs cropping out near Milk Creek and along Wildcat Creek. One tooth, belonging to a rhinocerotid or hyracodontid (UCMP 65230), was collected previously near Milk Creek. The middle unit, informally called the pumice lapilli-tuff unit, is a 20 m thick lapilli-tuff with distinct blue-green pumice lapilli that produced no fossils. The upper Wildcat Creek beds are 260 m of altered volcaniclastic tuffs and lapillistones. Thirty-four fossil specimens of at least 14 taxa of terrestrial mammals have been recovered from this unit, which is the primary focus of this study.

The Burnt Mountain Tuff of the Fifes Peak Formation unconformably overlies the Wildcat Creek beds and is distinguished by exhibiting relatively less alteration. Exposures of rocks similar to the Wildcat Creek beds crop out north of the study area, but are beyond the scope of this project.

Lower Wildcat Creek Beds

Swanson (1964, 1978) defined the Milk Creek tuff as red to violet tuffs exposed south of Kloochman Rock (Figure 4). The contacts overlying and underlying the Milk Creek tuff are covered by vegetation, but the similar dip to the Wildcat Creek beds exposed along Wildcat Creek, 15 to 20 degrees to the northeast, suggests a conformable contact between the Milk Creek tuff and the pumice lapilli tuff (Swanson 1964, 1978).

The Milk Creek tuff is 15 m of pedogenically altered silts and clays. One soil profile, with five units, was measured. Unit one is 26 to 36 cm thick and consists of a slightly calcareous silty layer with mud-rich pebbles. Clay-rich coatings are common throughout this unit. The upper boundary is irregular and sharp with 2 to 3 cm of relief.

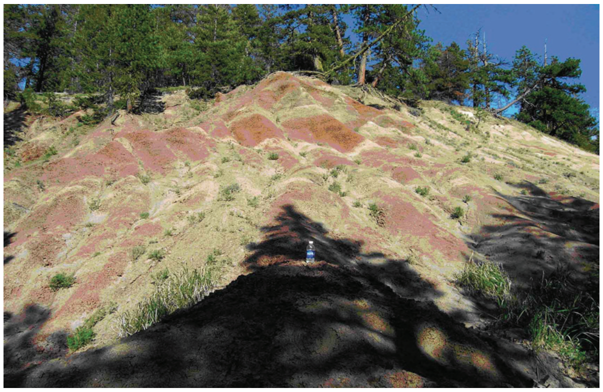

FIGURE 4. Milk Creek tuff, exposed south of Kloochman Rock. Light gray layers represent unit 1, and the red layers encompass units 2 through 5.

Unit two is a silt-rich mudstone with medium to coarse subangular blocky ped structure, 16 to 35 cm thick. The exterior of peds is covered in argillans. The upper boundary is smooth and sharp.

Unit three, about 30 cm thick, is a claystone-rich layer with medium-sized sand grains with platy to medium subangular blocky structure. The unit is weakly calcareous with abundant fine prominent mottles. The upper boundary is smooth and sharp.

Unit four is about 40 cm thick and consists of silty claystone with medium subangular blocky structure. Prominent fine mottles discontinuously coat ped surfaces. The upper boundary is gradual and smooth, 5 to 10 cm in relief.

Unit five is 31 cm thick and consists of silty claystone with medium subangular blocky to fine prismatic structure. Common medium mottling occurs throughout this unit. The upper boundary is smooth and sharp, and the overlying unit resembles unit one.

The small amount of illuvial material in units one and two is suggestive of C and BC horizons, respectively. Units three and four are interpreted as Bt_2 and Bt horizons, respectively, because of the abundant argillans, and Unit five is a Bw horizon. Bt horizons are characteristic of Argillisols (Mack et al. 1993).

Along Wildcat Creek, the lower Wildcat Creek beds consist of 30 m of massive extremely fine to fine tuffs. The contacts below and above this unit are covered. Common slickensides, orange mottling, and low chroma color indicate that the lower Wildcat Creek beds are Gleysols or gleyed Protosols (Mack et al. 1993).

FIGURE 5. The pumice lapilli-tuff unit exposed along State Highway 12 (1). Long tube pumice lapilli clasts are shown in hand sample (2) and thin section (3).

Upper Wildcat Creek Beds

The upper Wildcat Creek beds crop out north of the Tieton River, 2 km east of the mouth of Wildcat Creek, and along the north side of the Wildcat Creek drainage to Burnt Mountain. The four exposures examined are correlated by the lapilli-tuff unit (Figure 5). The pumice lapilli tuff unit is at least 13.5 m thick and contains abundant pebble sized long tube pumice lapilli that make up about 10% of the rock. The abundance of the pumice lapilli increases abruptly 50 cm below the top to the unit, making this unit more resistant. The contact between the pumice lapilli-tuff and the upper Wildcat Creek beds is gradual, about 1 m of extremely fine ash, with no pumice.

The thickness of the exposed upper Wildcat Creek beds increases from the southeast to the northwest, from 150 m at the Highway 12 locality to 260 m along Thunder Creek. The upper Wildcat Creek beds are separated into two main lithologic units, a lower unit A and unit B. Unit A is characterized by massive pale olive extremely fine to fine tuffs with crudely bedded pale olive to pale green coarse tuff intercalations. Contacts between the massive and crudely bedded layers are undulatory, up to 20 cm in relief (Figure 6.1). The crude beds are coarse ash tuffs with subparallel bedding, typically forming laterally discontinuous ledges less than tens of meters in extent (Figure 6.2). Subrounded and coarse ash-sized pumice clasts comprise 10% to 20% of the finer tuffs and are typically normally graded. The coarse tuffs contain medium to very coarse ash-sized sub-euhedral plagioclase feldspar phenocrysts, coarse to very coarse ash-sized pumice clasts, rare hornblende phenocrysts, and rare lithic clasts. The fine tuffs contain less than 5% very fine ash-sized plagioclase. Horneblende and opaque minerals are rare. X-ray diffraction analyses indicate the matrix is primarily

FIGURE 6. Bedding characteristics in outcrop view. Undulatory contacts (1) and discontinuous bedding (2) are common in the upper Wildcat Creek beds.

FIGURE 7. FIGURE 7. Lapillstone ledges east of the unnamed tributary (1). A prominent lapillistone, shown with an arrow, was used to correlate the break in section in Figure 11. Handsample view of a lapillistone (2).

clinoptolite and heulandite, zeolites that are typical alteration products in weathered vitreous volcaniclastic sediments (Fisher and Schminke 1984). No fossils were recovered from unit A.

Unit B is characterized by massive 0.5 to 10 m thick fine ash tuffs intercalated with 10 to 50 cm lapillistone beds (Figure 7). The contact between units A and B is placed at the lowest lapillistone bed. The lapillistones commonly form resistant ledges, which are traceable within an outcrop, but are difficult to correlate between localities due to similarities between lapillistones. The lapillistones contain well sorted, subangular to rounded, very coarse to fine lapilli-sized mudclasts and pumice, and glass shards, finer plagioclase and amphibole crystals. The lapillistones contain no matrix and are cemented primarily by heulandite, appearing white in handsample. The lapillistones grade to lapilli-tuffs, with fewer and finer mudclasts supported by fine ash matrix. Thirty-four fossil mammal specimens representing 14 taxa have been collected from unit B and are detailed below.

An accessory unit, a breccia couplet, is found in most sections but at varying stratigraphic levels (Figure 8). It is a massive framework-supported breccia, approximately 20 to 50 cm thick overlain by a matrix-supported breccia. Poorly sorted angular granule- to pebble-sized lithic clasts comprise both breccias, but the matrix-supported breccia is crudely bedded and consists predominantly of coarse ash with rare lapilli-sized pumice fragments. The framework-supported breccia is more resistant and crops out where the matrix- supported breccia is covered, except on ridges and roadcuts. Framework-supported breccias are found in unit B, without the overlying matrix-supported breccia. No fossils have been collected from the breccias.

Highway 12 Section. The exposure north of State Highway 12 along the Tieton River, 2 km downstream from Wildcat Creek, was measured. The section measures from the pumice lapilli tuff, near State Highway 12, to the covered top of the upper Wildcat Creek beds in drainages to the north (Figure 9). The pumice lapilli tuff unit is at least 13.5 m thick, with a covered base.

The lower 60 m of the upper Wildcat Creek beds comprise unit A, and are largely covered in vegetation except for drainages and roadcuts. A 1 m thick extremely fine tuff overlies the pumice lapilli tuff, with a sharp contact. Where exposed, coarse tuffs crop out as discontinuous ledges. A breccia couplet is best exposed in a roadcut along Highway 12, 40 m above the pumice lapilli-tuff, and exhibits no significant change in thickness. There is a sharp contact between a lapillistone ledge, representing the base of unit B and unit A.

Unit B is 100 m thick. The lapillistones and massively bedded fine tuffs show no significant change in thickness, and can be traced approximately 750 m throughout the locality. R-type accretionary lapilli (*sensu* Schumacker and Schminke 1991) are preserved near the top of an extremely fine tuff bed exposed along a road cut about 300 m east of the measured section (Figure 10). A 20 cm thick cross bedded coarse tuff crops out as a prominent ledge, 135 m above the pumice lapilli tuff, near the top of the exposure. Fossil localities are shown in Figure 2.

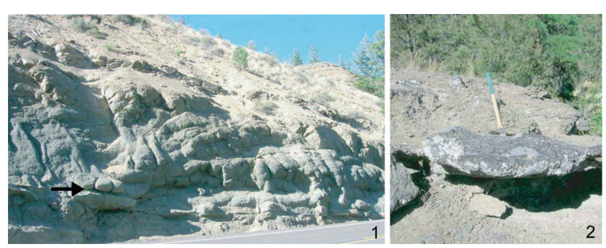

FIGURE 8. Breccia couplets along Highway 12 (1) and the western unnamed tributary (2). An arrow (1) shows the contact between the framework-supported breccia and the overlying matrix-supported breccia.

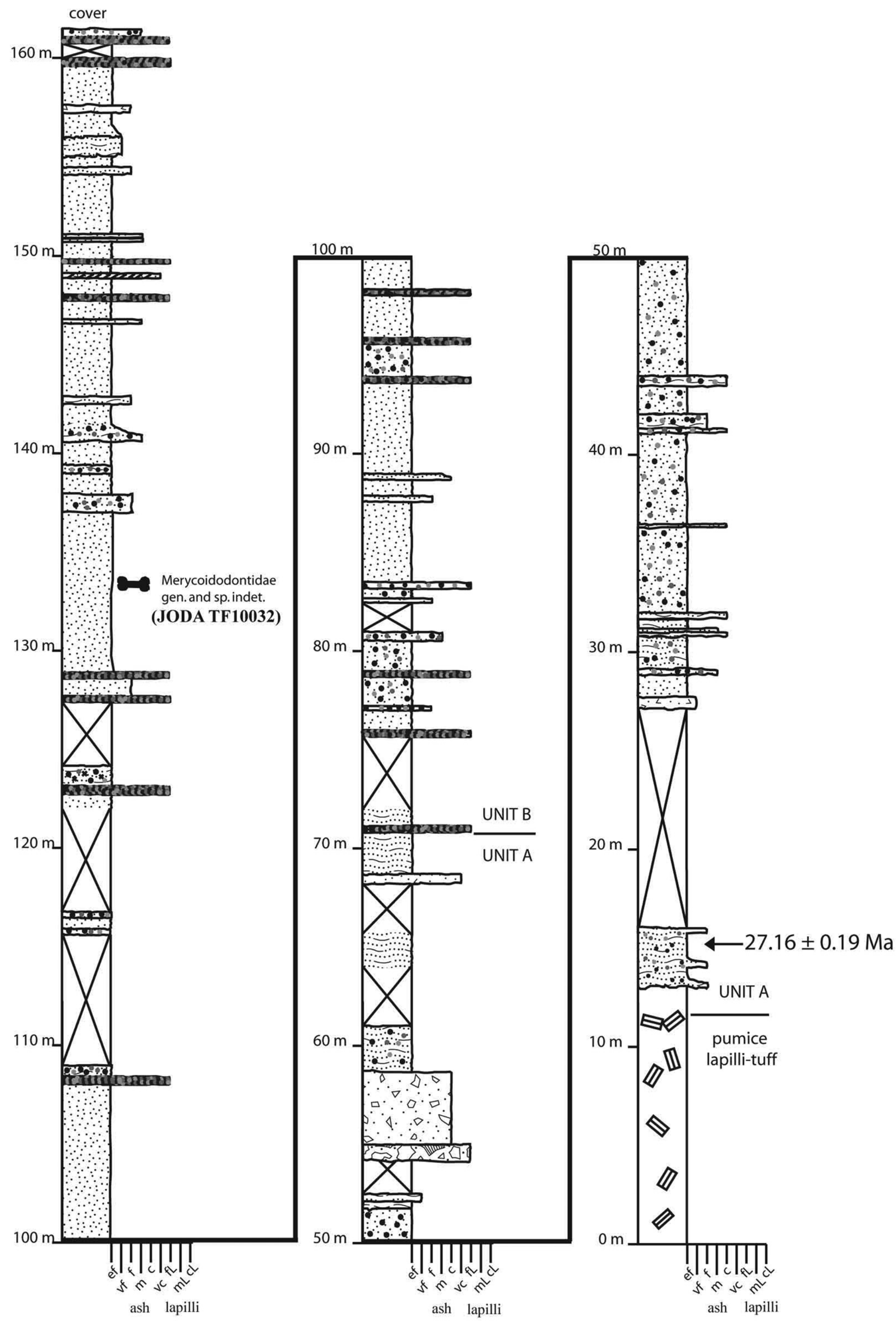

FIGURE 9. Highway 12 Section. Symbols as in Appendix.

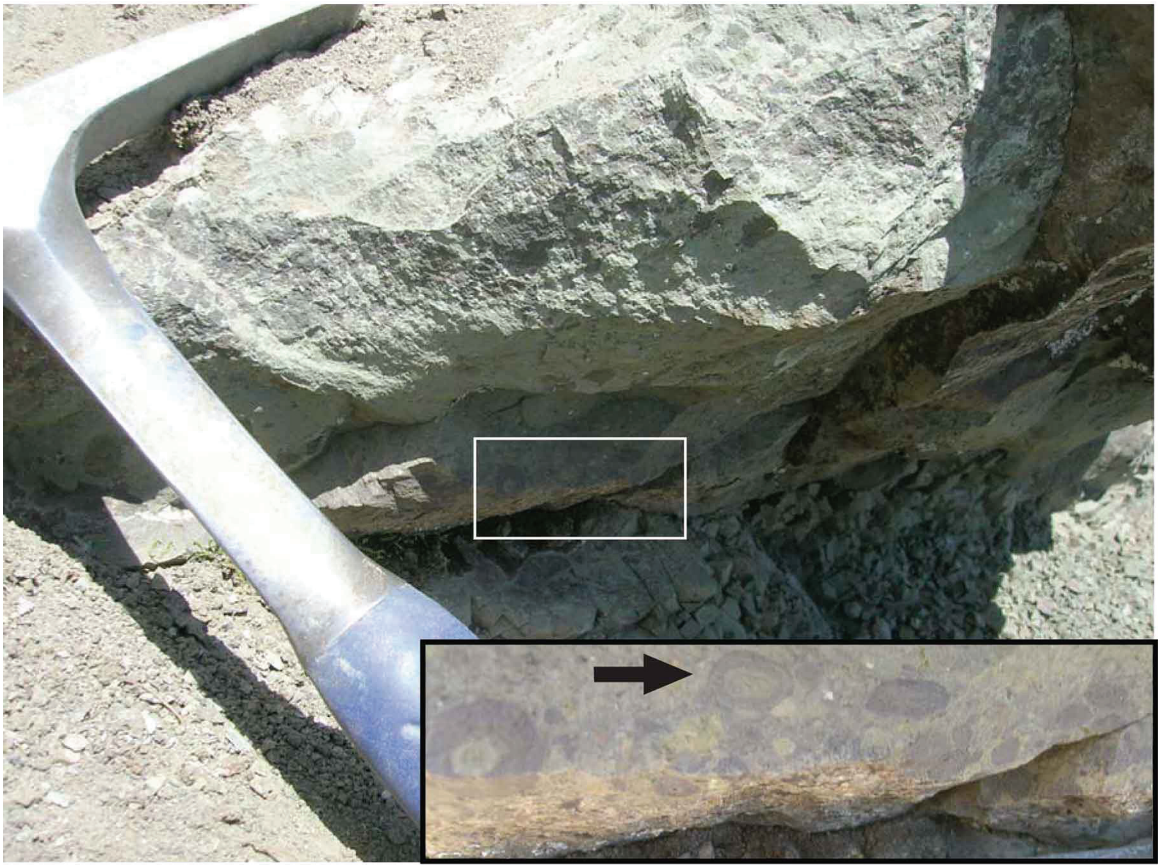

FIGURE 10. Accretionary lapilli in hand sample.

Unnamed Tributary-East Section. The upper Wildcat Creek beds are exposed east of an unnamed tributary of Wildcat Creek, where fossil collecting efforts in the area have focused since Grant's initial discovery in 1939. This section contains 165 m of the upper Wildcat Creek beds, from the top of the pumice lapilli-tuff to vegetation cover (Figure 11). The pumice lapilli tuff crops out in a small ridge along Wildcat Road. The layer with the highest concentration of pumice lapilli correlates with the top of the unit, as in the exposures along State Highway 12.

The lower 60 m of the section, unit A, is covered with vegetation. The strata above the cover crop out on steep slopes and are coarse tuffs and 0.2 to 0.5 m thick lapillistone intercalations of unit B.

The base of the exposure is a 1 m massive coarse tuff overlain by a lapillistone. This lapillistone is treated as the contact of units A and B, 60 m above the pumice lapilli tuff. Crude normal grading of ash matrix and mudstone clasts is common in the lower 40 m of unit B. The highest strata, 150 m above the pumice lapilli tuff, are exposed in the eastern part of this locality. Reverse grading and massive bedding are common in these upper strata, and they contain abundant, very coarse ash-sized, euhedral plagioclase phenocrysts, and pumice fragments. The highest exposed bed is a 0.1 m thick framework-supported breccia.

Unnamed Tributary-West Section. Exposures along the fork of the unnamed tributary represented the western extent of fossil vertebrate discoveries prior to this work. A prominent ledge, near the fork of the two arms of the unnamed tributary, is the top of the pumice lapilli-tuff. This section includes 210 m up from the base to vegetation cover (Figure 12). The base of the outcrop is largely covered, but thin, 10 to 20 cm coarse tuffs crop out intermittently above the pumice lapilli tuff. Unit A is 50 m thick and represented by extremely fine tuff beds, 0.5 to 10 m thick, and 0.1 m very coarse tuff beds. Normal and reverse graded beds crop out in the upper 20 m of unit A. A lapillistone intercalation, 50 m from the base of the section, marks the base of unit B. The presence of cross-bedding below this intercalation, in unit A, contrasts with the exposures to the east, where

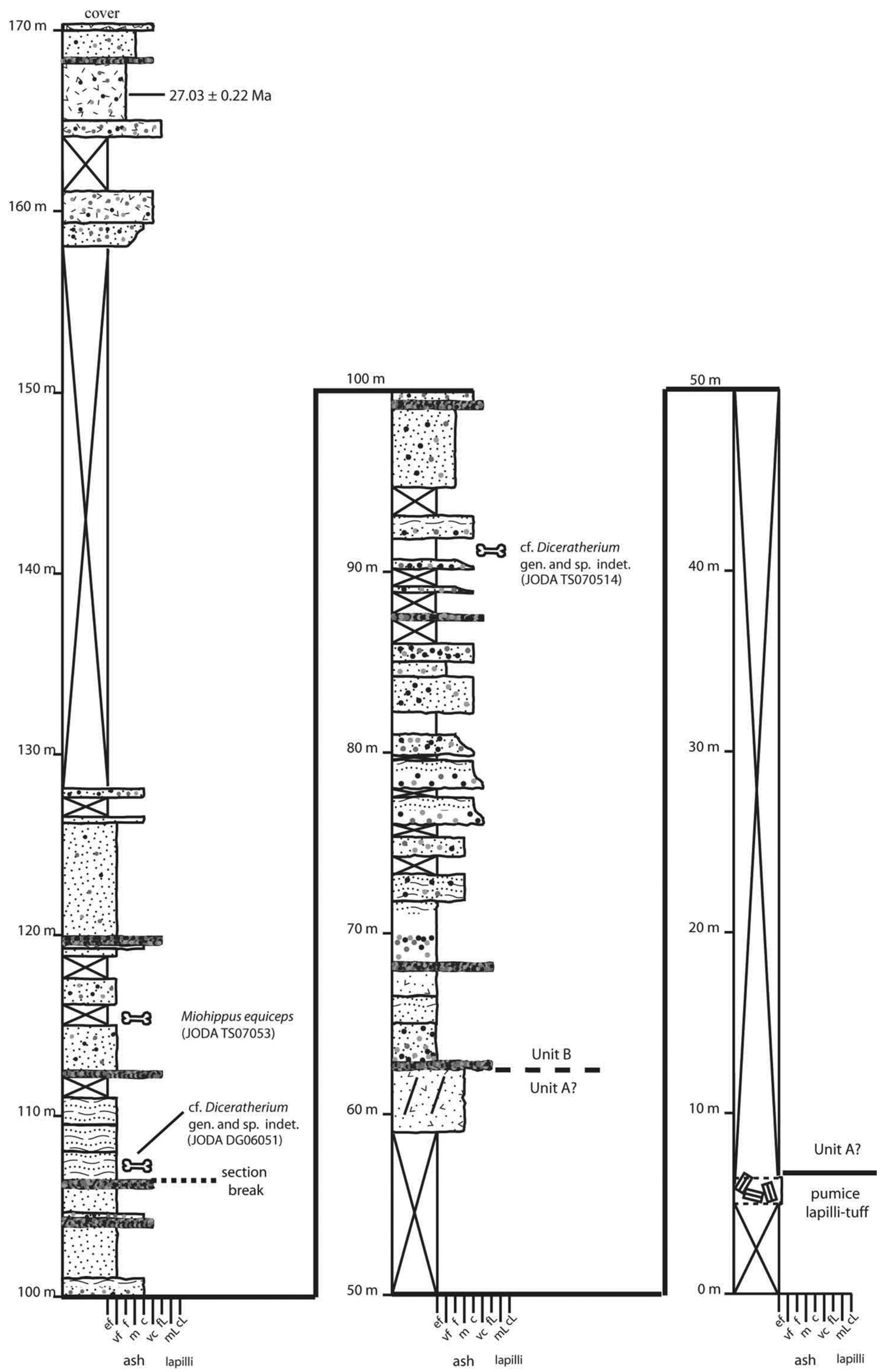

FIGURE 11. Unnamed Tributary East Section.

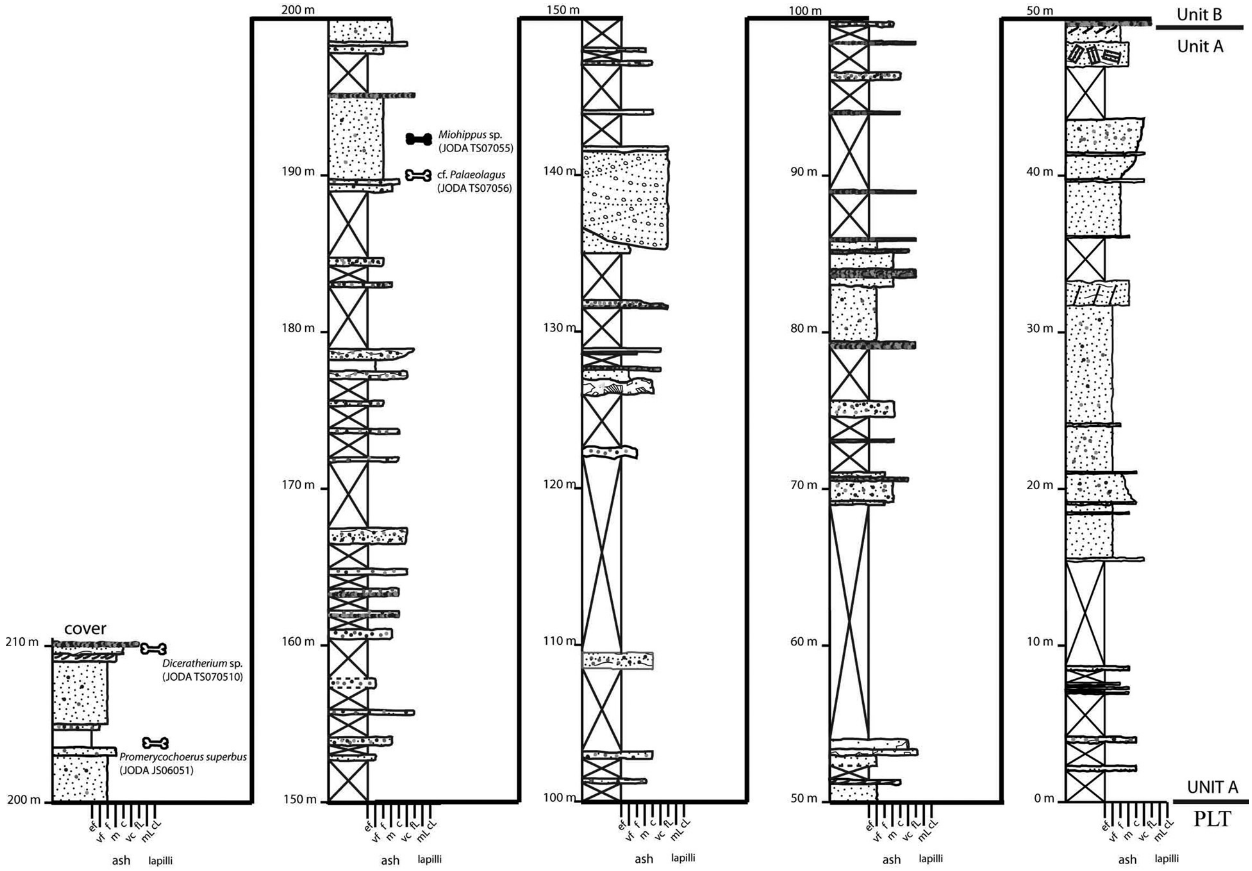

FIGURE 12. Unnamed Tributary West Section.

crossbedding, if preserved, is present near the top of the exposures in unit B.

A breccia couplet forms the southern point of the ridge that separates the east and west arms of the unnamed tributary. A 0.5 m thick framework-supported breccia is overlain by a coarse ash matrix-supported breccia. The contact between the two is abrupt and wavy with 0.05 to 0.1 m of relief. The thickness of the matrix-supported breccia is not known. Unit B is 165 m of coarse ash tuffs with intercalated lapillistones (Figure 13). An angular lithic clast framework-supported breccia, 1 m thick, crops out 60 m into unit B and contains lapilli-sized pumice clasts.

A prominent coarse tuff, 10 m thick, crops out on the ridge, and pinches out laterally. The tuff contains cross beds defined by normal grading. The uppermost 60 m of strata are extremely fine to fine

FIGURE 13. Unit B, upper Wildcat Creek beds, exposed along the western unnamed tributary. Arrow indicates location of prominent coarse tuff at base of fossil bearing strata.

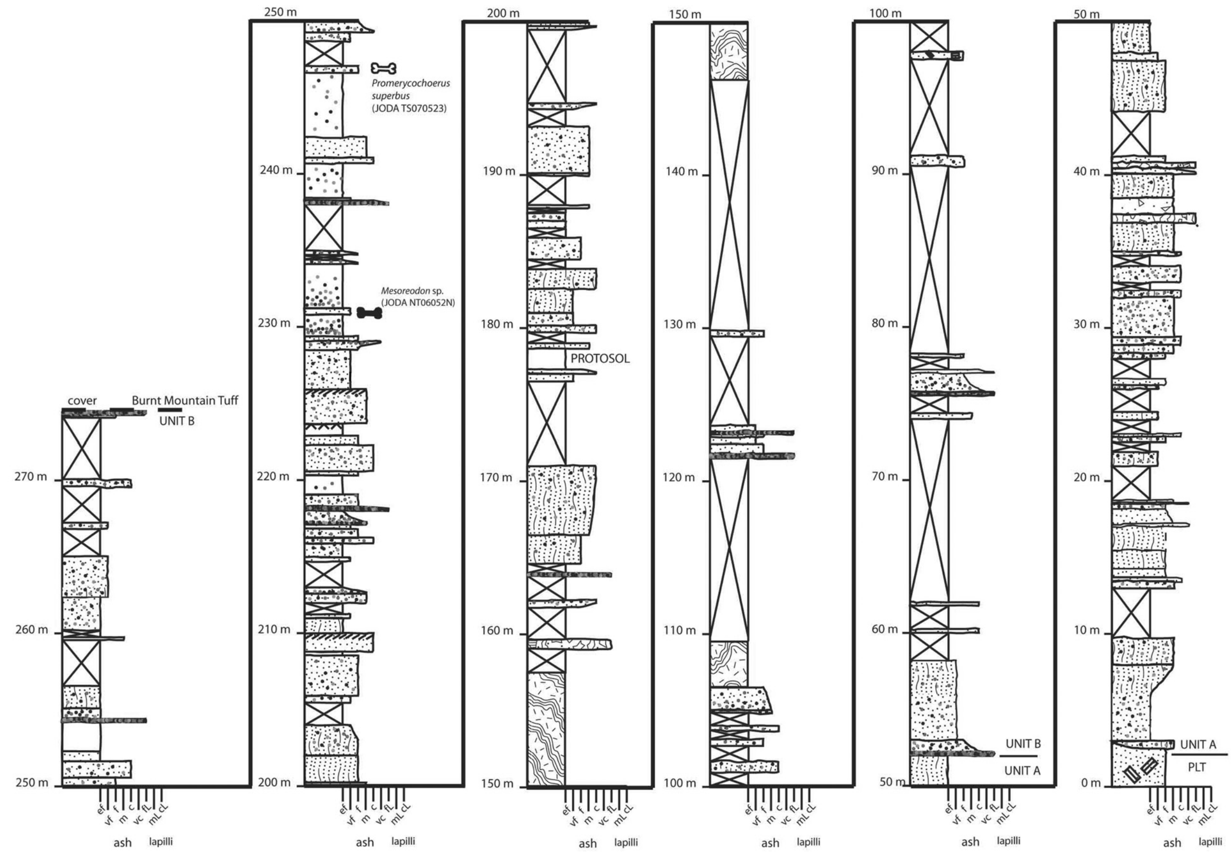

FIGURE 14. Thunder Creek South Section.

tuffs with intercalated coarse tuffs and lapillistones. A coarse tuff with cross-stratification is preserved in the top meter of exposure.

Thunder Creek-South Section. The complete sequence of the upper Wildcat Creek beds, from the pumice lapilli-tuff unit to the Fifes Peak Formation, crops out along Thunder Creek. Two sections describe the full sequence of the upper Wildcat Creek beds and the nature of the overlying contact.

The Thunder Creek South section includes the upper 3 m of the pumice lapilli-tuff unit and 260 m of the upper Wildcat Creek beds (Figure 14). The base of unit A is a 50 cm medium tuff pinching out 10 m laterally to fine tuffs in contact with the pumice lapilli-tuff. The succeeding 5 meters show a coarsening upwards sequence that includes four ridge-forming layers. Bedding within the coarse tuffs is crude. Medium and coarse tuffs dominate the overlying 25 m of unit A.

A 50 cm framework-supported breccia crops out intermittently along strike, 35 m above the pumice lapilli tuff. The overlying matrix-supported breccia is 1.5 m thick. A second framework-supported breccia is 1.5 m above the breccia couplet.

Unit B is 235 m of fine to coarse tuffs with lapillistone intercalations. A dike intrusion, 11 m thick, cuts the strata along a North-South trend. The lower 120 m of unit B is largely covered, but four lapillistone to coarse-tuff graded beds were identified. A breccia, 108 above the base of unit 3, is supported by angular pebble lithic clasts.

A mudstone-rich tuff, 178 m above the pumice lapilli tuff, contains light greenish gray mottles. The pale olive drab color and mottling suggest the weak pedogenic development representing a Protosol (Mack et al. 1993).

The upper 110 m are coarse tuffs with lapillistone intercalations. Mudclasts and pumice fragments are common. Mudcracks and crude cross stratification are present. The Burnt Mountain Tuff is covered, but the color change in detritus from olive to buff is inferred as the contact (Figure 15). The collection of *Mesoreodon* sp. (JODA NT06052N) and *Promerycochoerus superbus* (JODA TS070524), 45 m and 30 m below the Burnt Mountain Tuff, respectively, extends the highest stratigraphic occurrence of fossils in the Wildcat Creek beds.

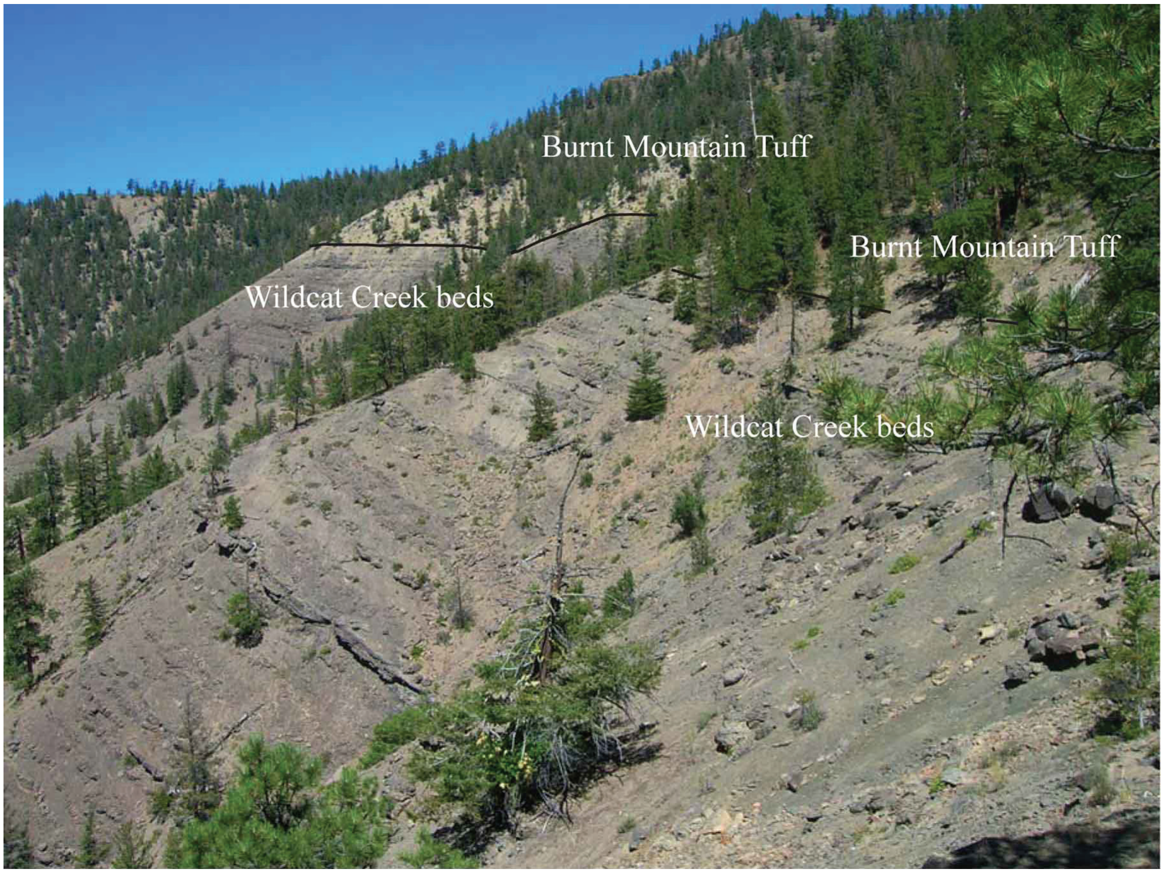

FIGURE 15. Contact between the upper Wildcat Creek beds and the overlying Burnt Mountain Tuff in the Thunder Creek drainage.

Thunder Creek-North Section. The ridge north of the Thunder Creek South Section preserves the uppermost portion of the Wildcat Creek beds and the overlying Burnt Mountain Tuff. The section (Figure 16) is measured from a prominent dike along the ridge to the Burnt Mountain Tuff and includes 100 m of massive fine tuffs intercalated with 0.2 to 3 m coarse tuff beds and 0.1 to 0.2 m lapillistone ledges. The upper 3 m of the upper Wildcat Creek beds is a fine tuff layer preserving R-type accretionary lapilli.

A prominent 10 m thick breccia, buff in color, at 100 m in the section, is the lowest occurrence of the Burnt Mountain Tuff. The breccia changes in thickness laterally and meter-scale relief below this breccia shows an unconformable relationship with the Wildcat Creek beds.

Depositional Environment

The Wildcat Creek beds were deposited as ash falls, ash flows, and debris flows. The lack of intercalated lava flows, finer grained volcaniclastics and thinner bedding than the Ohanapecosh Formation indicates they represent more distal volcaniclastic facies deposition, as suggested by Swanson (1964, 1978) and Vance et al. (1987). This conclusion is supported by abundant mudclast lapilli found in the upper Wildcat Creek beds. The lapilli are similar to the C-type accretionary lapilli, described and figured by Schumacker and Schminke (1991) that are found in volcanic deposits over 4 km from the source.

The uniformly thick, clast-supported breccias are similar to hyper-concentrated flows with high sediment load described by Smith (1987). Debris flows are preserved as matrix-supported breccias with crude bedding, coarse normal grading, and poorly sorted gravel (Smith 1987). Unit B was deposited as air-fall deposits characterized by massive beds of extremely fine to fine ash, well sorted lapillistones, and crude normal grading.

Reverse grading is rare, but occurs with pumiceous clasts (Figure 17); it forms by ground-hugging ash clouds concentrating low density pumice at the top of flows (Fisher and Schminke 1984). Well-defined normally graded deposits of unit B

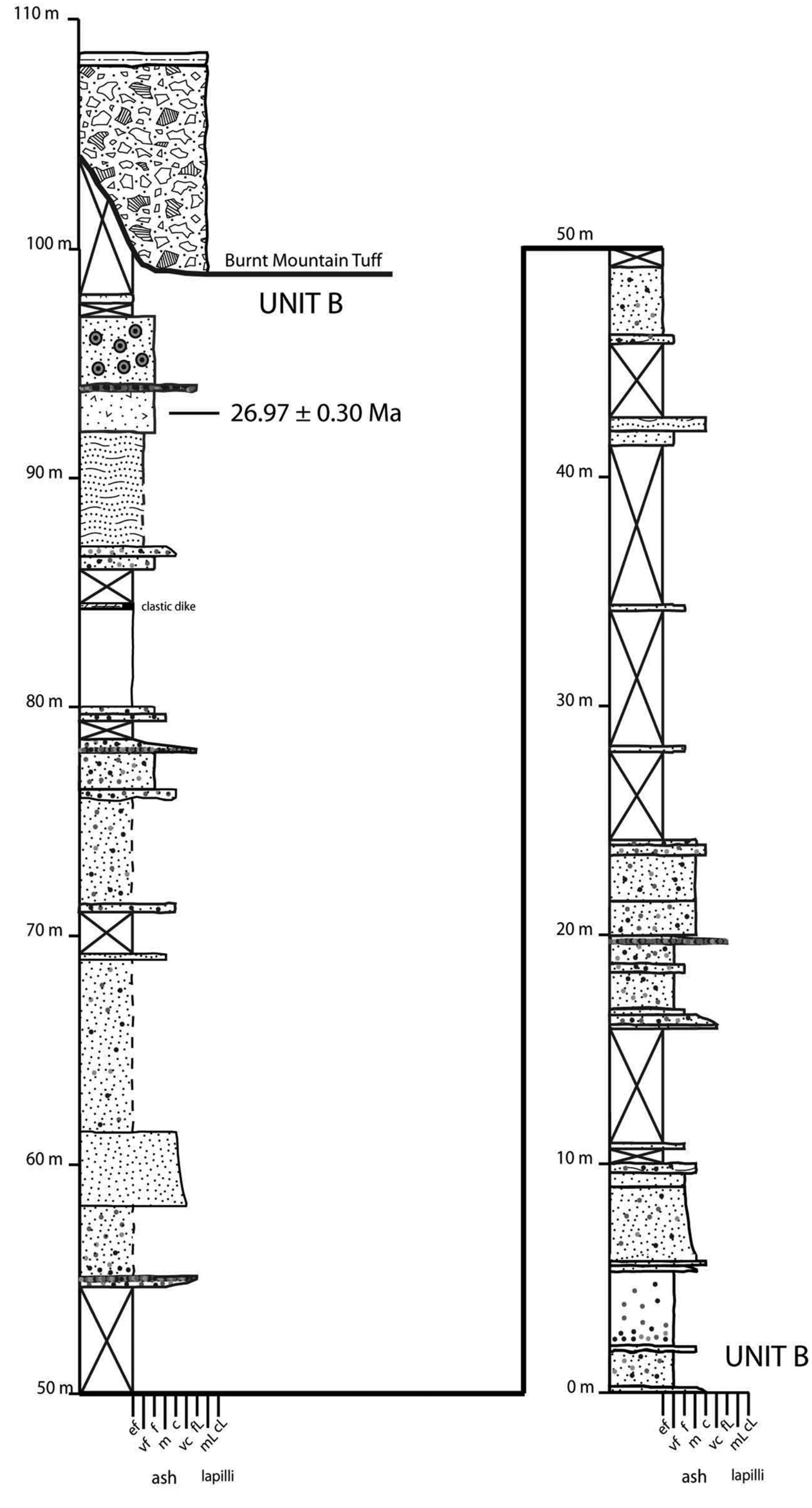

FIGURE 16. Thunder Creek North Section.

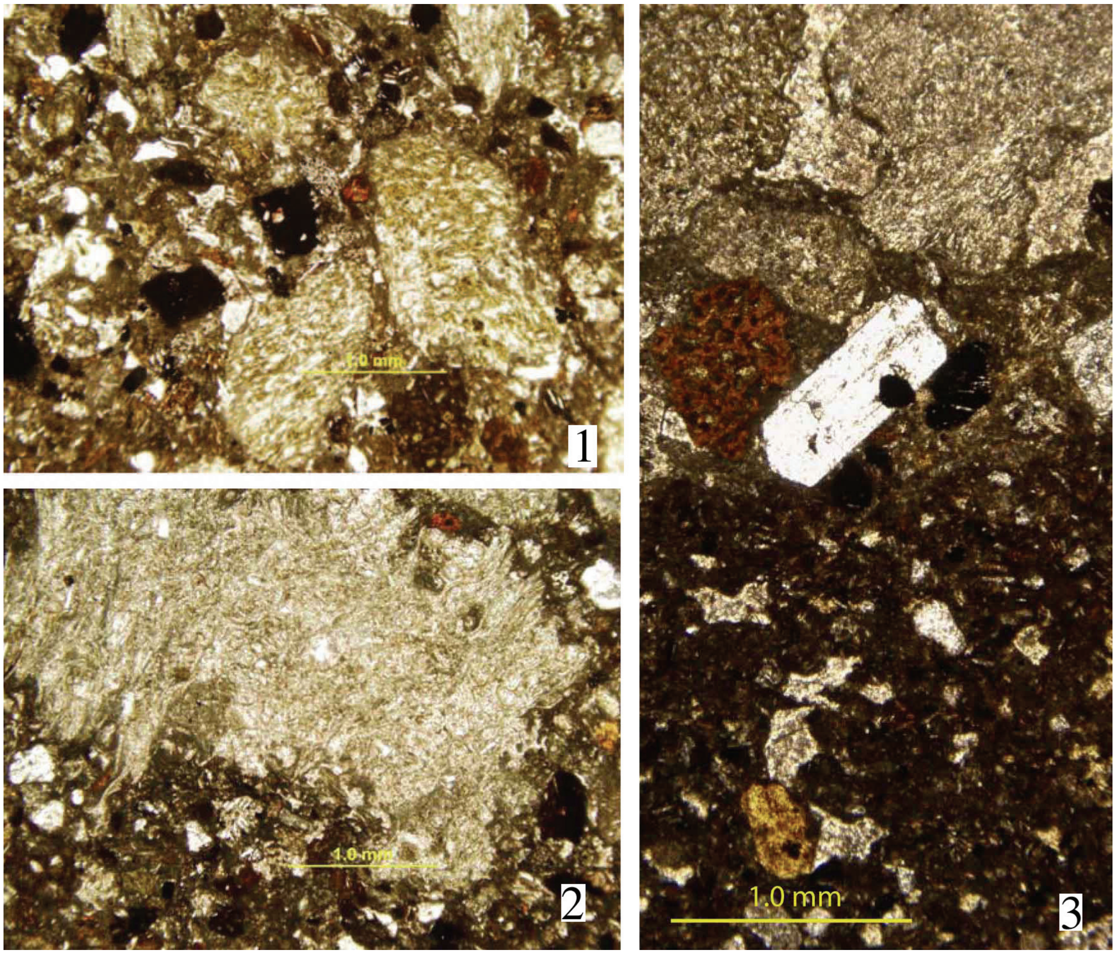

FIGURE 17. Pumice lapilli fragments in thin section (1 and 2), and in a reverse graded bed (3).

were interpreted as subaqueous deposits by Swanson (1964, 1978), though normal grading occurs in terrestrial debris flows (Smith 1987). A terrestrial setting is supported by mudcracks, pedogenic development, and abundant terrestrial fossils preserved in unit B.

The predominance of massive bedding and abundant euhedral phenocrysts indicate little to no reworking. Specimens JODA TF10032, JODA TS07055, and JODA NT06052N were preserved in massive extremely fine tuffs, suggesting preservation in ash falls. The disarticulated condition of the fossils and rodent gnawing, as seen on specimen UCMP 47165, indicates the bones were exposed prior to burial.

The Argillisols of the lower Wildcat Creek beds and gleyed Protosols of the upper Wildcat Creek beds indicate moist conditions in well drained and poorly drained environments, respectively (Mack et al. 1993), although presence of mudcracks in these strata connotes intermittent drying. Moist conditions are supported by Goshen-type floras found in the Ohanapecosh Formation to the west, including plant taxa with large broad leaves and drip tips, typical of temperate riparian environments (Wolfe 1978; Retallack et al. 2004). The temperate climate shown in these deposits suggests a dryer climate than the tropical floras of the Chuckanut Formation, late Paleocene to Eocene in age, in western Washington (Mustoe 2002). This change is consistent with contemporaneous floral changes in Oregon (Retallack et al. 2004).

The weakly developed paleosols of the upper Wildcat Creek beds suggest an unstable landscape characterized by rapid deposition, in contrast with slower rates implied by better soil formation of the lower Wildcat Creek beds (Mack et al. 1993). The well drained soils of the lower Wildcat Creek beds support the hypothesis of Vance et al. (1987) that the Tieton River area was a local topographic high prior to the deposition of the pumice lapilli tuff and upper Wildcat Creek beds.

TABLE 1. Occurrences of taxa by locality in the Wildcat Creek beds.

	WC-1	WC-2	WC-3	WC-4
Cormocyon copei	X	X		
Enhydrocyon		X		
Parenhydrocyon josephii		X		
Cricetidae			X	
cf. *Palaeolagus*			X	
?Miohippus equinanus		X		
Miohippus equiceps		X		
Miohippus		X	X	
Diceratherium annectans	X	X		
Diceratherium			X	
Tayassuidae		X		
Hypertragulus		X		
Eporeodon		X		
Merycoides		X		
Mesoreodon		X		X
Promerycochoerus superbus		X	X	X

SYSTEMATIC PALEONTOLOGY

The occurrences of the taxa by locality are presented in Table 1. Synonomy of previous locality names to this work are shown in Table 2.

Class MAMMALIA Linnaeus, 1758
Order CARNIVORA Bowdich, 1821
Family CANIDAE Fischer de Waldheim, 1817
Genus *Cormocyon* Wang and Tedford, 1996

Cormocyon copei Wang and Tedford, 1996
Figures 18, 19, and 20

Referred material. UWBM 39227, partial cranium, UWBM 39225, partial right dentary with p4 to m1, UWBM 40738, partial right dentary with p2, p4-m2, JODA 8942, partial left P4, JODA 8945, left m1: dental measurements in Table 3.

Localities. WC-1 ,WC-2.

Description. A posterior skull (UWBM 39227) contains the occipital, posterior temporal, and basicranial regions. The parietals form a distinct sagittal crest. The anterior portion of the squamosal and the frontals are not present, revealing an endocast of the braincase. The left auditory bulla is inflated and is 18.6 mm long. The paraoccipital process is prominent and projects ventrally.

A fragmentary P4 (JODA 8942) has no distinct parastyle. The anterolingual cingulum shows a distinct protocone.

A posterior portion of the p2 (UWBM 40738) shows a distinct posterior cingular cusp. The position of the p3 alveolus relative to the p4 in specimens UWBM 40738 and UWBM 39225 (Figure 20) indicates closely spaced premolars. The principal cusps are anteriorly placed on the p4. Distinct anterior cingular cusps, posterior accessory cusps, and posterior cingular cusps occur along the midline of the tooth.

The m1s (UWBM 39225, UWBM 40738, and JODA 8945) have a talonid basin formed by a crest-like hypoconid and enlarged entoconid. The trigonid is elongate and opened by a longitudinally

TABLE 2. Synonomy of locality names.

Locality (this study)	Locality names from prior studies
MC-1	UCMP V-6337
WC-1	UCMP V-5435, USFS-1, USFS-17, JODA-WCTF10032
WC-2	UCMP V-3958-1-3, UCMP V-6603, UCMP V-6233, UCMP V-6338,UWBM A-8762, USFS-9-16, JODA-WCTS07053, JODA-WCTS070516, JODA-WCDG06051
WC-3	UCMP V-3958-4, UCMP V-82350, UCMP V-82351, UWBM A-5162, JODA-WCTS07056, JODA-WCTS07055A, JODA-WCTS070510, JODA-WCJS07051
WC-4	JODA-WCNT06052, JODA-WCTS07023

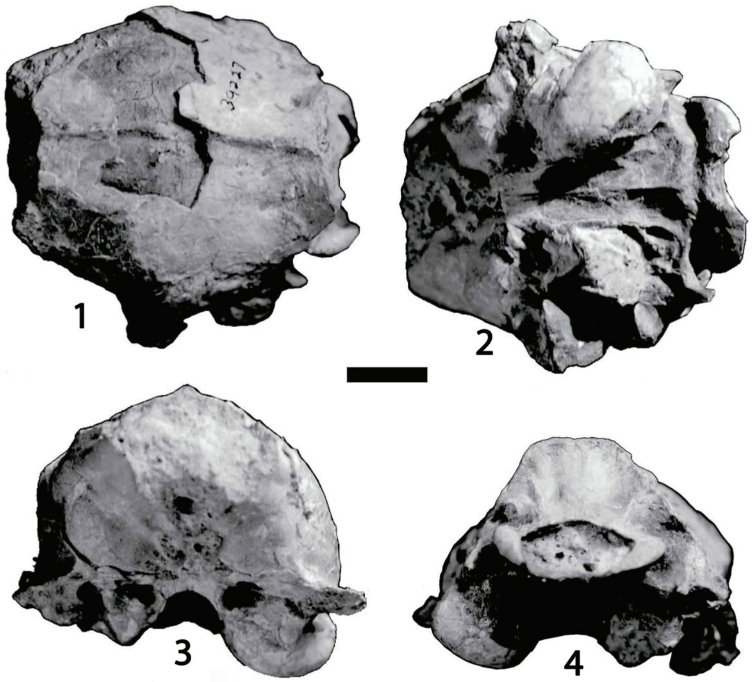

FIGURE 18. Partial skull (UWBM 39227) of *Cormocyon copei* in dorsal (1), ventral (2), anterior (3), and posteroventral (4) views. Scale bar equals 1 cm.

oriented paraconid blade. The metaconid is prominent and projects lingually from the protoconid. The m2 has enlarged metaconids relative to the protoconid.

Discussion. The inflated entotympanic bullae place the skull within the Canidae. The ventrally projected paroccipital process is not found in *Hesperpocyon* or the borophagines *Archaeocyon, Rhizocyon*, or *Otarocyon*, and the sagittal crest differs from the parasagittal crest condition of *Cynarctoides*. The paroccipital process does not fuse with the entotympanic, as in *Mesocyon*, *Enhydrocyon*, and *Parenhydrocyon*.

Some hesperocyonines, canines, and primitive borophagines lack a parastyle on the P4 (Wang 1994; Wang et al. 1999). The size is similar to *Hesperocyon gregarius*, "*Mesocyon*" *temnodon, Phlaocyon ,* and *Cormocyon*. The tooth lacks the well-developed anterior cingulum found in "*Mesocyon*" *temnodon* and *H. gregarious,* and the metacone blade is not shortened as in *Phlaocyon*.

The talonid basin of the m1 and tall metaconid on the m2 are characteristic of borophagine and canine canids (Wang et al. 1999). The distinct accessory cusps on premolars and absence of diastems distinguish the dentaries from canines and the elongate trigonid differs from *Archaeocyon* and *Rhizocyon*. The lower molars lack a protostylid, which is found on *Phlaocyon* and *Cynarctoides*, and the latter genus has a more slender horizontal ramus. The crest-like talonid cusps on the m1 differ from *Desmocyon* and later borophagines. The sizes of the teeth are at the large end of the ranges for *Cormocyon copei* and larger than *Cormocyon haydeni* (Wang et al. 1999, their Appendix III).

Geographic occurrence. Wang et al. (1999) identified *C. copei* from the Turtle Cove Member of the John Day Formation, and specimens questionably assigned to *C. copei*, have been recovered from the medial Arikareean of Colorado and late Arikareean of Florida (Wang et al. 1999; Munthe 1998).

Genus *Enhydrocyon* Cope, 1879
Enhydrocyon sp.
Figure 21

Referred material. JODA 8948, partial right dentary with p2-p4: dental measurements in Table 3.

Locality. WC-2.

Description. The premolars of JODA 8948 have a transversely widened base with no diastema between. The anterior two teeth are imbricated and oriented from posterolingual to anterobuccal. Matrix anterior to the p2 preserves a mold of the canine. The dentary is broken along the posterior

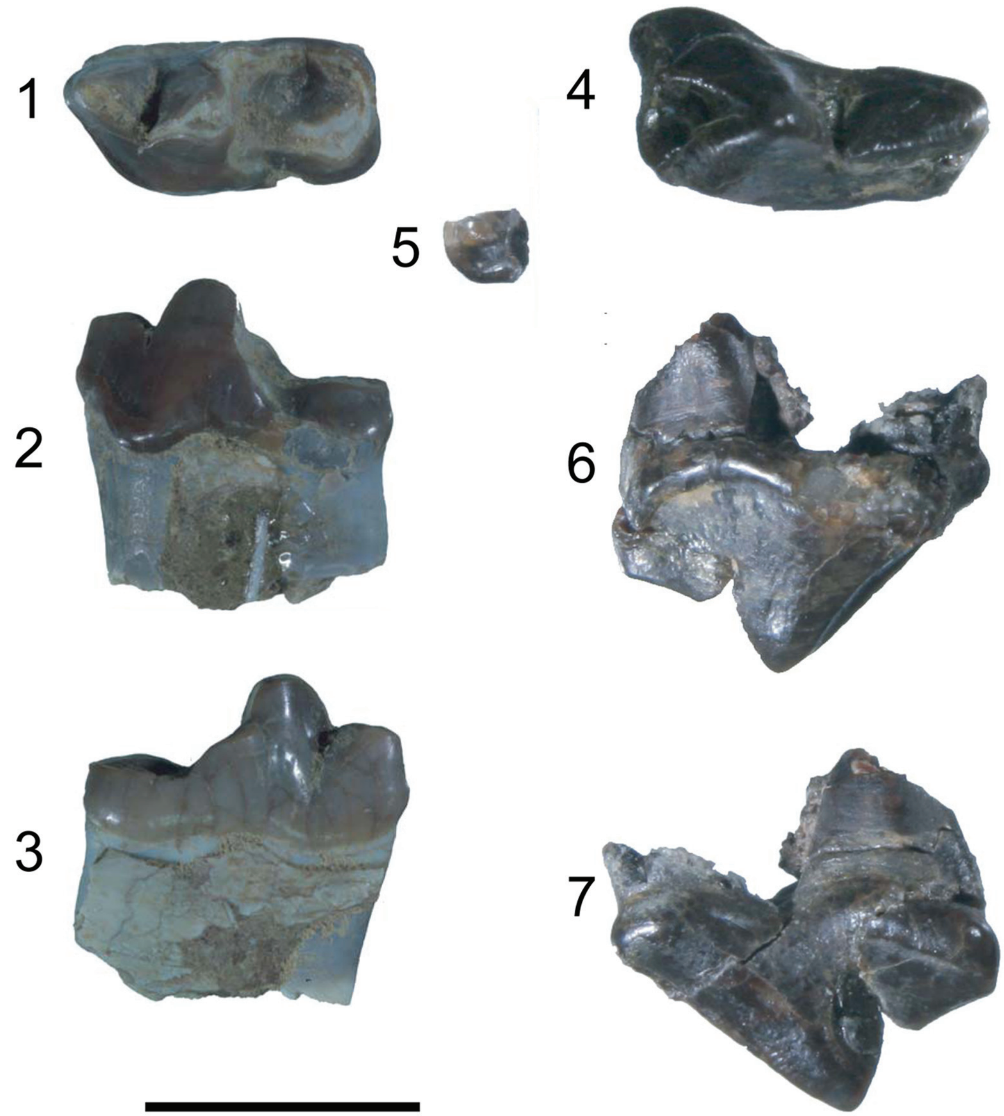

FIGURE 19. Left m1 (JODA 8945) of *Cormocyon copei* in occlusal (1), buccal (2), and lingual (3) views. Right P4 (JODA 8942) of *Cormocyon copei* in occlusal (4),buccal (5), and lingual (6) views. Scale bar equals 1 cm.

FIGURE 20. Partial right dentary with p4-m2 (UWBM 39225)of *Cormocyon copei* in occlusal (1), buccal (2), and lingual (3) views. Partial right dentary with p2, p4-m2 (UWBM 40738) of *Cormocyon copei* in occlusal (4), buccal (5), and lingual (6) views. Scale bar equals 1 cm.

TABLE 3. Measurements for dentition of *Cormocyon copei* (JODA 8942, JODA 8945, UWBM 39225, UWBM 40738), *Enhydrocyon* sp. (JODA 8948), and *Parenhydrocyon josephii* (UWBM 39226). An asterisk indicates a measurement from a partial tooth and a lower case d indicates a measurement from deciduous dentition.

Element	Measurement	JODA 8942	JODA 8945	UWBM 39225	UWBM 40738	JODA 8948	UWBM 39226
P4	length	12	---	---	---	---	---
	width	7	---	---	---	---	---
p2	length	---	---	---	---	---	---
	width	---	---	---	---	5.8	---
p3	length	---	---	---	---	10.5	---
	width	---	---	---	---	6.8	---
p4	length	---	---	8.4	7.5	12.7	10.5
	width	---	---	3.6	3.5	7.7	4.5
m1	length	---	10.9	11.2	11.5	---	14.9
	length trigonid	---	---	---	---	---	9.8
	width	---	---	---	---	---	6.2
	width trigonid	---	5.1	4.9	5.2	---	---
	width talonid	---	5.3	5.1	4.9	---	---
m2	length	---	---	6.2	6.9	---	---
	width	---	---	4.3	4.6	---	---

part of the canine root, which runs nearly to the base of the dentary. The principal cusps are slightly anteriorly placed and increase progressively in height from the p2 to p4. The p2 has ridges that run along the midline from the distinct anterior cingular cusp, to the principal cusp and posterior cingular cusp. Distinct posterior accessory cusps and posterior cingular cusps form along the midline of the p3 and p4. The accessory cusps are more prominent on the latter tooth, which has a distinct anterior cingular cusp. The posterior portion of the preserved dentary is broken along the m1 alveolus.

Discussion. The tooth positions are identified by the posterior position relative to the canine, indicated by an alveolus and posterior enamel a tooth larger than the p2, and the anterior position relative to the m1, indicated by the alveolus postero-lingual of the p4. Absence of the p1, large premolars that are wide, and no diastemas are diagnostic characters of *Enhydrocyon* and *Philotrox*. *Philotrox* retains the p1 and is much smaller (Wang 1994). *Enhydrocyon basilatus* is much larger than this specimen, and *E*. *crassidens* (Wang 1994). Specimen JODA 8948 shows the presence of accessory cusps as in *Enhydrocyon pahinsintewakpa* and *Enhydrocyon stenocephalus*; however, premolar morphology and size do not distinguish these species (Wang 1994). Molar and skull morphology characters not preserved in specimen JODA 8948, distinguish *E*. *pahinsintewakpa* from *E*. *stenocephalus*.

Geologic occurrence. *Enhydrocyon* is known from the Arikareean of the Great Plains and Oregon. *Enhydrocyon pahinsintewakpa* and *E*. *stenocephalus* are confined to the early Arikareean of the Great Plains and Oregon, respectively.

Genus *Parenhydrocyon* Wang, 1994
Parenhydrocyon josephi (Cope, 1881)
Figure 21

Referred material. UWBM 39226, partial right dentary with p4 and m1: dental measurements in Table 3.

Locality. WC-2.

Description. The alveolus of the p3, and the p4 and m1 are present with no diastemata in UWBM 39226. The p4 has a worn principal cusp, and the m1 has a worn paraconid blade and protoconid. The p4 is slender with a distinct posterior accessory cusp and posterior cingular cusp. The trigonid of the m1 is dominated by the protoconid, but has an unreduced metaconid. The talonid is trenchant and dominated by the hypoconid. The entoconid forms a wide shelf.

Discussion. The trenchant talonid on the m1 differs from the basined condition in the amphicyonid *Daphoenus*, and is present in the amphicyonids *Daphoenictis* and *Brachyrhynchodon* and in hesperocyonine canids (Hunt 1998; Wang 1994). The narrow p4 is diagnostic of the hesperocyonine *Parenhydrocyon* (Wang 1994; Munthe 1998). The metaconid in *Parenhydrocyon jospehi* is not reduced as in *Parenhydrocyon wollovianus* and

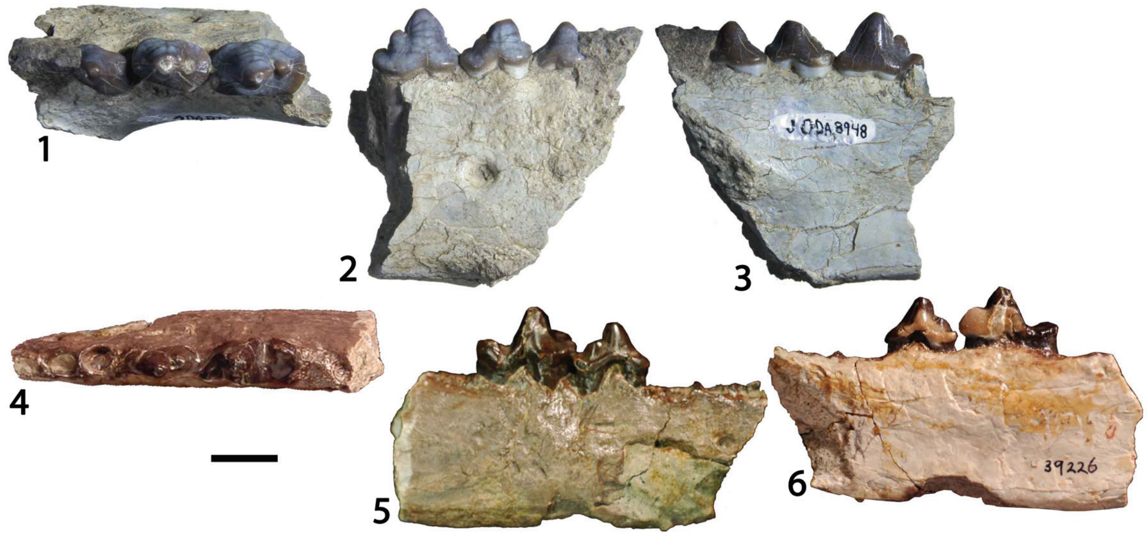

FIGURE 21. Partial right dentary with p2-p4 (JODA 8948) of *Enhydrocyon* sp. and partial right dentary with p3-p4 (UWBM 39226) of *Parenhydrocyon josephii* in occlusal (1, 4), buccal (2, 5), and lingual (3, 6) views. Scale bar equals 1 cm.

Parenhydrocyon robustus (Wang 1994). The p4 retains accessory cusps, which are variable in *P. jospehi* (Wang 1994).

Geologic occurrence. *Parenhydrocyon josephi* is known from the Whitneyan through the Arikareean of the Great Plains and Oregon.

Order RODENTIA Bowditch, 1821
Family CRICETIDAE Fischer von Waldheim, 1817
Genus and species indeterminate
Figure 22

Referred material. UCMP 119462, partial lower incisor.

Locality. WC-3.

Description. A fragment of a lower incisor, specimen UCMP 119462, contains enamel restricted to the anterior surface. Approximately one-half of the enamel surface is smooth, and three lateral ridges run longitudinally along the tooth. The tooth measures 1.9 mm wide.

Discussion. Longitudinal ridges on incisors are present in several families of rodents in the North America Paleogene (Korth 1998), but three small and one large ridge are found on the lower incisors of *Paciculus* and *Leidymys* (Lindsay 2008).

Geologic occurrence. Both genera first appear in Oregon in the late early Arikareean (Albright et al. 2008). In the Great Plains, these taxa occur earlier than Oregon where *Leidymys* and *Paciculus* are known as early as 30 Ma and extend into the Miocene.

Order LAGOMORPHA Brandt, 1855
Family LEPORIDAE Gray, 1821
Genus *Palaeolagus* Leidy, 1856

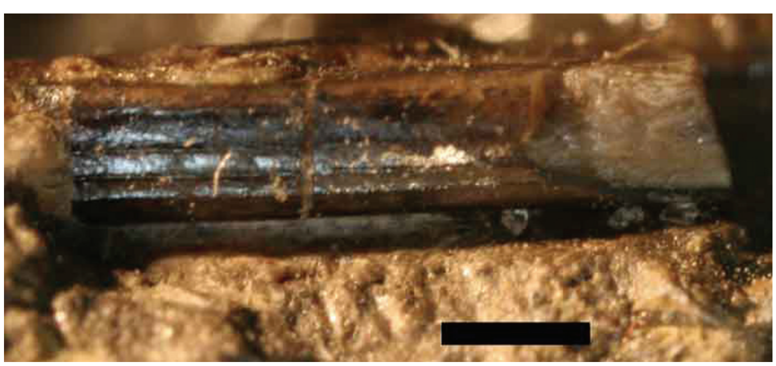

FIGURE 22. Lower incisor (UCMP 119462) of an indeterminate cricetid. Note the longitudinal ridges that run along the incisor. Scale bar equals 1 mm.

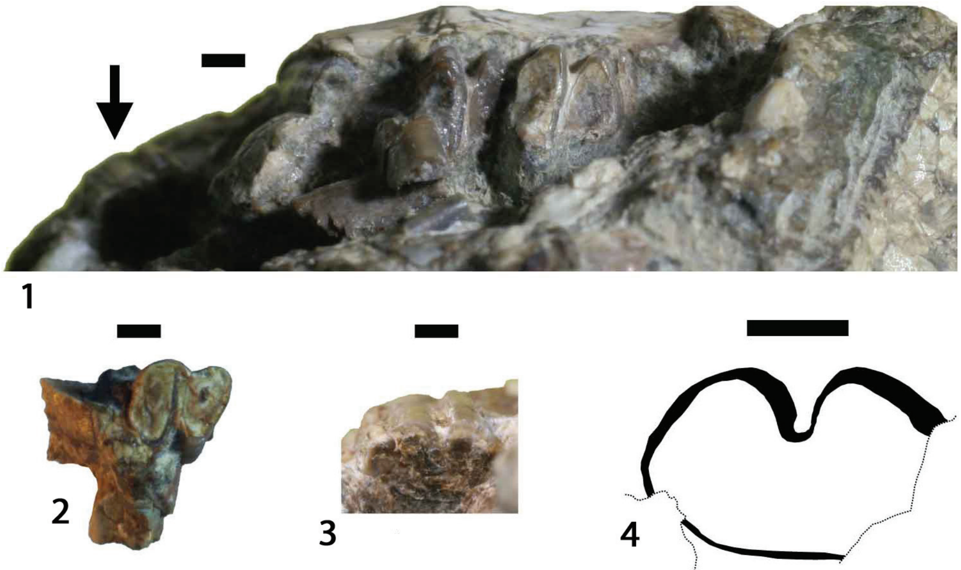

FIGURE 23..Partial right dentary with m1-m2 (1), lower left cheek tooth (2), and right p3 (3) (JODA TS07056) of *Palaeolagus*. Arrow (1) shows location of the right p3. Occlusal outline of the p3 (4). Scale bar equals 1 mm.

cf. *Paleolagus* sp.
Figure 23

Referred material. JODA TS07056, partial right dentary with three cheek teeth, right partial p3: dental measurements in Table 4.

Locality. WC-3.

Description. The bone on the specimen is badly weathered and broken. The incisors are shattered. A partial dentary preserves three molariform cheek teeth and a p3. The teeth are hypsodont. The enamel is thicker on the posterior and buccal sides of the trigonid and talonid. A thin band of enamel connects the trigonid and talonid lingually.

The right p3 was prepared down to the base to show an occlusal cross section, where the bone and enamel are better preserved. An external reentrant extends one-third across the tooth and separates the trigonid from the talonid. The long axis of the reentrant is transverse and not oriented obliquely.

TABLE 4. Measurements for dentition of cf. *Palaeolagus* (JODA TS07056). An asterisk indicates a measurement from a partial tooth and a lower case d indicates a measurement from deciduous dentition.

Element	Measurement	JODA TS07056
p3	length	2.2
	width trigonid	1.5
	width talonid	1.8
p4 or m1	length	2.3
	width trigonid	2.2
	width talonid	2.1
m1 or m2	length	2.5
	width trigonid	2.7
	width talonid	2.2

Discussion. Whereas the dentary is poorly preserved, the p3 has at least one external reentrant. The overall shape of the p3 is similar to *Archaeolagus* as figured by Dice (1929, Figure 1) and described by Dawson (1958, 2008), but differs in lacking an anteroexternal reentrant that persists during wear. The internal reentrants of p3s in palaeolagines disappear during heavy wear (Dice 1929). Only the base of the tooth is preserved, representing a heavily worn p3. The absence of the anteroexternal and internal reentrants is consistent with a well worn p3 of a palaeolagine leporid. The cheek teeth are more hyspodont than *Mytonolagus* and smaller than *Megalagus* described by Dawson (1958 table 2). The p3 is not reduced as in *Desmatolagus* and not shortened as in *Chadrolagus* (Dawson 1958, 2008). *Palaeolagus intermedius*, *Palaeolagus philoi*, and *Palaeolagus*? sp. are similar in size and lack persistent internal reentrants. Characters distinguishing *P. intermedius* and *P. philoi* are in upper cheek-tooth morphology (Dawson 1958).

Geologic occurrence. *Palaeolagus* is known from the Chadronian to the early Arikareean of the Great Plains, the Chadronian of Saskatchewan, Whitneyan of California, and early Arikareean of Texas

FIGURE 24. Right P2 (1,2), left upper cheek tooth (3,4), and partial left upper cheek tooth (5,6) (JODA 8946) of ?*Miohippus equinanus*. Specimens shown in (1, 3, and 5) occlusal, (2, 4) buccal, and (6) lingual views. Scale bar equals 1 cm.

and Oregon (Prothero and Emry 2004; Tedford et al. 2004).

Order PERISSODACTYLA Owen, 1848
Family EQUIDAE Gray, 1821
Genus *Miohippus* Marsh, 1874
?*Miohippus equinanus* Osborn, 1918
Figure 24

Referred material. JODA 8946, right P2, left P or M, and partial left P or M: dental measurements in Table 5.

Locality. WC-2.

Description. Distinct paraconules and metaconules form on the protoloph and metaloph of the P2 and the left P or M. The P2 is identified by an anteriorly positioned parastyle. The two other teeth are not distinguishable between molars or premolars because of the molariform premolars in equids. The protoloph connects to the ectoloph. A spur on the lingual portion of the ectoloph projects to, but does not connect to, the metaloph. A strong intervallic cusp is on the P2.

A weak intervallic cusp is seen on the P or M. The anterior cingulum is strong on the P or M. A small pocket forms between the anterior portion of the hypostyle and the posterior cingulum. The ectoloph is partially preserved on the P or M and shows a shallower W-shaped morphology.

Discussion. The distinction between *Miohippus* and *Mesohippus* is not clear (Prothero and Shubin 1989; MacFadden 1998). MacFadden (1998) stated that a comprehensive reevaluation of the species of *Mesohippus* and *Miohippus* is needed. Prothero and Shubin (1989) reevaluated several species of these two genera from the Great Plains, but drew no conclusions about many species outside of that geographical area. Prothero and Shubin (1989) used the size of the hypostyle to distinguish between *Mesohippus* and *Miohippus*. The referred teeth display large class 3 hypostyles, larger than those of any species of *Mesohippus*. The size of the teeth is slightly larger than ?*Miohippus equinanus*, the smallest species of *Miohippus*, and smaller than *Miohippus obliquidens* measured by Prothero and Shubin (1989, table 10.2), but metaconules are more pronounced, and the metaloph and protoloph are less obliquely oriented than in the latter species. The prominent paraconules and metaconules distinguish JODA 8946 from *Miohippus acutidens, Miohippus anceps*, and *Miohippus equiceps* described and figured by Osborn (1918). The large class 3 hypostyles, prominent parastyle on the P2, small size relative to other species of *Miohippus* shown in specimen JODA 8946 best fit ?*M. equinanus* (Osborn 1918; Prothero and Shubin 1989). JODA 8948 is much smaller than *Kalobatippus* (Osborn 1918). Osborn (1918) placed ?*M. equinanus* questionably in *Miohippus* as it features an advanced dentition for a

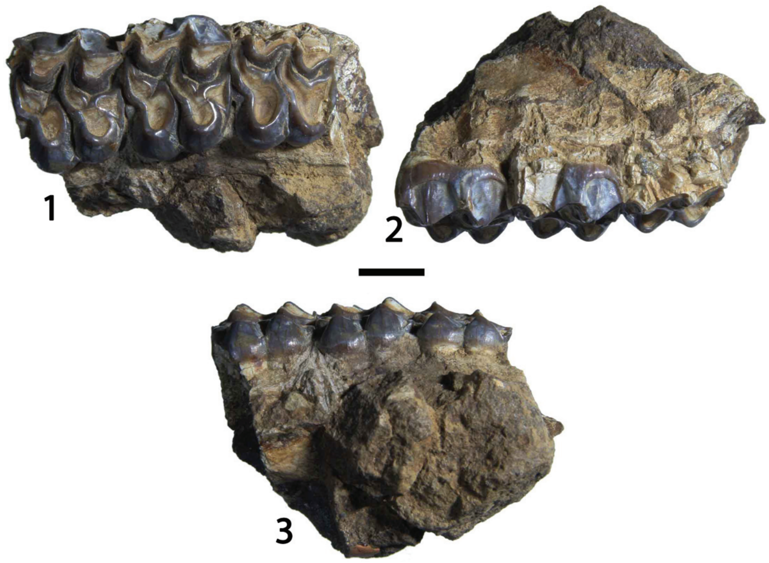

FIGURE 25. Partial left maxilla (JODA TS07053) of *Miohippus equiceps*. Specimen shown in occlusal (1), buccal (2), and lingual (3) views. Scale bar equals 1 cm.

Mesohippus sized equid, but is only known from dental material.

Geologic occurrence. ?*M. equinanus* is known from the Whitneyan to early Arikareean of South Dakota, and the Whitneyan of Oregon (MacFadden 1998).

cf. *Miohippus equiceps* (Cope), 1878
Figure 25

TABLE 5. Measurements for dentition of ?*Miohippus equinanus* (JODA 8946) and *Miohippus equiceps* (JODA TS07053), and *Miohippus* sp. (UCMP 63590, JODA TS07055A, UWBM 29150). An asterisk indicates a measurement from a partial tooth and a lower case d indicates a measurement from deciduous dentition.

Element	Measurement	JODA 8946	JODA TS07053	UCMP 63590	JODA TS07055A	UWBM 29150
P2	length	13.5	---	---	---	---
	width	13.9	---	---	---	---
P3	length	---	13.5	---	---	---
	width	---	16.3	---	---	---
P4	length	12.9	12.8	---	---	---
	width	15.1	16.1	---	---	---
M1	length	---	12.7	---	---	---
	width	---	---	---	---	---
p2	length	---	---	---	15	---
	width	---	---	---	8.9	---
p3	length	---	---	---	14.1	---
	width	---	---	---	10.2	---
p4	length	---	---	12.9	14.2	---
	width	---	---	11	9.8	---
m1	length	---	---	12.3	13.2	---
	width	---	---	10.2	9.9	---
m2	length	---	---	12.8	14.1	---
	width	---	---	13	10.1	---
m3	length	---	---	---	17.5	13.1
	width	---	---	---	8.9	9.3

Referred material. JODA TS07053, partial left maxilla with three upper cheek teeth: dental measurements in Table 5.

Locality. WC-2.

Description. Three heavily worn teeth have enlarged paraconules and metaconules that are distinct on the metaloph and paraloph, respectively. The anterior portions of the parastyles are missing. The metaloph connects to the ectoloph on P3. Lingual cingulum is weak and forms a weak intervallic cusp. The anterior cingulum is strong and forms a tubercle. The metaloph connects to the ectoloph. The hypostyles are triangular and represent at least class 2 hypostyles (Prothero and Shubin 1989). The anterior portion of the enamel on the ectoloph is preserved and suggests a W-shaped morphology.

Discussion. The size of teeth, distinct paraconules and metaconules, intervallic cusps, metaloph connecting to the ectoloph, and large triangular hypostyles are similar to *Miohippus equiceps* (Osborn 1918; Prothero and Shubin 1989). *Miohippus annectans* and *M. gidleyi* are larger species (Prothero and Shubin 1989; Osborn 1918), and the teeth differ from similar sized *M. obliquidens* and *M. assiniboiensis* in having prominent metaconules and strong lingual cingula.

Geologic occurrence. *Miohippus equiceps* is known from the Whitneyan and early Arikareean of Oregon, and early Arikareean of the Great Plains (Osborn 1918; MacFadden 1998).

Miohippus sp.
Figures 26 and 27

Referred material. UCMP 63590, partial left dentary with p4-m2, UWBM 29150, partial right dentary with partial m3, JODA TS07055A, partial mandible with left p1-m3, and right i3, pq-m3: dental measurements in Table 5.

Localities. WC-2, WC-3

Description. The lower cheek teeth are molariform. The cingulum is continuous along the hypoconid and the protoconid. The paralophid is continuous with the metastylid. The metaconid and metastylid are indistinct and form a high pillar. The paralophid and hypolophid do not connect.

Discussion. The teeth have the metaconid-metastylid pillar and similar size to *Miohippus* (Osborn 1918). The m2 and m3 resemble *Miohippus annectens* figured by Osborn (1918). The variation in tooth size amongst these specimens may indi-

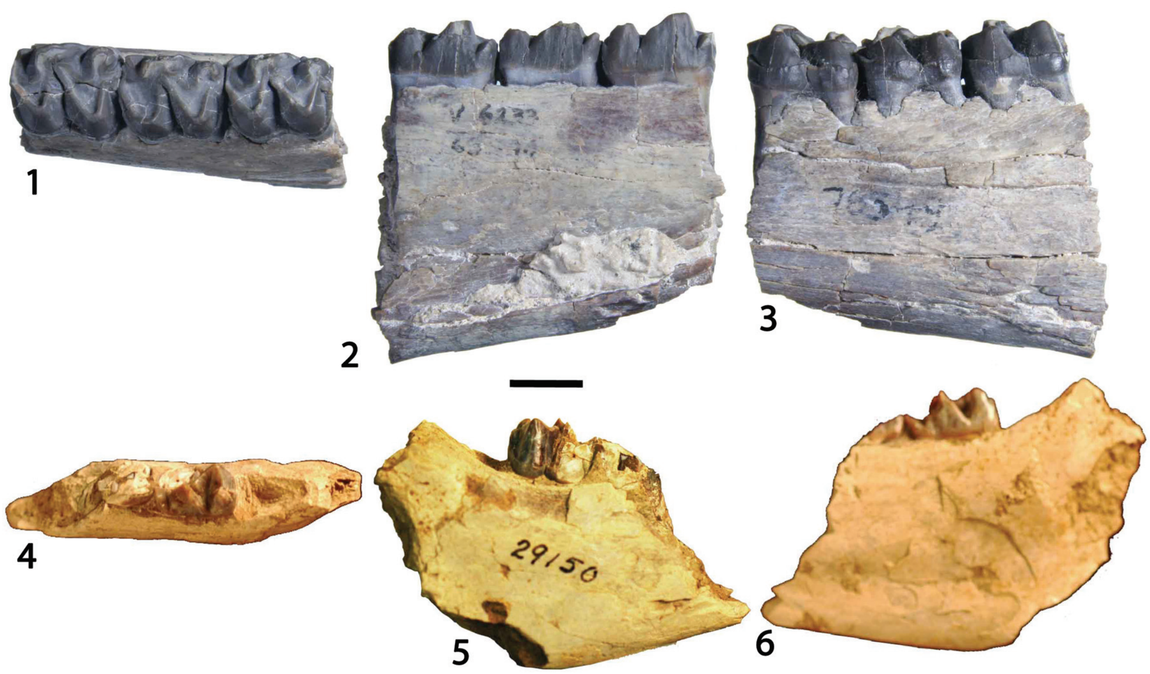

FIGURE 26. Partial left dentary with three cheek teeth (UCMP 63590) (1-3), and partial left dentary with m3 (UWBM 29150) (4-6) of *Miohippus*. Specimens shown in occlusal (1, 4), lingual (2, 5), and buccal (3, 6) views. Scale bar equals 1 cm.

FIGURE 27. Partial mandible (JODA TS07055) of *Miohippus*. Left dentary with p1-m3 and right i2 shown in (1) occlusal, (2) buccal, and (3) lingual views. Right dentary with p1-m3 shown in (4) occlusal, (5) buccal, and (6) lingual views. Scale bar equals 1 cm.

cate multiple species different species, but diagnostic dental characters distinguishing species of *Miohippus* are found in the upper dentition (Osborn 1918; Prothero and Shubin 1989).

Family RHINOCEROTIDAE Gray, 1821
Genus *Diceratherium* Marsh, 1875
Diceratherium annectens Marsh, 1875
Figure 28

Referred material. UCMP 65229, partial left P or M, JODA 8949, left P or M.

Localities. WC-1, WC-2.

Description. The molariform teeth have a simple square-shaped loph morphology. A weak crochet is present. The buccal enamel is rugose, and the anterior and lingual cingula are strong. A complete tooth (JODA 8949) is 27.1 mm long and 38.9 mm wide. A partial tooth is missing the buccal portion of the ectoloph, and the metaloph and protoloph are worn to the point that they unite.

Discussion. The simple square-shaped loph, strong cingula, and size place these specimens within *Diceratherium annectens* (Prothero 2005, table 4.4).

Geologic occurrence. *D. annectens* is known from the Arikareean of the Great Plains, early to middle Arikareean of Oregon, and the late Arikareean of Texas (Prothero 1998b, 2005).

Diceratherium sp.

Referred material. JODA TS070510, partial left P or M.

Locality. WC-3.

Description. An upper left cheek tooth preserves a nearly complete metaloph and anterior hypoloph. The enamel is rugose. The anterior cingulum is strong and runs buccally. A cuspid projects posteriorly from the posterior portion of the metalophid.

Discussion. The large tooth exceeds the size of *D. annectans* and approaches *D. armatum* (Prothero 2005), but accurate measurements are not possible.

cf. *Diceratherium* sp.
Figure 29

Referred material. JODA DG06051, partial left lower premolar, JODA TS070516, partial right lower molar.

Locality. WC-2.

Description. A lower premolar (JODA DG06051) includes a complete metalophid and the anterior portion of the hypolophid. The metalophid and hypolophid do not connect. The anterior cingulum is weak. The specimen measures approximately 21.3 mm wide.

The lower molariform tooth (JODA TS070516) has a nearly complete protolophid and partial metalophid. The protolophid shows a simple L-shaped morphology. The tooth is high crowned, and the enamel is rugose.

Discussion. The loph pattern and size indicate *Diceratherium* (Prothero 2005).

Family HYRACODONTIDAE or
RHINOCEROTIDAE
Figure 30

Referred material. UCMP 65230, partial left lower cheek tooth.

Locality. MC-1.

Description. The specimen preserves a nearly complete L-shaped metalophid. The metalophid is 21.3 mm wide. Posterior cingulum is present.

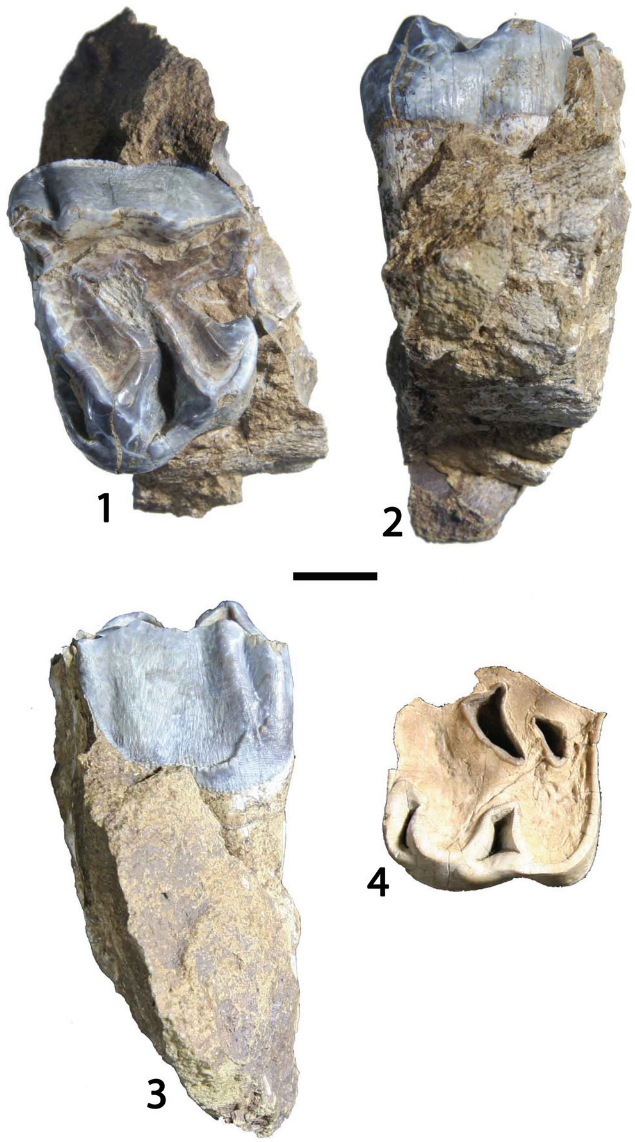

FIGURE 28. Left upper cheek tooth (JODA 8949) (1-3) and partial left upper premolar (UCMP 65229) (4), of *Diceratherium annectens*. Shown in occlusal (1, 4), lingual (2), and buccal (3) views. Scale bar equals 1 cm.

Discussion. This specimen was collected as float by D.A. Swanson from the Milk Creek tuff, south of Kloochman Rock, and is the lowest stratigraphic occurrence of a terrestrial vertebrate in the Tieton River area (Swanson 1964, 1978). L-shaped metalophids are characteristic of hyracodontids and rhinocerotids, both present in the Eocene and Oligocene of North America (Prothero 1998a, 1998b).

Order ARTIODACTYLA Owen, 1848
Family TAYASSUIDAE Palmer, 1897
genus and species indeterminate
Figure 31

Referred material. UCMP 72169, partial right dentary with m2: dental measurements in Table 6.

Locality. WC-2.

Description. The partial dentary has a complete m2 and roots of p4, m1, and m3. The m2 is slightly worn, rectangular in outline, and bunodont. Four primary cusps are present and nearly identical in size. The protoconid and metaconid tips are slightly higher than the tips of the hypoconid and entoconid. A small hypoconulid occurs on the posterior cingulum. A cuspid lies in the anterior portion of the valley between the hypoconid and entoconid. The anterior cingulum is weak. The buccal cingulum is

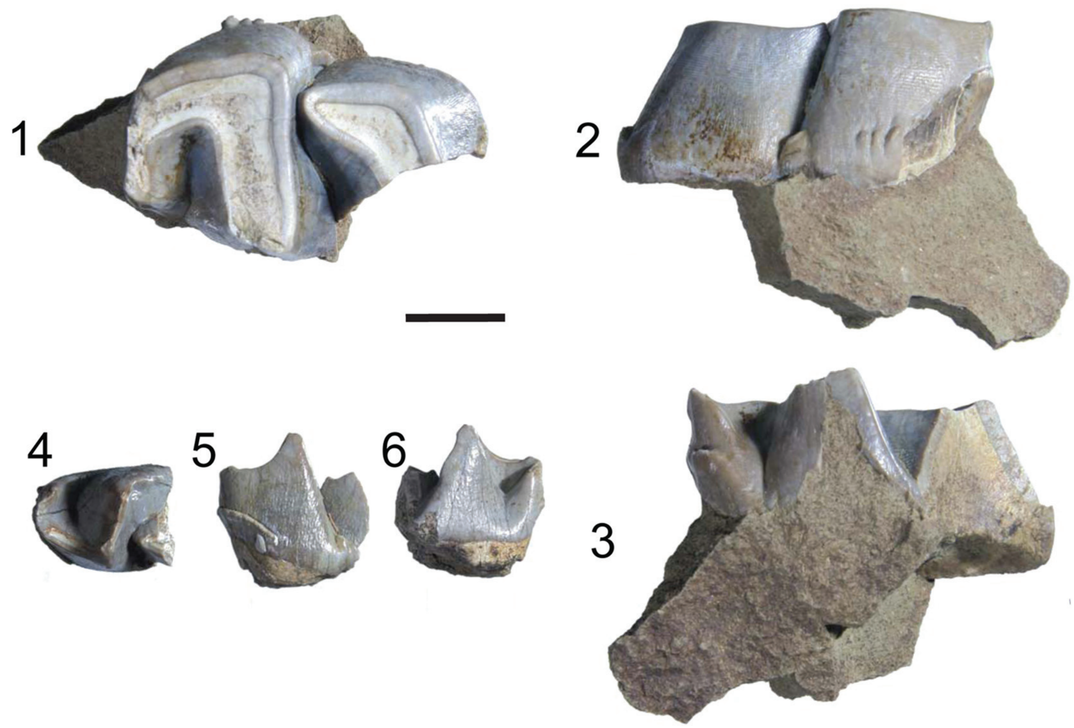

FIGURE 29. Partial right lower cheek tooth (JODA TS070516) (1-3) and partial left lower premolar (JODA DG06051) (4-6) of cf. *Diceratherium*. Specimens shown in occlusal (1, 4), buccal (2, 5), and lingual (3, 6) views. Scale bar equals 1 cm.

present but does not continue along the metaconid and hypoconid.

Discussion. The m2 is identified on the basis of size relative to adjacent roots. The rectangular outline of the molar, the bunodont condition of the tooth, with four nearly subequal principal cusps is characteristic of tayassuids (Pearson 1923, Wright 1998).

The m2 is identical in cusp morphology to the lower m2 of *Cynorca* cf. *C. sociale* illustrated in Woodburne (1969, Figure 3) and of *Perchoerus* described and figured by Pearson (1923, Figure 17). Woodburne (1969) described the species *C. sociale* as similar to *Perchoerus*, but stated that the lower dentition is conservative in tayassuids. This specimen could represent either, but *Perchoerus* is known from the Whitneyan and early Arikarrean of the Great Plains and Oregon.

Family HYPERTRAGULIDAE Cope, 1879
Genus *Hypertragulus* Cope, 1873
Hypertragulus sp.
Figure 32

Referred material. UCMP 47181, partial right dentary with m1 and m2, UCMP 47170, partial right dentary with p4, m1, and partial m2, UWBM 29151, partial left dentary with p4-m3, JODA 8944, partial left dentary with m1-m3: dental measurements in Table 6.

Localities. WC-2, WC-3.

Description. The dentaries have closely spaced cheek teeth. The p4 in specimen UWBM 29151 shows a prominent paraconid and metaconid, which form a crest extending posterior to a subcircular hypoconid.

The lower molars are selenodont and have crescent-shaped cuspids. A cingulum is present on the anterior portion of the molars, located between the anterior and posterior selenes, and forms a small intervallic cuspid.

Discussion. These specimens are assigned to Hypertragulidae by the small size, selenodont dentition, and prominent paraconids and metaconids on the p4s. The strong cingula and cuspids, and low crowns allow assignment to *Hypertragulus* and distinguish these specimens from *Nanotragulus* (Webb 1998; Metais and Vislobokza 2007).

Geologic occurrence. *Hypertragulus* is known from the Whitneyan to the late early Arikareean of Oregon and the Great Plains (Webb 1998).

Family MERYCOIDODONTIDAE Hay, 1902
Genus *Eporeodon* Marsh, 1875

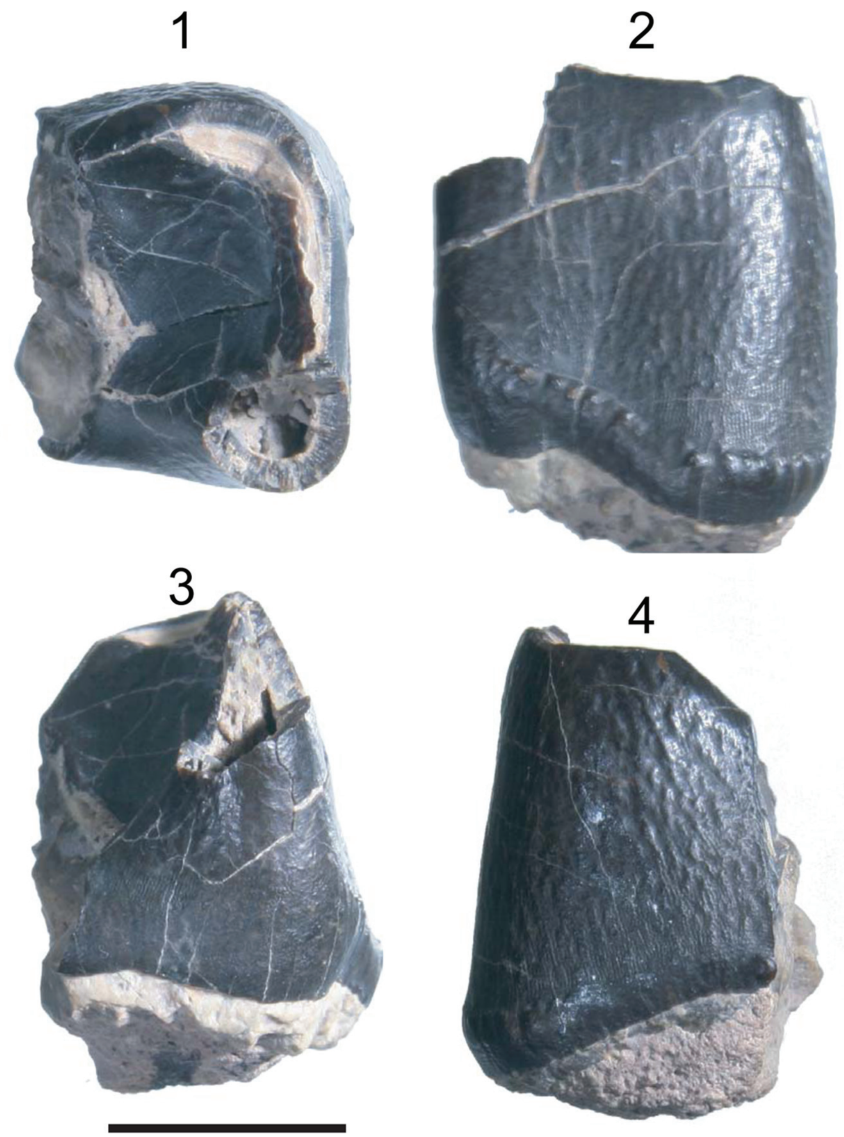

FIGURE 30. Partial right lower cheek tooth (UCMP 65230) of a rhinocerotid or hyracodontid. Specimen shown in occlusal (1), posterior (2), lingual (3), and buccal (4) views. Scale bar equals 1 cm.

Eporeodon sp.
Figure 33

Referred material. UCMP 36054, partial left dentary with dp4-m2, and partial right dentary with dp4-m2, UCMP 47169, partial right dentary with p3, partial p4: dental measurements in Table 6.

Localities. WC-2, WC-4.

Description. The teeth are selenodont. A partial left dp4 preserves the median and posterior lobes and the partial right dp4 preserves the posterior lobe. The selenes are rotated so that the apex of the crests and crescents point slightly posterior. The anterior crescents of the cheek teeth have strong mesostylids that overlap but do not connect to the anterior part to the posterior crescents. The metastylids overlap the anterior portions of the following tooth's anterior crescent. Parastylids are absent. The anterior and posterior crests do not meet, and are divided by a deep valley. A cingulum is present on the anterior portions of the teeth and between the anterior and posterior crests. The dorsal surface of the mandible widens at the m2.

The anterior, median, and posterior crests are strong on the p3 and p4. The posterior intermediate crest is prominent and extends from the middle of the median crest and runs parallel to the posterior crest. The anterior and posterior crescents are

FIGURE 31. Partial right dentary with m1 or m2 (UCMP 72169) of a tayassuid. Shown in occlusal (1), buccal (2), and lingual (3) views. Scale bar equals 1 cm.

weak. The posterior basin on p3 is not closed, and a prominent posterior intermediate crest is parallel to the posterior crest.

Discussion. Recent overviews of the higher level taxonomy of oreodonts are discussed in Lander (1998) and Stevens and Stevens (1994, 2007). The identifications of these specimens follow earlier generic and specific descriptions by Thorpe (1937) and Schultz and Falkenbach (1949, 1968) and these are placed within the larger taxonomic framework of Stevens and Stevens (2007).

All specimens identified as oreodonts, described above and below, show selenodonty that exclude these as agriochoerids. None of the oreodont specimens from the Wildcat Creek beds shows the hypsodont condition or the shallow valleys separating selenes in the molars of leptauchineine oreodonts. Enamel is thicker in these specimens than in *Miniochoerus*.

Two specimens preserving lower dentition from the recent collections are referred to *Eporeodon*. These specimens were compared with *Eporeodon* in the UCMP collections and examples

TABLE 6. Measurements for dentition of an indeterminate tayassuid (UCMP 72169), *Hypertragulus* sp. (UCMP 47181, JODA 8944, and UWBM 29151), *Eporeodon* sp. (UCMP 36054 and UCMP 47169), *Merycoides* sp. (UCMP 47166), and *Mesoreodon* sp. (JODA 8947 and JODA NT06052N), and *Promerycochoerus superbus* (JODA TS070523). An asterisk indicates a measurement from a partial tooth and a lower case d indicates a measurement from deciduous dentition.

Element	Measurement	UCMP 72169	UCMP 47181	JODA 8944	UWBM 29151	UCMP 36054	UCMP 47169	UCMP 47166	JODA 8947	JODA NT06052N	JODA TS 070523
M2	length	---	---	---	---	---	---	---	---	---	---
	width	---	---	---	---	---	---	---	---	---	26.1
M3	length	---	---	---	---	---	---	---	---	---	31.2
	width	---	---	---	---	---	---	---	---	---	23.8
p2	length	---	---	---	---	---	---	10.5	9.9	---	---
	width	---	---	---	---	---	---	4.9	6.3	---	---
p3	length	---	---	---	---	---	12.3	12.8	---	15.2	---
	width	---	---	---	---	---	5.9	7.3	---	9	---
p4	length	---	---	5.6*	6.1	---	15.9	11.5	---	d 23.2	---
	width	6.1*	---	3.0*	3	10	9.5	9.3	---	d 11.5	---
m1	length	11.9*	5.8	6.1	5.7	6.8	---	---	---	21	---
	width	7.9*	5.2	4.5	4.2	15.7	---	---	---	13	---
m2	length	12.3	6.9	6.7	6.7	9.8	---	---	---	---	---
	width	9.2	5.6	5.2	5	18	---	---	---	---	---
m3	length	---	---	9.8	10.2	---	---	---	---	---	---
	width	8.1*	---	5.7	5	---	---	---	---	---	---

figured and described by Loomis (1924), Thorpe (1937), and Schultz and Falkenbach (1968). In particular, the p3 characterizes *Eporeodon* in having prominent posterior intermediate crests on the premolars that extend posteriorly from the median crest and divide an open posterior basin.

These specimens are smaller than *Mesoreodon*. The molars are not as transversely widened

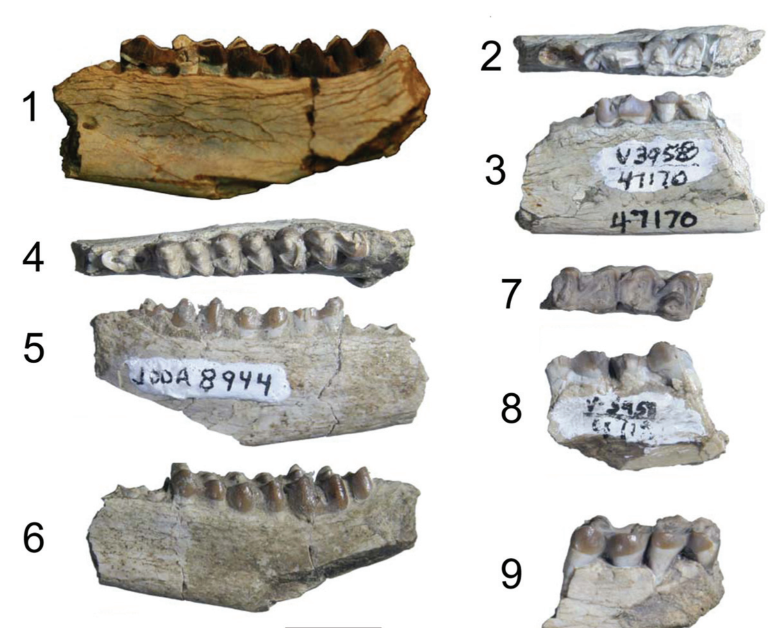

FIGURE 32. Partial left dentary with p4-m3 (UWBM 29151) (1), partial right dentary with p4 and m1 (UCMP 47170) (2, 3), partial left dentary with m1-m3 (JODA 8944) (4-6), and partial right dentary with m1 and m2 (UCMP 47165) (7-9) of *Hypertragulus*. Specimens shown in occlusal (2, 4, 7), buccal (3, 5, 8), lingual (1, 6, 9) views. Scale bar equals 1 cm.

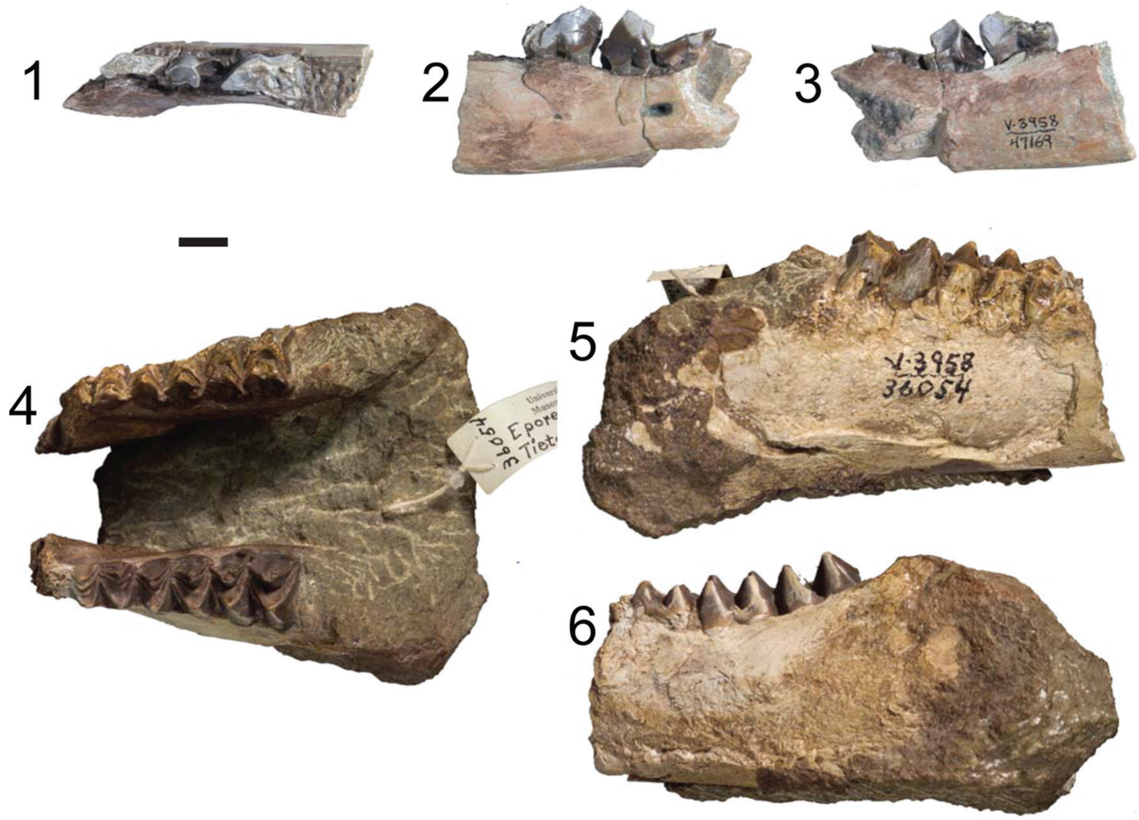

FIGURE 33. Partial left dentary with p3 and partial p4 (UCMP 47169) (1-3), and partial right and left dentaries (UCMP 36054) (4-6) of *Eporeodon*. Specimens shown in occlusal (1, 4), buccal (2, 5, 6), and lingual (3) views. Scale bar equals 1 cm.

as in *Merycoidodon* (Stevens and Stevens 1994). The premolars have stronger crescents and posterior intermediate crests than *Merycoides*, *Paroreodon,* and *Phenacocoelus*. The premolars of these specimens do not show the degree of molarization as *Ticholeptus*. The premolars are not anteroposteriorly shortened as *Paroreodon*, *Oreodontoides*, *Merychyu*s, and *Paramerychyus* (Schultz and Falkenbach 1947; Stevens and Stevens 2007). These specimens represent oreodonts smaller than *Desmatochoerus*, *Promerycochoerus*, *Megoreodon*, *Hypsiops*, *Merycochoerus*, and *Submerycochoerus*.

Geologic occurrence. *Eporeodon* is known from the Whitneyan through the early Arikareean of the Great Plains, California, and Oregon (Stevens and Stevens 2007).

Genus *Merycoides* Douglass, 1907
Merycoides sp.
Figure 34

Referred material. UCMP 47166, partial left dentary with p3-m2: dental measurements in Table 6.

Locality. WC-2.

Description. The occlusal enamel of the p3 and m2 is nearly worn through. Anterior, median, and posterior crests are present on the p3, but the median crest is mostly broken. The posterior intermediate crest extends from the median crest and runs parallel to the posterior crest. The posterior crescent is reduced. The p4 has more prominent anterior, median, and posterior crests, lacks an anterior crescent . The posterior intermediate crest projects from the median crest, is reduced, and does not connect to the posterior cingulum. The apex of the crests and crescents of the m1 and m2 project posteriorly. The anterior and posterior crests are divided by a deep valley; the cingulum is strong in the valley.

Discussion. This specimen is referred to *Merycoides* because it has anterioposteriorly shortened premolars, reduced crests on the p3, and posterior and posterior intermediate crests on the p4 that form an undivided posterior basin (Thorpe 1937, Stevens and Stevens 2007). Anteroposteriorly shortened premolars are found in merychyines (Stevens and Stevens 2007), but UCMP 47166 lacks the tooth row offset, as in *Oreodontoides* and

FIGURE 34. Partial left dentary with p3 to m2 (UCMP 47166) of *Merycoides* sp. Specimen is shown in occlusal (1), buccal (2), and lingual (3) views. Scale bar equals 1 cm.

Phenacocoelus (Schultz and Falkenbach 1947). UCMP 47166 retains the labial cingula, unlike *Merychyus* (Stevens and Stevens 2007). The tooth row is more crowded than *Paramerychyus* and *Paroreodon* (Schultz and Falkenbach 1947). This specimen differs from ticholeptines in lack of elongate premolars (Stevens and Stevens 2007).

Geologic occurrence. *Merycoides* first occurs in the John Day Formation and is known from North America from the latest Whitneyan through the Arikareean (Tedford et al. 2004; Stevens and Stevens 2007).

Genus *Mesoreodon* Scott, 1893
Mesoreodon sp.
Figures 35 and 36

Referred material. JODA NT06052N, partial right dentary with p3, dp4, and m1, JODA 8947, right p3, right M1 or M2, and left partial maxilla with P3: dental measurements in Table 6.

Localities. WC-2, WC-4.

Description. The p3, dp4, and m1 (JODA NT06052N) show light wear. A partial p3 preserves a strong anterior crest. The anterior, median, and posterior lobes of the dp4 are rotated so that the apices of the crests and crescents point posteriorly.

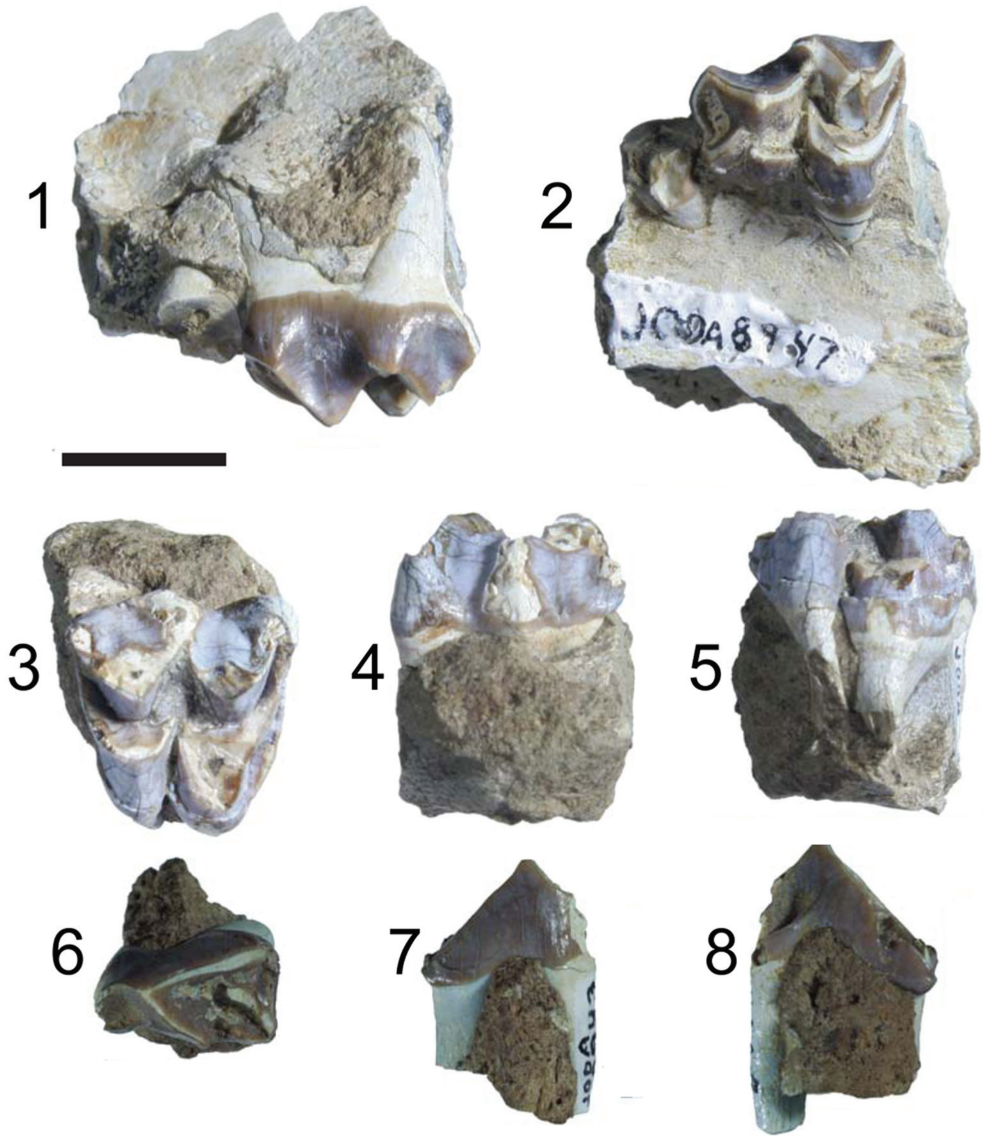

FIGURE 35. Partial left maxilla with P3 (1,2), upper left molar (3-5), and lower right p3 (6-8) (JODA 8947) of *Mesoreodon* sp. Specimens shown in occlusal (2, 3, 6), buccal (1, 4, 7), and lingual (5, 8) views. Scale bar equals 1 cm.

The posterior portion of each crescent overlaps the anterior portion of the following crescent. The anterior and posterior crests do not join and are divided by a deep valley.

The p3 has prominent anterior, median, and posterior crests. The median crest directs posterior and lingually from the primary cusp, and joins with the posterior crescent. The posterior intermediate crest is prominent and extends from the posterior cingulum and partially divides the posterior basin.

The anterior crest and crescent are reduced and small relative to the posterior crest and crescent on P3. The anterior intermediate crest is reduced. The partial right upper molar shows an anterior crest and mesostyle with strong ribs. Its posterior cingulum is reduced.

Discussion. Specimen JODA NT06052N was collected in situ in Thunder Creek and represents the highest such occurrence, 228 m above the pumice lapilli-tuff. Specimens are referred to *Mesoreodon* by having reduced anterior intermediate crests on the upper premolar, and prominent posterior intermediate crests and crescents on the lower premolars (Loomis 1924; Thorpe 1937; Shultz and Falkenbach 1949). These specimens are larger, have more prominent crescents on the lower p3, and have posterior intermediate crests that originate from the posterior cingulum, not the median

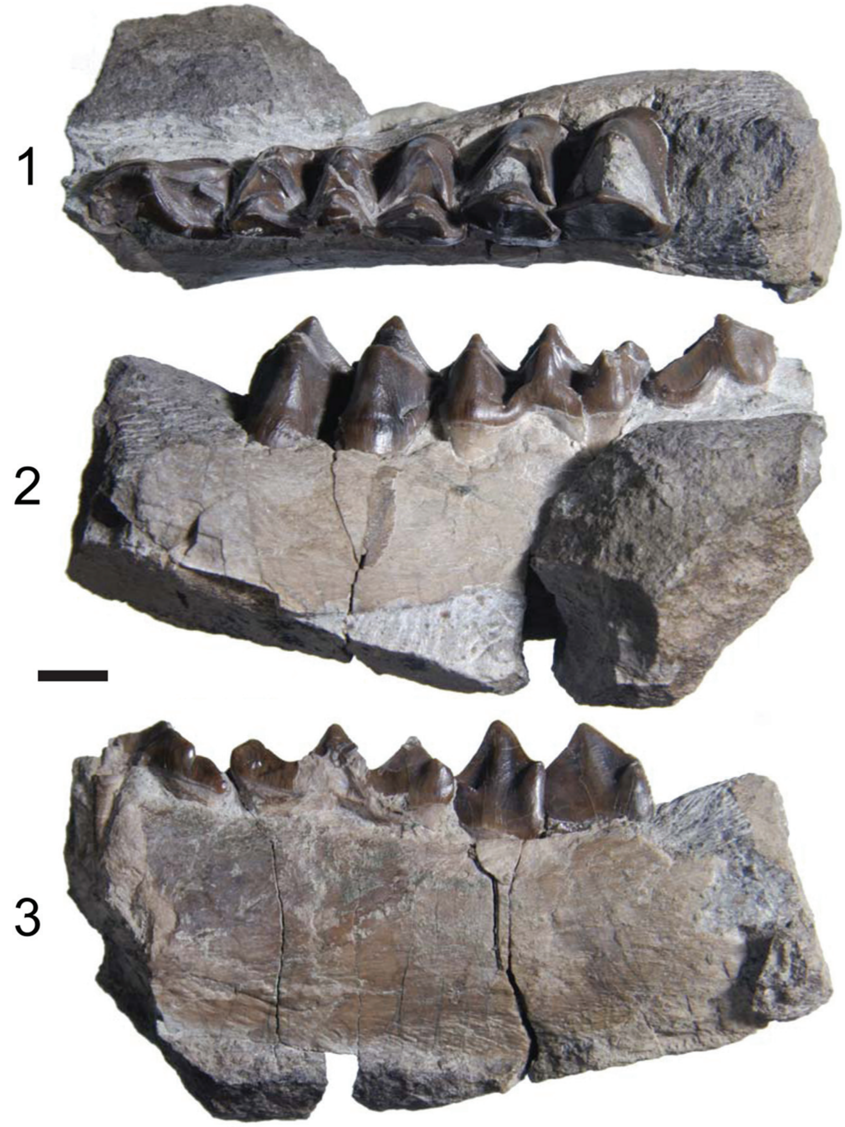

FIGURE 36. Partial right dentary with p3 dp4, and m1 (JODA NT06052N) of *Mesoreodon* sp in occlusal (1), buccal (2), and lingual (3) views. Scale bar equals 1 cm.

crest as in *Eporeodon*. The prominent posterior intermediate crest on the premolars differs from *Promerycochoerus* and *Hypsiops* (Schultz and Falkenbach 1949). These teeth represent individuals smaller than *Desmatochoerus* and *Merycochoerus* (Stevens and Stevens 2007). The premolars are not reduced as in *Merycoidodon*, *Merychyus*, *Submerycochoerus*, and *Paroreodon*, and are not rotated as in *Oreodontoides*, *Phenacocoelus*, *Paramerychyus*, and *Ticholeptus* (Schultz and Falkenbach 1941, 1947; Stevens and Stevens 2007). The tooth row is not crowded as in *Merycoides* and *Megoreodon* (Schultz and Falkenbach 1954).

Geologic occurrence. *Mesoreodon* first appeared in the Chadronian of Texas, and is known from the Chadronian through the early Arikareean of the Great Plains and the early Arikareean of Oregon (Stevens and Stevens 2007).

Genus *Promerycochoerus* Douglass, 1901
Promerycochoerus superbus (Leidy, 1870)
Figures 37, 38, and 39

Referred material. UCMP 128070, partial cranium, UCMP 128071, partial cranium, JODA TS07023, partial cranium with right M1 or M2, left M1-M3, JODA JS07051, partial upper or lower molar: dental measurements in Table 6.

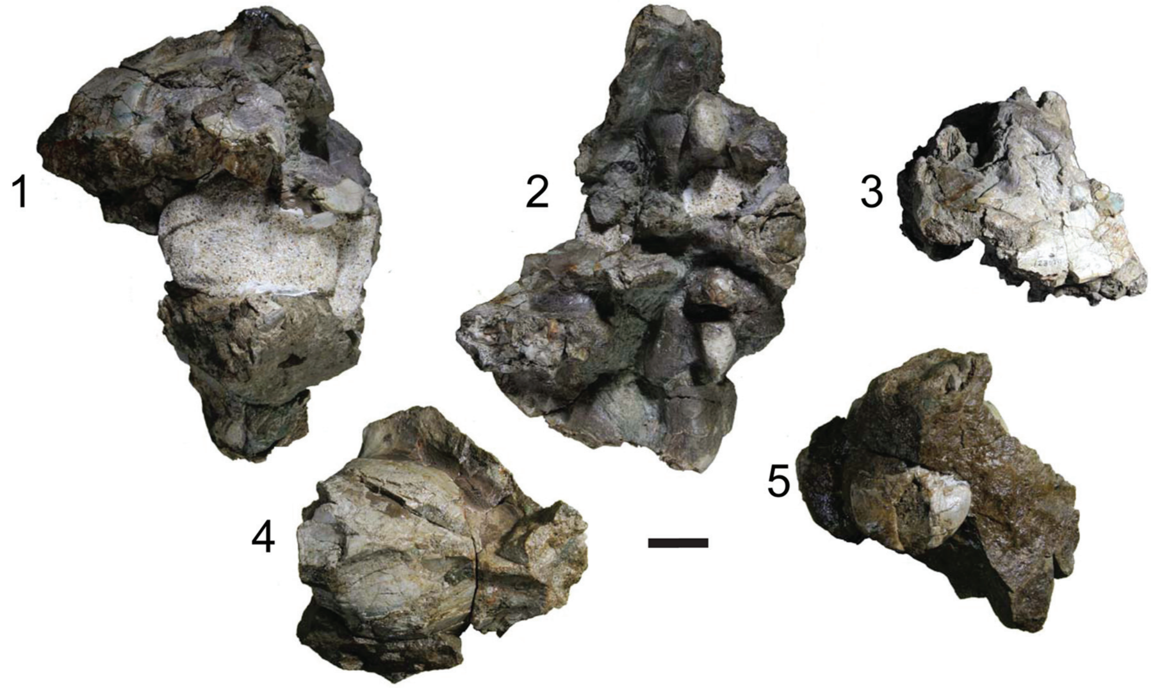

FIGURE 37. Partial crania (UCMP 128070) (1-3) (UCMP 128071) (4, 5) of *Promerycochoerus superbus.* Specimens shown in dorsal (1, 4), ventral (2), lateral (3), and posterior (5) views. Scale bar equals 3 cm.

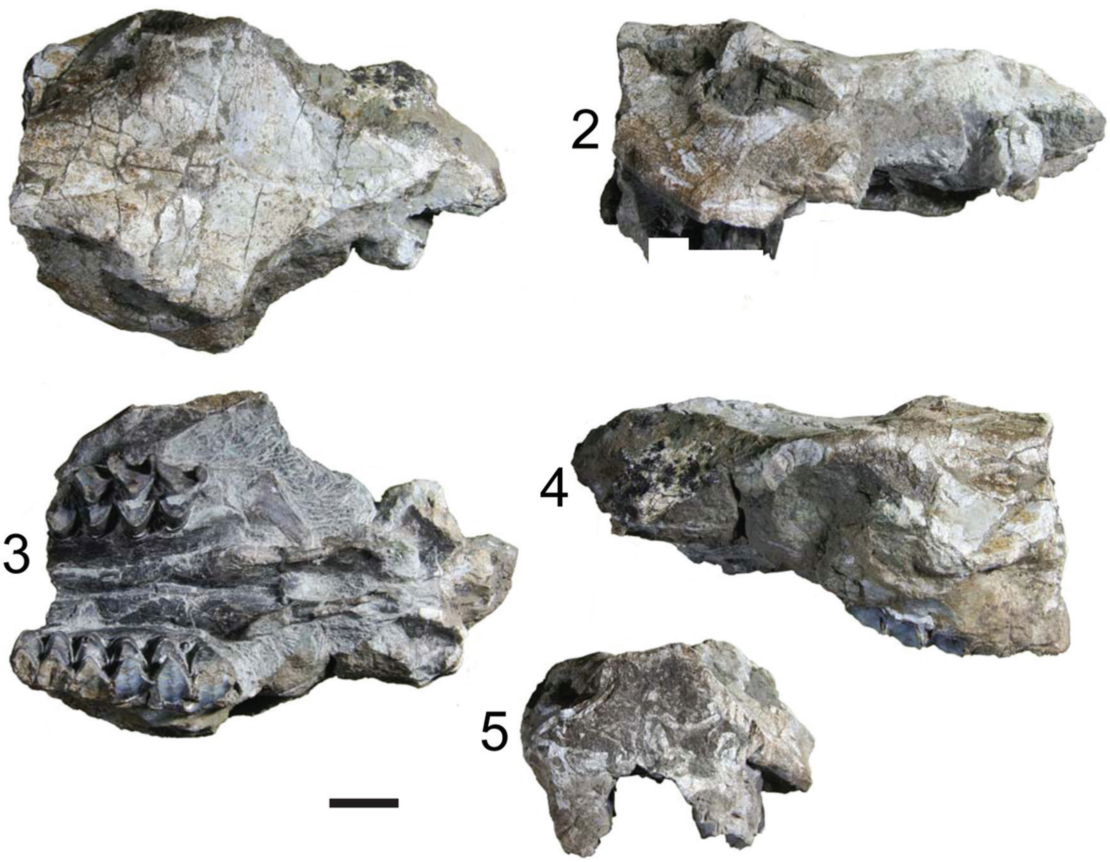

FIGURE 38. Partial cranium with right partial m1-m3 and left partial m2, m3 (JODA TS070523) of *Promerycochoerus superbus*. Specimen shown in dorsal (1), left lateral (2), ventral (3), right lateral (4), and anterior (5) views. Scale bar equals 3 cm.

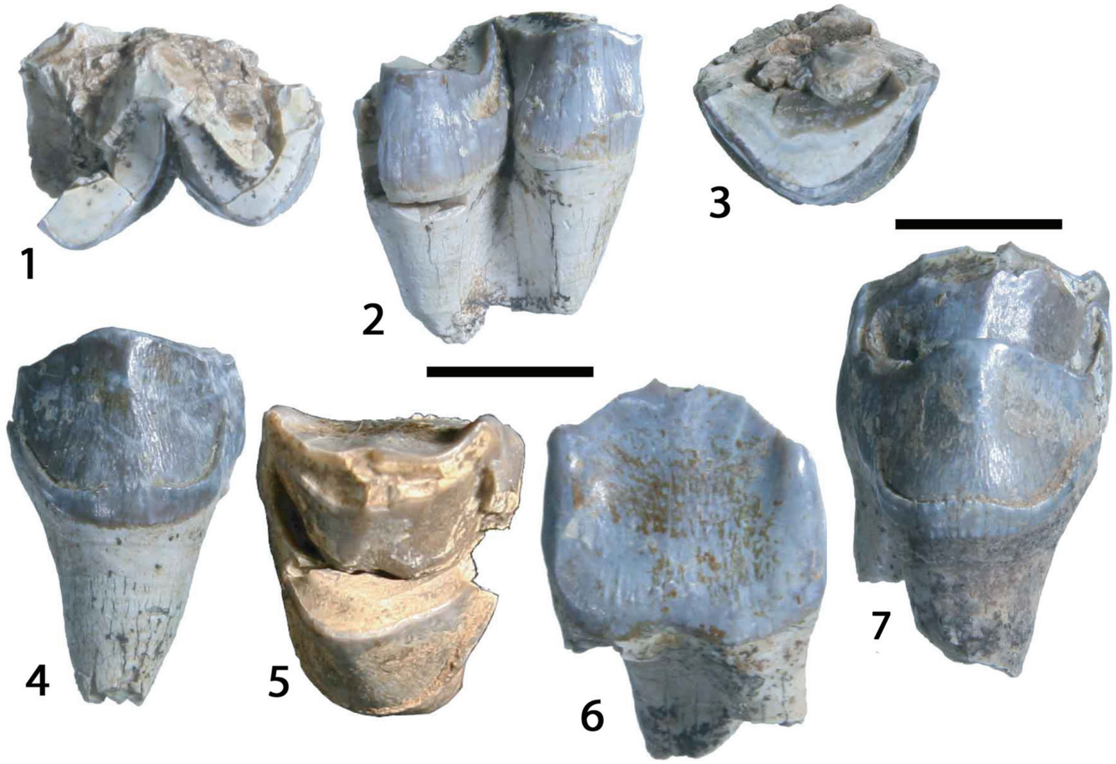

FIGURE 39. Partial upper or lower cheek tooth (1, 2), partial left P4 (3, 4), and partial right P4 (5-7), (JODA JS07051) of *Promerycochoerus superbus.* Specimen shown in occlusal (1, 3, 5), buccal (6), and lingual (2, 4, 7) views. Scale bar equals 1 cm.

Localities. WC-3, WC-4.

Description. Specimen UCMP 128070 includes the right M2 and M3 tooth roots, partial right jugal, postglenoid process, basioccipital region, and foramen magnum. The snout, most of the palate, occipital condyles, auditory bullae, and the dorsal skull are missing. The postglenoid processes are heavy. The jugal is robust and relatively flat on the lateral side. The preserved tooth roots are large. The M3 metastyle is the only preserved portion of the dentition, and it is prominent and posteriorly projected.

Specimen UCMP 128071 includes the braincase from the postorbital constriction of the frontals to the foramen magnum. Matrix obscures most of the ventral morphology. The braincase is relatively large. The preserved dorsal surface indicates a prominent sagittal crest. The postglenoid process is robust. The occiput is fully fan shaped. The paraoccipittal process is robust, projects laterally and is slightly anteriorly rotated.

Specimen JODA TS070523 includes the frontal region to the postorbital constriction and has a partial right and left M2 and M3. The skull is dorsoventrally flattened, and the right buccal crests are deformed lingually. The preorbital fossa is broad and shallow. The jugals are broad, and the frontals are wide.

The teeth are selenodont. The apex of the crests and crescents projects anteriorly. The anterior and posterior crescents are divided by a valley, and do not meet. The lingual cingulum is strong and forms a prominent intervallic cusp on the M3. The styles and ribs are prominent on the M3 and the metasyle projects buccally from the tooth. A large partial P4 is indicated by the undivided selene.

Discussion. Lander (1998) identified specimens UCMP 128070 and UCMP 128071 as *Merycochoerus chelydra chelydra*, a revision of the previous assignment by Lander and Swanson (1989) as *Merycochoerus superbus*. However, the reasoning behind the reassignment was not presented.

These specimens, taken together, represent *Promerycochoerus superbus*, based on the prominent and robust postglenoid processes, paroccipital processes prominent, fan-shaped occiput, extension of the palate posterior to the M3, and

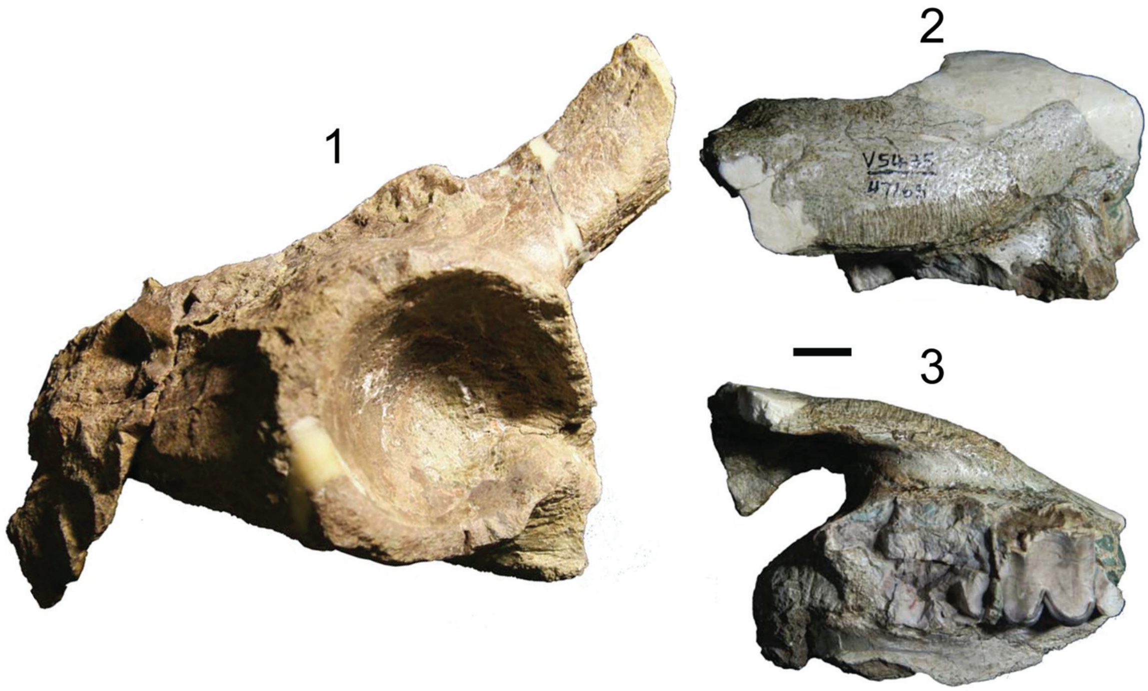

FIGURE 40. Partial left acetabulum (JODA TFWC10032) (1) and partial right maxilla (UCMP 47165) (2, 3) of indeterminate merycoidodontids. UCMP 47165 is shown in buccal (2) and occlusal (3) view. Note the rodent gnaw marks (2, 3). Scale bar equals 1 cm.

strong external ribs on the molars (Thorpe 1937; Schultz and Falkenbach 1949). The specimens are substantially larger than *Mesoreodon* and *Desmatochoerus* and differ from *Ustatochoerus* by having a pronounced facial vacuity and lower crowned teeth (Stevens and Stevens 2007). The large, wide, robust, postglenoid processes differ from *Megoreodon* and *P.* [*Paramerycochoerus*] *barbouri*, but are not as robust as *Promerycochoerus carrikeri* and *Promerycochoerus chelydra* described and figured by Schultz and Falkenbach (1949, 1954).

Geologic occurrence. *Promerycochoerus superbus* occurs from the late early and early late Arikareean of South Dakota but first occurs at the Deep Creek Tuff, dated at 27.8 Ma, of Oregon (Janis et al. 1998; Stevens and Stevens 2007).

Merycoidodontidae genus and species indeterminate
Figure 40

Referred material. UCMP 47165, partial right maxilla, JODA TF10032, partial right maxilla.

Locality. WC-1

Description. A partial pelvis includes complete right acetabulum and parts of the ilium, ischium and pubis. The base of the ilium is wide, but no ridge is preserved.

A partial maxilla preserves the anterior portion of the zygomatic arch. The teeth are from a large, *Promerycochoerus superbus*-sized oreodont. The zygomatic arch has rodent gnawmarks 8 mm long and about 0.5 mm wide.

Discussion. Specimen JODA TF10031 is the lowest in situ occurrence of a fossil in the Wildcat Creek beds, 120 m above the pumice lapilli tuff. Rodent gnawing on specimen UCMP 47165 indicates the fossil was exposed prior to burial.

BIOSTRATIGRAPHY AND BIOCHRONOLOGY

The Milk Creek tuff produced one fossil, a rhinocerotoid or hyracodontid tooth. The size of the tooth compares to rhinocerotids and hyracodontids younger than middle Chadronian, about 34 Ma. A zircon fission track age of 33.7 Ma supports the correlation and places this specimen as the oldest non-marine mammal collected in Washington (Vance et al. 1987).

The upper Wildcat Creek beds produced 34 specimens representing at least 14 different taxa. This work, supplemented with prior collections data, places fossil occurrences in unit B of the upper Wildcat Creek beds (Figure 41). Comparing these taxa, the Wildcat Creek local fauna, to assemblages from the John Day Formation in Ore-

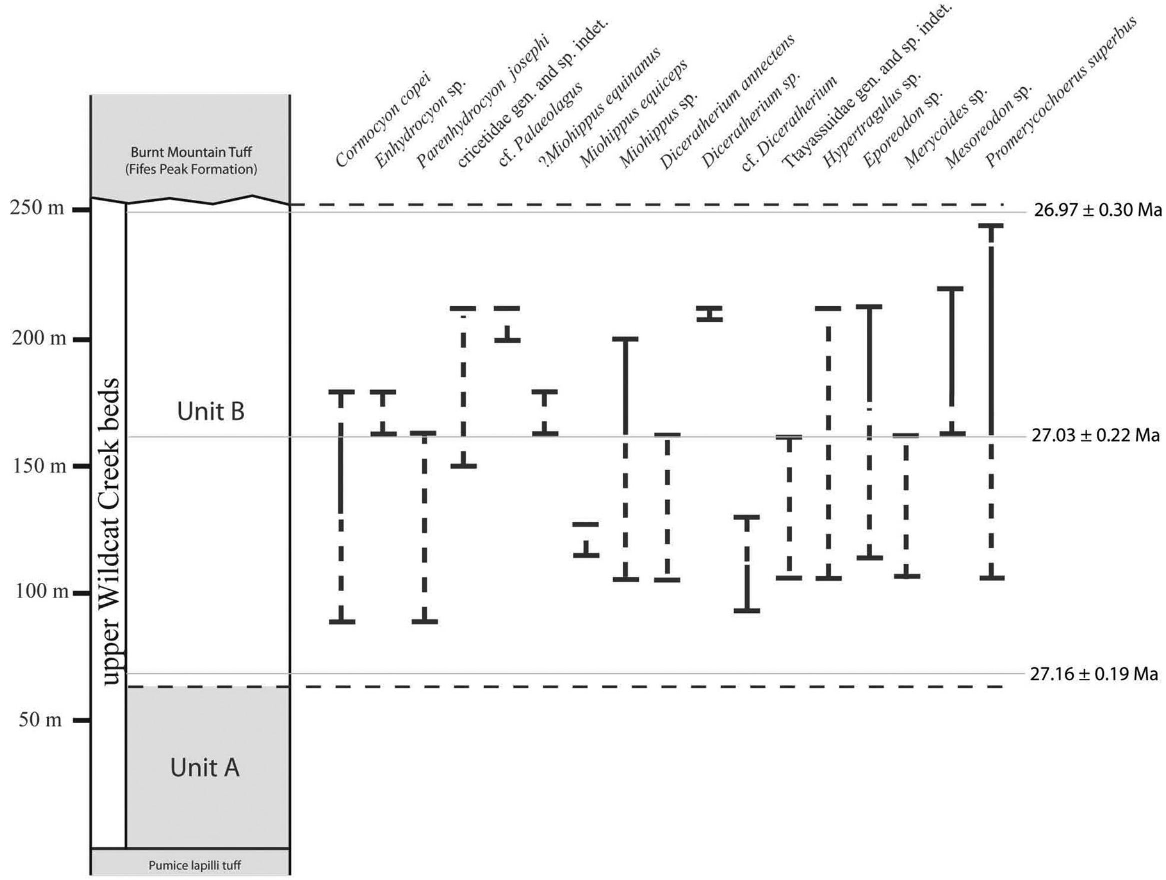

FIGURE 41. Stratigraphic distribution of the Wildcat Creek local fauna.

gon and from assemblages in Montana and the Great Plains, suggests a medial early Arikareean age, 26-28 Ma (Figure 42).

Taxa indicative of this correlation are *Cormocyon copei*, *Enhydrocyon*, *Parenhydrocyon josephi*, cf. *Palaeolagus*, *Miohippus equiceps*, *Diceratherium annectens*, *Hypertragulus, Eporeodon*, *Merycoides*, *Mesoreodon*, and *Promerycochoerus superbus*. Many of these taxa are represented in early early Arikareean (Ar 1) and late early Arikareean (Ar 2) assemblages, though *Enhydrocyon* sp., ?*Miohippus equinanus*, *Miohippus equiceps*, *Diceratherium* sp., *Hypertragulus*, and *Eporeodon* sp. are also present in earlier, Whitneyan, deposits (Tedford et al. 2004; Albright et al. 2008). ?*Miohippus equinanus* does not extend to the Ar 2 in Oregon, but is known to persist through the Oligocene of the Great Plains (MacFadden 1998). *Cormocyon copei*, *Parenhydrocyon josephi* and *Mesoreodon* sp. first occur in the Ar 1 of Oregon and continue into the Ar 2 (Wang 1994; Stevens and Stevens 2007).

Palaeolagus sp., *Merycoides* sp., *Promerycochoerus superbus,* and the cricetid rodents *Leidymys* and *Paciculus*, (likely referral of UCMP 119462) are characteristic of an Ar 2 assemblage of Oregon, first occurring above the Deep Creek Tuff, dated at 27.8 Ma (Tedford et al. 2004; Stevens and Stevens 2007; Albright et al. 2008). *Cormocyon copei*, *Enhydrocyon* sp., *M. equiceps* and *Diceratherium annectens* last occur below the Tin Roof Tuff, dated at 25.9 Ma, though *D. annectans* reappears in the latest Oligocene (Tedford et al. 2004; Albright et al. 2008). *Hypertragulus* sp., *Eporeodon* sp., and *Mesoreodon* sp. persist into the late Arikareean of Oregon, (Albright et al. 2008).

The medial Arikareean correlation for unit B of the upper Wildcat Creek beds is supported by Ar/Ar age analyses restricting the deposition from 27.16 ± 0.19 Ma to 26.97 ± 0.30 Ma (Table 7, Hammond, personal commun., 2006). This chronology refines prior assessments of the Wildcat Creek beds and suggests the later persistence of ?*M. equinanus* in the Pacific Northwest.

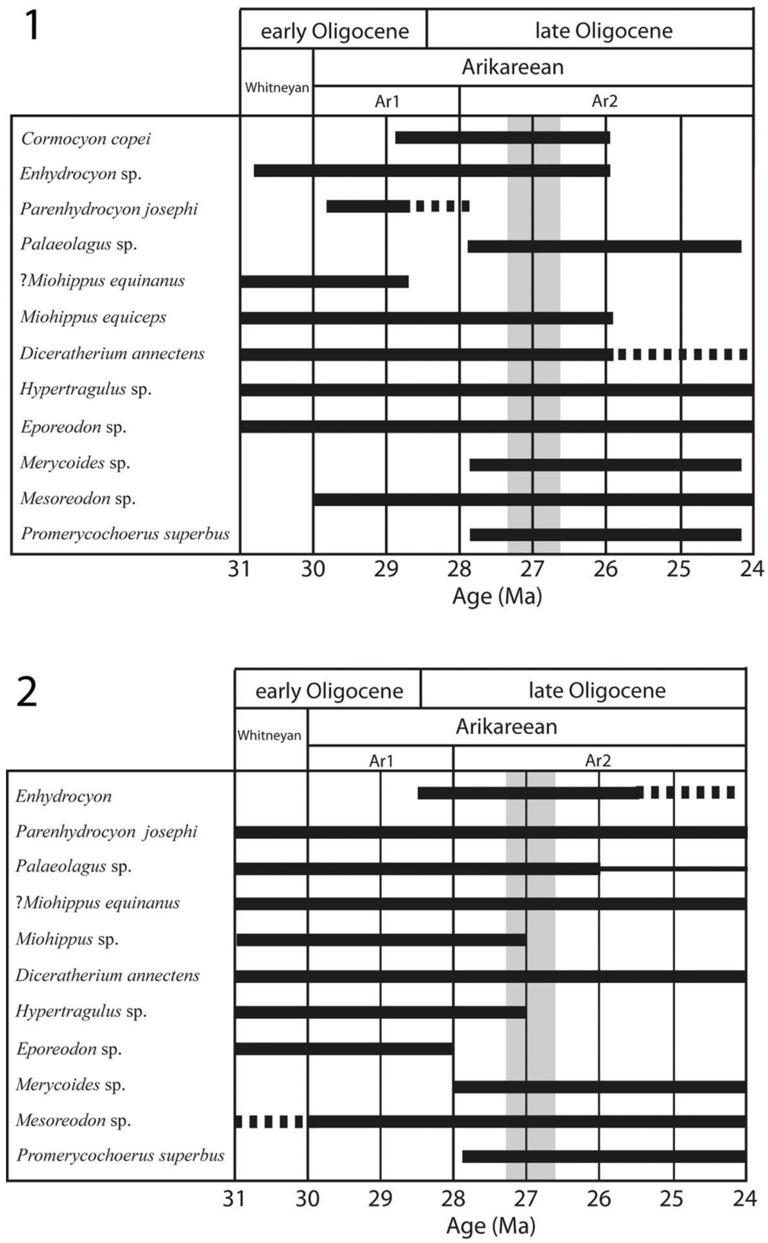

FIGURE 42. Biochronology of taxa from the Wildcat Creek beds in Oregon (1) and east of the Rockies (2).

TABLE 7. $^{40}Ar/^{39}Ar$ age estimates from plagioclase crystals (Hammond, unpublished data).

Sample	Stratigraphic level (m)	Age (Ma)	±1?
TC052-6	265	26.97	0.30
WR-12	160	27.03	0.22
HYE-4	50	27.16	0.19

CONCLUSIONS

Fossil mammals and pedogenic development preserved in two units of the volcanogenic Wildcat Creek beds provide evidence of terrestrial environments in south central Washington. A partial rhinocerotid or hyracodontid tooth recovered from the Milk Creek tuff compares to taxa younger than the middle Chadronian. A published zircon fission track age of 33.7 Ma supports this estimate.

The upper Wildcat Creek beds produced 34 fossils belonging to at least 14 taxa of non-marine mammals. Fossil discoveries and prior collections data indicate the fossils occur in the upper 200 m, within unit B.

The correlation between the Wildcat Creek beds and the John Day Basin of eastern Oregon was first indicated by the discovery of a lower jaw of *Eporeodon* sp. (Grant 1941). Specimens recovered since that time also support this correlation. The fossil assemblage preserved in the upper Wildcat Creek beds, the Wildcat Creek local fauna, contains *Cormocyon copei*, *Enhydrocyon* sp., *Parenhydrocyon josephi*, a cricetid, cf. *Palaeolagus* sp., ?*Miohippus equinanus*, *Miohippus equiceps*, *Diceratherium annectens*, a tayassuid, *Hypertragulus* sp., *Eporeodon* sp., *Merycoides* sp., *Mesoreodon* sp., and *Promerycochoerus superbus*.

These taxa occur primarily between the Deep Creek Tuff and Tin Roof Tuff of the Turtle Cove Member of the John Day Formation, and indicate a northern extension of that late early Arikareean (Ar 2) fauna. This correlation is supported by bracketing Ar^{39}/Ar^{40} radiometric ages of 26.97 and 27.16 Ma. Of the taxa recovered, only ?*M. equinanus* is not known from Oregon during this time, and the presence here indicates the taxon persists later in the Pacific Northwest.

The pedogenic succession from Argillisols, in the Milk Creek tuff, to Gleysols and gleyed Protosols, in the lower and upper Wildcat Creek beds, indicates a moist environment that changed from well-drained in the late Eocene, to poorly drained conditions of the upper Wildcat Creek beds, about 27 Ma.

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APPENDIX

Symbols and abbreviations used for stratigraphic sections.